



# Social, Political and Economic Analysis Group – Integrative Report

**International Lake Champlain - Richelieu River Study**

A REPORT TO THE INTERNATIONAL JOINT COMMISSION

*Submitted by*

SPE Analysis Group

November 2022



# ACKNOWLEDGMENTS

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This report received valuable review and comments from the Study Board members and study managers.

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This report is a collaborative effort of the Social, Political and Economic (SPE) Analysis Group (AG). It benefitted from the contributions and expertise of professors, professionals, and research assistants from six organizations in Quebec, Vermont and New York: the École nationale d'administration publique (ENAP), OURANOS, SUNY Plattsburgh, Université de Montréal (UdeM), University of Vermont (UVM) and USGS.

The report and studies carried out by SPE benefitted from the work of the other groups composing the International Lake Champlain-Richelieu River Study. We also would like to thank all the stakeholders throughout the Lake Champlain-Richelieu River (LCRR) Basin who gave their time and contributed to SPE's studies.

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# EXECUTIVE SUMMARY

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This report documents the work carried out by the Social, Political and Economic (SPE) Analysis Group (AG) of the International Lake Champlain-Richelieu River (LCRR) Study Board. The SPE AG was dedicated to studying the social acceptability and the economic and political feasibility of proposed flood mitigation measures.

The Social, Political, and Economic Analysis Group's primary role was advising the Study Board on the complex social, political and economic issues that form an important component of flood mitigation and management in the LCRR social-ecological system's transboundary context. The integration of the information collected through this study supported the development of a suite of flood mitigation recommendations that considered the wants and needs of the community they would impact, and were politically feasible and economically desirable.

The SPE AG carried out a variety of research activities in Quebec, Vermont and New York that revolved around five questions, summarized below. Methods and data collection used to answer these questions included a cost-benefit analysis, a social network analysis of public and private organizational actors, surveys of emergency responders, workshops and focus groups with stakeholders, and participation/observations in public meetings. The SPE AG also conducted theoretical and empirical analyses of how public intervention should be structured. Between 2017 and 2022, the SPE AG reported to the LCRR Study Board and provided detailed reports based on these research activities. By doing this, SPE contributed to the Study and the refinement of recommendations. This integrative report presents some key results and general conclusions from the different research activities revolving around the five questions that guided SPE's contribution to the Study.

## 1 How is flooding a priority for stakeholders?

Priorities depend on personal and community experience with flooding. The question of whether flooding is a priority context-dependent and changes over time. The ways that residents of the LCRR consider and prioritize flooding has changed since 2011, when the largest flood event on record occurred. SPE found that, although differences exist between jurisdictions, the social context is favorable to action and implementation of flood mitigation measures, particularly in Quebec. Results also showed that flooding is not the only important issue actors face in the LCRR basin. Acceptability of mitigation measures will be assessed in terms of their ability to reduce flooding, and also on their ability to improve water quality, ecosystems, erosion, and other factors.

## 2 How do stakeholders prioritize decision criteria?

SPE explored stakeholders' prioritization of decision criteria and preferences that will influence the acceptability of flood mitigation measures. Results show some consistency across Quebec, New York and Vermont. Respondents in all three jurisdictions prioritized 1) the consideration of human life and prevention of injury and damages, and 2) reduction of harm to vulnerable populations, as top priorities. Secondary priorities were 3) maintenance of environmental resources, clean water and biodiversity; 4) prevention of spread of aquatic invasive species; 5) reduction in the number of homes damaged by flooding; 6) reduction of financial losses from flooding. Lower-level priorities were 7) reduction in harm to economic activity; 8) protection of historic and cultural sites; 9) reduction of street closures and other infrastructure disturbances.

### 3 What do we know about social and community vulnerability?

SPE performed analyses of social and community vulnerability in the LCRR basin. Vulnerability analysis is multifaceted and multi-scale. It is useful as a diagnostic, a performance indicator and a basis for recommendations for mitigation and adaptation strategies and measures. Vulnerability analysis is relevant to both risk management and land use planning. SPE focused on the exposure, social sensitivity, territorial sensitivity, adaptive capacity and accessibility of communities in lake and river flood zones. This analysis provides sensitivity maps of areas throughout the basin, as well as recommendations for local actions.

### 4 What are stakeholder reactions and preferences to mitigation measures within each Theme, and what factors hinder and enable the implementation of proposed measures?

SPE investigated stakeholders' preferences to mitigation measures within the four Themes explored by the Study (reduce water levels through moderate structural solution, impede flows through nature-based solutions, flood response and floodplain management). SPE concludes that the causes and impacts of flooding are integrated and multidimensional, and therefore the study's recommendations should integrate measures from the four Themes, rather than rely on single solutions. There exists some support for Theme 1 structural mitigation measures that reduce water levels, but stakeholders are wary of their effectiveness, costs, unintended environmental consequences and equity. This report details the cost effectiveness of some of these measures, regardless of how they are perceived. There is also concern over how structural measures that influence water levels are managed over the long term, and how binational governance may work. In general, measures that affect water levels are likely to be unfeasible without capacity building and trans-jurisdictional dialogue within the governance structures at all scales. Although not cost-effective, there is strong support for Theme 2 solutions (impede flows through nