



University
of Vermont

On Matters of Life and Death

Recommended Actions to Improve the Safety of Vermonters During Major Flooding Events

Christopher Koliba,* Rodrigo Soares, Scott Merrill, Trisha Shrum,
Ruth Quainoo, Molly Myers, Masood Ali Kahn,
Jessica Balerna, and Emma Spett

University of Vermont

March 8, 2024

This research is funded through the Cooperative Institute for Research to Operations Hydrology (CIROH), a consortium of universities and research consulting firms focusing on support for the National Oceanographic and Atmospheric Administration (NOAA) and the National Weather Service to improve weather forecasting capacity for the nation. NOAA's mission is to use flood forecast information to save lives and property.

*For questions, please contact lead researcher: ckoliba@uvm.edu

On Matters of Life and Death

Recommended Actions to Improve the Safety of Vermonters During Major Flooding Events

EXECUTIVE SUMMARY

This policy brief offers the following series of recommendations directed toward policy makers in Vermont seeking to improve the resiliency of Vermont communities.

A) Investment in Community and County Level Capacity-Building

- A.1: Document location and implications of smaller towns that may lack emergency management or “incident command” capacity across all phases of a flood crisis.
- A.2: Provide select board members and other local officials with routine incident command/emergency management training and orientation.
- A.3: Advance community-wide discussions on flood risks, trade-offs, and adaptation measures that could be undertaken to mitigate them.
- A.4: Shift accountability for disaster response from towns to counties or regions to capture the watershed scale of flood hazards.
- A.5: Require Flood Response Annex to the Local Hazard Mitigation Plans (LHMP).

B) Investment in Human Resources

- B.1: Conduct a gap analysis pertaining to the roles and responsibilities of actors across the emergency response and immediate recovery network across the state of Vermont, including local officials.
- B.2: Increase investments in provisioning for emergency management personnel at the state and local levels.
- B.3: Provide cross-training to temporary staff mobilized during flood events.

C) Review and Engage Risk Communication Plans

- C.1: Assess gaps and generate recommendation for risk communication “two-way” channels, plans and protocols using SMART standards for emergency responses that include meteorological, hydrological, and emergency response professionals; locally

elected, appointed, and volunteer leaders; and major infrastructure providers.

C.2: Provide timely comprehensible, translated risk communication to the public and vulnerable communities during crisis situations.

C.3: Provide greater education, guidelines, and resources for volunteers and residents regarding the public health risks of living and volunteering in flood hazard zones.

D) Enhance Dam Emergency Planning, Preparation, and Communication

- D.1: Undertaking routine tabletop exercises related to major dam failures. A.2: Provide select board members and other local officials with routine incident command/emergency management training and orientation.
- D.2: Provide better integration of dam failure scenarios into actionable Emergency Action Plans (EAPs).
- D.3: Fund and resource inundation mapping for all dams (publicly and privately owned).

E) Actions to Aid Recovery

- E.1: Streamline permit processes for recovery and mitigation.
- E.2: The State should take responsibility for all floodplain regulations.
- E.3: Provide comprehensive support for downtown businesses located in vulnerable floodplains and their long-term recovery.

F) Prioritization of Nature-Based Flood Mitigation Efforts

- F.1: Invest in public and community education on watershed ecosystems.
- F.2: Prioritize investment criteria that consider the ecosystem services of flood hazard mitigation actions.
- F.3: Increase focus on the removal of small dams and restoration of floodplains where it can be done.
- F.4: Prioritize the co-benefits of flood hazard mitigation and water quality for planning and resource allocation.

On Matters of Life and Death

Recommended Actions to Improve the Safety of Vermonters During Major Flooding Events

INTRODUCTION

Vermont has experienced three significant flooding events (in August of 2011, July of 2023, and December of 2023) and several more localized but significant floods in the span of 13 years, two of which resulted in losses of life and significant property damage. **The specter of climate change bodes that such events will continue to occur with greater frequency.**

The responses of everyday Vermonters and the professional emergency managers and responders, town officials, and river and dam managers to the Tropical Storm Irene flooding of 2011 and the Great Vermont Flood of 2023 should be commended. Their dedication to responding to these natural disasters likely resulted in the saving of lives, property, and untold trauma. Their successes hinged in part, on the levels of preparation and communication protocols currently in place. And there is evidence to suggest that Vermonters learned from the 2011 flooding and used this knowledge to prepare for and respond to the flood events of 2023.

However, the relative successes of the responses of 2011 and 2023 also hinged on some luck and circumstances. None of the flood events, for instance, resulted in major dam failures. Rising flood waters were preceded by forewarning. Had conditions been different, for instance, had a major dam been breached, the capacity of local town officials and state emergency managers and water resource managers to effectively assess and communicate risk to those in harms-way is limited by gaps in capacity. **Steps can and should be taken to invest in building up this capacity to avoid catastrophic loss of life in the future.**

We have intentionally titled this policy brief to grab one's attention. The findings and recommendations summarized from this report were culled from extensive engagement with the people who experienced and responded to the 2011 and 2023 floods in the Winooski watershed of Vermont. Their insights need to be elevated and taken seriously.

This policy brief summarizes the outcomes of the two focus groups convened after the "Great Vermont Flood of July 2023," involving Vermonters with professional obligations for response and recovery to flood disasters within the Winooski watershed, an area of Central Vermont that was hard hit by the flooding. These professionals included emergency managers, river and dam managers and engineers, regional planners, and town officials. The fuller findings and recommendations stemming from these focus groups can be found separate technical brief Operational Considerations Resulting from a Review of the Response and Recovery to the "Great Vermont Flood of 2023."

SUMMARY OF FINDINGS AND RECOMMENDATIONS

A) Investment in Community and County Level Capacity-Building

By most accounts, the responses of the state, regional, and local emergency responders to the Great Vermont Flood of 2023 were commendable. Professionals and volunteers alike worked long hours over many days and weeks to ensure that the response and early recovery from the emergency conditions were carried out, potentially saving lives, personal property, and untold trauma.

The lack of county infrastructure and strong reliance on local control places a great deal of responsibility on elected, appointed, or volunteer local officials to serve as local incident commanders. While it is believed that local officials stepped up and did their best to respond to the Great Vermont Flood of 2023, the flow of information to and from local and state officials could be improved, particularly during times of major risks. Evacuation decisions are locally determined in consultation with the state and occur in high-risk situations. Assessment of risk is rendered better when situations are clear and expert judgment is considered. *However, the capacity of local communities to manage crises and mitigate risks varies drastically across Vermont.*

The lack of capacity in some towns is a critical weakness. In many communities, social capital and community involvement are limited. Pre-planning is key (e.g., having Flood Emergency Response Plans is critical). In rural areas, road integrity during an emergency to get to shelter/aid/healthcare is particularly fraught. During an emergency, the response of real people on the ground is crucial.

Sometimes these can emerge from formal organizations or informal networks. However, it is important to have centralized and



targeted messages and information flow regarding safe actions, available support, and coordinated responses, including shelters and safe passages.

Recommendation A.1: Document location and implications of smaller towns that may lack emergency management or “incident command” capacity across all phases of a flood crisis. It is anticipated that such a comprehensive review of local capacities will yield troubling and significant variability in local town capacities when planning for and responding to flood disasters. The focus group participants cited many examples of some of the even more well-resourced towns of the Winooski watershed, which lacked the capacity to conduct adequate flood hazard response planning. A comprehensive assessment should focus on the unmet needs of smaller towns that may lack emergency management or “incident command” capacity across all phases of a flood crisis. In addition, greater attention should be applied to the role of regional planning commissions. Such a study could be funded and contracted out to researchers.

Recommendation A.2: Provide select board members and other local officials with routine incident command/emergency management training and orientation. This recommendation is not offered in lieu of recommendation A.3 but is an important feature of the shared responsibilities of state-county-regional-local emergency management officials. Most town officials serve in volunteer capacities and turnover is likely frequent. Given the authority that these local officials have in informing residents, ordering evacuations, and communicating flooding impacts that are unfolding “on the ground,” it is critical that they understand their community’s vulnerabilities and the best ways to respond to disaster conditions. Such training can be coordinated between the state and educational service providers.

Recommendation A.3: Advance community-wide discussions on flood risks, trade-offs, and adaptation measures that could be undertaken to mitigate them. As the immediacy of the flood recedes, people are shifting their focus from the community and the neighborhood to their own issues and needs. Avoiding damage is not something people like to think about, particularly during and immediately after a flood. Therefore, it is important to consider ongoing awareness-raising and risk communication discussions on how to systematically address the lessons learned from previous crises in an effort to minimize future risks undertaken at the community scale. Such efforts could be facilitated by trusted facilitation and capacity-building non-governmental organizations, including watershed associations.

Recommendation A.4: Shift accountability for disaster response from towns to counties or regions to capture the watershed scale of flood hazards. With flood recurrence intervals shortening, town wide attention to flood resilience and mitigation impacts should be planned for at *and* beyond the municipal level. It is believed that this would best work at the county level or watershed scale, as many communities are connected through riverine systems and cannot be considered in isolation. Maintaining this discussion over time requires a full-time commitment of professionals operating at the county, regional, or watershed scale, rather than being part of a mix of duties carried out by most municipal authorities. Such a shift in disaster management responsibilities aligns with enhanced capacity at the state level (see recommendations B.1-3; E.2).

Recommendation A.5: Require Flood Response Annex to the Local Hazard Mitigation Plans (LHMP). With enhanced capacity at county/regional levels, these plans would include assessments of local vulnerabilities, local communication protocols, and redundancy or backup roles and responsibilities of local officials. The town-level government makes this challenging; however, emergency action plans should be mandatory for towns and overseen at the state level to ensure that they are up-to-date and account for town hazards.

Ultimately, full-time town, regional, or county officials are needed. Most communities in Vermont have local emergency operational plans. These are updated annually but are mostly limited to lines of emergency authority in the community. *Communities really need much more.* They need additional Flood Response Plans (as annexes) for the LHMP. This would require the community to consider local vulnerabilities with roads/culverts, community members who are particularly exposed/isolated/difficult with mobility or health conditions, or other complications. Part of the plan needs to point to future community conditions with safer homes, workplaces, reliable roads, and functional community services. One focus group participant suggested that after Town Meeting Day in March all towns could review and pass their LHMP every few years, “which is a great time to review the document and walk through with the staff involved and the Select Boards, the fire chief, etc.”

B) Investment in Human Resources

Among Vermont’s competing priorities for resources, emergency management planning and response needs developed attention, chiefly among them, increasing the capacity of VEM and building the capacity for emergency management at the county or regional scales. Several times over the course of the focus groups the observation that the state has just three regional emergency managers for 261 towns was mentioned. In times of crisis, as well as when planning, preparation, recovery, and mitigation are undertaken, this ratio is insufficient. Recommendation A.1, the assessment of a gap analysis, further underscores the need to invest in more human capital.

Recommendation B.1: Conduct a gap analysis pertaining to the roles and responsibilities of actors across the emergency response and immediate recovery network across the state of Vermont, including local officials. The focus group participants shared that the state needs a more robust assessment of who is doing what during a crisis.

While all the responders to the Great Vermont Flood of 2023 should be commended, some breaks in communication channels and overburdened emergency management professionals and engineers were evident. Pre-assigned roles and access to information must be determined during the pre-crisis stage; therefore, when a crisis occurs, the process of monitoring the response can be more effective. This recommendation complements recommendation A.1 and is likely to be accomplished in one study.

Recommendation B.2: Increase investments in provisioning for emergency management personnel at the state and local levels. It is recommended that the filling of vacant positions in the VEM staff be prioritized. VEM has three regional coordinators whose job is solely supporting local Emergency Management development. When data are available, they need to decide how to apply them, and who in the community needs translation. Three EM Regional Coordinators cannot cover 260+ risk management directors. As one participant noted, “there is a bottleneck there.” Emergency management directors should already be thinking about vulnerable populations, but it is the application of knowledge that often does not occur.

Increasing the number of EM Regional Coordinators is one way to increase the capacity. Growing human resources for emergency management at county and/or regional scales is also recommended and aligned (see Recommendation A.3).

Recommendation B.3: Provide cross-training to temporary staff mobilized during flood events.

The temporary mobilization of non-emergency management personnel and regional planning commission staff is essential during crises and is woven into existing state-level EM planning and mobilization. However, absorbing new staff during an active and ongoing crisis can place undue burdens on the existing EM staff. Cross-training of temporary staff mobilized during crises is recommended. It should also be noted that the current capacity of full-time EM staff is taxed, and additional resources to develop and implement such cross-training are needed. In addition, the capacity of RPCs to supply temporary staff to incident command centers varies drastically across the state. Some RPCs have emergency management professionals in place, whereas others do not. If cross-training sessions occur outside one’s professional duties, stipends for participation in the training should be offered to ensure equity. Mobilizing other content experts from the industry and academia has also been suggested.



C) Review and Engage Risk Communication Plans

A key feature of preparation and response to flooding disasters is the communication systems in place to convey forecast and real-time, in situ information about anticipated and existing flood conditions. While the communication channels around the response to the July 2023 floods were sufficient and resulted in good outcomes, redundant and clear channels of communication, particularly between dam engineers, hydrological modelers, emergency managers, and local and state officials, are needed. Lapses or challenges in conveying information in real time to the right people could result in misinformation or lack of information regarding risks and recommended actions. In most cases, channels and protocols exist, but are not always well understood, and staff are limited. No system is perfect.

The Joint Information Center concept was introduced to DEC management in the spring of 2023 and is yet to be implemented. This will require training and time/resource commitment, which is currently not available.

The tension between the recommended model of communication – clear, consistent, authoritative, repetitive messaging – and a complex dynamic situation with many variations among towns is noted. It was suggested that consistent, authoritative, general messages, be complimented with the ability to have differentiated local authoritative messages as needed. Communication must be centralized and targeted. There is a need to centralize clear sources of public information. If dissemination of information becomes a second hand or more rapidly deteriorating, the validity of the information becomes compromised. While it is important to maintain official messaging, a portal allowing individuals to see the breadth of emergency information may aid people looking for further information. A clear challenge with the public is the assessment of the importance of the message. “Is it just another message?” or “Do I need to pay attention at this time?” Emergency information must be audience-centered and focused on considering how the right people know what is going on, and how unfolding events affect their safety, egress, emergency plans, family, workplaces, schools, homes, etc.

Meaningful data for flood-prone towns include knowing how to access the river forecast data, interpreting the maps of affected areas, and understanding the implications of location/building structure, egress, etc. This is best looked at in two stages: developing clear points of input from field professionals and local officials and the distribution of the information in clear, official channels. The first might benefit from input at the administration/agency level to develop uniform protocols and might necessitate an agency leading to the development, maintenance, and update of a uniform process of communication with external partners/emergency officials.

Recommendation C.1: Assess gaps and generate recommendation for risk communication “two-way” channels, plans and protocols using SMART standards for emergency responses that include meteorological, hydrological, and emergency response professionals; locally elected, appointed, and volunteer leaders; and major infrastructure providers. Consider leveraging non-flood-related networks and communication channels during a flood crisis. Review gaps in light of plans for the establishment of a Joint Information Center. This assessment should include the consideration of two-way information flows between state and local officials to improve the efficacy of providing information to the public about current or impending hazards and drawing on local officials, their comments, and understanding about the situation to inform messages to the public. This plan should include having information coming from as few sources as possible and one place the public can go for information. Categories such as dam safety, transportation and road closures, emergency shelter sites, and requests for volunteers should be included.

Recommendation C.2: Provide timely comprehensible, translated risk communication to the public and vulnerable communities during crisis situations. “Translation” here is understood both in terms of English as second language Vermonters, as well as in terms of taking technical information and distilling it down to the lay person. The needs of people who use English as a second language are not always considered during emergency responses. The response of the Vermont Agency of Health and Human Services in July 2023 is commendable in this regard. However, translation services should be fully integrated into the overall communication backbone. During the July flood response, translation services were slow. There were no real time translators on call ready to support the response process. VEM is aware of this issue and is working to do this more rapidly when responding to emergencies. Many of the translations and messages (alerts, flood warnings, closures) can be pre-packed and vetted by local community leaders and other authoritative members of the community who know the locality and demographics.

Some of these communication plans must include the most vulnerable, (such as nursing homes, manufactured home parks, and schools). The questions include: Who will reach out to whom? How should these messages be designed to be understood by different audience members?

Recommendation C.3: Provide greater education, guidelines, and resources for volunteers and residents regarding the public health risks of living and volunteering in flood hazard zones. Focus group participants raised concerns about the health and safety of volunteers and residents (e.g., sickness due to working in contaminated areas) and the need for more training in areas such as readiness and water literacy. Participants suggested that the state should play a more proactive role in supporting towns that do not have past experiences or the capacity to recruit or coordinate volunteers. Local governments and nonprofits may benefit from additional training, but groups of volunteers should have safety briefing information before performing work. With the ad hoc nature of immediate volunteers, work pamphlet information available at municipal offices for distribution may be a time-effective means of communicating hazards associated with flood waters. The State may want to consider this as a reason for distributing strategic hospital surplus, such as masks and gloves.

D) Enhance Dam Emergency Planning, Preparation, and Communication

It should be noted that the major dams in the Winooski watershed functioned properly during the July 2023 event and remained functionally sound. However, the functioning of flood-control dam structures has not eliminated the risk of downstream flooding, particularly in relation to the types of high precipitation events of 2011 and 2023 and the expectations for more such events in the future. During July 2023, at least two of the flood control dams for the Winooski watershed were filled and remained vulnerable to additional precipitation on top of a saturated landscape.

Had conditions been even slightly more severe and, for instance, a major dam had been breached, the capacity of local town officials, state emergency managers, and water resource managers to effectively assess and communicate risk to those in harm's ways would be limited. *Steps can and should be taken in order to avoid catastrophic loss of life when the next flood disaster strikes.* Recommendations A1-A3; B1-B3; and C1-C3 are all designed to improve the capacity and communication of state, regional and local officials, and their messaging to the public. These communications should include status updates for dam safety and function.

Our focus group surfaced with specific considerations for dam management and safety. As noted in the full technical report, two of the major flood regulation dams of the Winooski were under constant assessment during the height of the July flooding. At the Wrightsville Dam, the water level came within 10 inches of spilling over the auxiliary spillway. The flow in the North Branch between the dam and the Winooski River was still controlled by the tunnel at the dam, which prevented the water from getting too far out of the bank and caused too much flooding. However, if the water level rose by just 10 inches or more, it would have activated the auxiliary spillway and more water would have made its way downstream to areas already stressed with flooding. *Both communication and emergency response plans were inadequate for local officials and the general public to be informed.* In addition to the major flood-regulating dams of the Winooski, the focus group also raised concerns about the regulation of smaller private dams.

Recommendation D.1: Undertaking routine tabletop exercises related to major dam failures. These tabletop exercises should include dam failure and/or unscheduled auxiliary channel release during high-precipitation events. Such exercises will help clarify communication plans, dispel misunderstandings, and provide stakeholders with a better sense of how the major flood-regulation dams of the Winooski (and all across Vermont) function.

It also highlights the vulnerabilities related to dam safety and is helpful in informing local flood response plans and EAPs.

Recommendation D.2: Provide better integration of dam failure scenarios into actionable Emergency Action Plans (EAPs). Some private dams in the state have Emergency Action Plans (EAPs), but there are no requirements to update them. Developing a standard for what these plans should look like and a process to continuously review and update them are critical for the safety of these dams. Emergency Management Directors (EMDs) should incorporate all dam EAPs into their Emergency Operations Plans. Funding, education, and resources are needed to better educate dam owners and EMDs regarding dam emergencies and proper planning. New EAP rules are emerging as part of the Dam Safety Rule Technical Standards by 2025. EAP templates already exist for SIGNIFICANT hazard dams and a general template is used for HIGH hazard dams. EAPs for privately owned dams are strongly encouraged to integrate tabletop exercises, but they are not required. Currently, safety regulations for small dam owners do not mandate tabletop exercise. EAPs for small dam owners provide a summary of information about the dam, potential risks of failure, and a few limited scenarios of what can possibly happen when a dam fails. They do not spell out what to do in case of an emergency. Communications between the owners of small dams and local town officials is not required. These issues deserve further attention.

Recommendation D.3: Fund and resource inundation mapping for more dams (publicly and privately owned). This is an initiative that is already underway, “but does not have the resources to get to the finish line.” The plan is to make the maps viewable on a public site. Larger dams have their own flood inundation maps for breaching or failure scenarios, whereas most smaller dams do not. A project to develop inundation mapping of more dam in the state would be beneficial even if these were simplified versions that only included dam water levels at the top of the dam and downstream flood conditions, assuming the spillway was running full.

In addition, policies around dam releases before a major flood event should be considered in light of water quality restrictions.

E) Actions to Aid Recovery

The recovery process needs to point to a safer outcome rather than the same outcome. We need clear, consistent messages about building safely, the need to “bounce forward,” not simply bounce back,” and to elevate new and replaced equipment. After a flood, clear communication and expeditious processing are crucial. Much of the problem currently is a lack of seeking guidance on permits and people disregarding legal requirements to build safely. It is feared that many professionals will install equipment while not meeting community standards or even seeking permits.

Expeditious action for permitting is needed, but these actions need to be informed by considerations of flood resilience outcomes, and avoiding allowing, for instance, “towns to decide to dredge their rivers without any real understanding of how bad of a decision that actually is.” Keeping the stream alteration permit still needs to be enforced.

In Vermont, towns have different permitting standards, making it difficult to get unified clear messaging out. If everybody (including the plumber, furnace installer, etc.) knew the standards, the permit process would be much easier. This challenge was noted by one participant as, “What one person hears in one town does not translate over and there's a lot of hearsay bouncing.”

Recommendation E.1: Streamline permit processes for recovery and mitigation.

Simplification of the permitting process in floodplains is needed. Current processes require local development review boards to approve simple actions such as replacing boiler systems. Simplifying this process makes the recovery simpler, quicker, and less costly.



The processes undertaken by the Development Review Boards (DRB) involve time-intensive actions that are ill-suited to emergency demands. Specific to immediate flood recovery, having consultants on retainer to assist towns may help inform the DRB in an expedited fashion by developing complete projects for review in a timely manner.

Recommendation E.2.: The State should take responsibility for all floodplain regulations.

The participants noted the need for statewide floodplain bylaws. This is important because of the vast variation in bylaws between towns. The outcomes of recommendations A.2, A.3, and B.2 complement this action and address this issue.

Recommendation E.3: Provide comprehensive support for downtown businesses located in vulnerable floodplains and their long-term recovery.

The lack of direct FEMA aid for businesses impacted by flooding has created a major resource gap between support for local businesses and residents. This lack of federal aid is a significant burden, particularly for small businesses that often comprise downtowns. Many businesses in historic buildings/downtowns are located in vulnerable buildings and often put inventory in the basement, disregarding the risk. Many of these historic buildings need considerable work to make them at least somewhat more floodproofed (for smaller, more frequent flood events). There is often a contradiction between the priorities of off-site owners and on-site renters.

Small businesses vulnerable to flooding often do not have control over their buildings, high expenses and levels of debt, and find it difficult to plan ahead for real-world risks.

These historic buildings/downtowns require attention to identify opportunities to make these settings less vulnerable. Better assistance to small business owners, particularly those renting, to highlight the need for inventory insurance, placement of assets in flood-prone basements, and steps to take for flood recovery are needed. This assistance should come in the form of structured information campaigns prior to floods and proactive outreach to businesses impacted by floods during the recovery phases. In addition, policies around dam releases before a major flood event should be considered in light of water quality restrictions.

F) Prioritization Of Nature-Based Flood Mitigation Efforts

The CIROH research plans to continue the data collection process over the next year and focus on efforts that can be taken to reduce the harmful impacts of flood events in the region. Efforts will be made to engage with more local officials and community leaders in hard hit towns such as Montpelier, Barre, and Waterbury, to better understand how the Great Vermont Flood of 2023 and to a lesser extent the smaller flood events of December 2023 have led to more concentrated efforts to invest in longer term mitigation efforts. The extent of discussions among focus group participants around mitigation efforts centered on the uses of “nature-based solutions” related to enhancing the capture and storage of floodwaters by connecting rivers to floodplains.

Efforts are underway to engage in such projects in the Waterbury region. Other towns with few opportunities for adjacent flood storage are left to consider other flood hazard mitigation needs such as modifying or moving structures. The larger flood mitigation picture to be painted here, however, is one of the considerations at watershed scales. Reducing flood risks for towns such as Montpelier will require the advancement of upstream flood mitigation measures. Just who champions and pays for such efforts should be a matter of interest to the entire state. To this extent, recommendations A.2, A.3, and E.2 should enhance the capacity of the region to think wholistically and coordinate resource flood hazard mitigation projects that reduce flood risks. However, this requires continued education. To quote one of our focus group participants:

“The public education piece is incredibly important here – we’re also talking to a lot of towns that think there is a silver bullet, i.e., remove the dam in downtown, and their flood risk magically goes away – that just isn’t the case, we’re talking about minor reductions in flood levels and incremental progress from each mitigation action. But with rainfall coming heavier and faster and that trend anticipated to continue... We have to have the hard conversations now before the next one.”

More recommendations relative to mitigation measures are forthcoming. However, drawing on our current data, the following recommendations are offered:

Recommendation F.1: Invest in public and community education on watershed ecosystems. Educate the public on the relationship between the upstream and downstream dynamics associated with flood hazards. Introduce the concept of nature-based solutions. Consider some of the tough trade-offs that need to be made, for example, choices about rebuilding versus disinvestment, opening new tracts of land for concentrated development, etc. Educate on the impacts of woody debris on flood risk and water quality. These efforts could be undertaken by non-governmental organizations in the region.

Recommendation F.2: Prioritize investment criteria that consider the ecosystem services of flood hazard mitigation actions. More comprehensive accounting of the total ecosystem service valuation of buildings in flood plains can drive state and federal investments. Reduce reliance on standards defined by the National Flood Insurance (NFI) program and by inferring FEMA maps to drive zoning and building requirements inside floodplains.

Recommendation F.3: Increase focus on the removal of small dams and restoration of floodplains where it can be done. The US Army Corps of Engineers plans an assessment of the Wrightsville and East Barre dams (with the \$500k from the governor’s budget as a match for this project), and other efforts are already underway to address needs at the Waterbury Dam. The vast majority of dams are not meant for flood control; however, removing them and restoring the floodplain reduces the likelihood of failure and causes much greater flooding, since many are not in good shape. Instead, removal has a significant benefit in improving and restoring the river function.

Recommendation F.4. Prioritize the co-benefits of flood hazard mitigation and water quality for planning and resource allocation. The Tactical Basin Plan process, run by the Agency of Natural Resources, can serve as a communication channel for flood hazards. The process can provide communities with explanations about the planning processes and mitigation efforts, and why they are done, so that they understand the purposes and benefits (e.g., flood resilience). Sharing the co-benefits of water quality and flood control has been successfully used during planning and communication processes, encouraging people, for example, to have riparian buffers, which have been found to have both nutrient sequestration and flood hazard mitigation co-benefits. It is also noted that apparent trade-offs between flood hazard mitigation and water quality need to be considered, particularly in light of dam management (see recommendations D.1-D3). Watershed-scale efforts to prioritize and fund water quality projects can be leveraged, in some cases, to support mitigation projects that support nature-based solutions (e.g., water absorption and retention).

CONCLUSIONS

Following the devastation of Tropical Storm Irene in 2011, the Institute for Sustainable Communities initiated a process to engage stakeholders from across the state of Vermont to enhance resilience and reduce the risks associated with flooding and other natural disasters. The “Vermont’s Roadmap to Resilience” (VRR) report was written following a robust, consensus-driven process of stakeholder engagement. A series of 23 recommendations relating to risk communication, elevated and integrated emergency management, alignment of rules and investments, and steps to enhance collaboration were offered to much fanfare. Although some of these recommendations were likely taken up, many appear to have not been pursued.

Greater attention is still needed regarding the coordination between state and local officials, and increasing the capacity to coordinate planning, response, and mitigation measures at the regional and county scales are desperately needed. *Problems AND solutions to flooding events occur at watershed scales.* Vermont’s efforts to take a watershed-scale approach to water quality serve as an excellent example to refer to and replicate for emergency management. Building regional planning capacity occurs through the resourcing and building capacity of all RPCs, or by considering a new county-level approach. *A serious and sustained and approach to moving Vermont into robust regional planning and a coordinated response approach is needed.*

*Christopher Koliba, *Rodrigo Soares, Scott Merrill, Trisha Shrum, Ruth Quainoo, Molly Myers, Masood Ali Kahn, Jessica Balerna, and Emma Spett*

This research is funded through the Cooperative Institute for Research to Operations Hydrology (CIROH), a consortium of universities and research consulting firms focusing on support for the National Oceanographic and Atmospheric Agency (NOAA) and the National Weather Service to improve weather forecasting capacity for the nation. NOAA’s mission is to use flood forecast information to save lives and property.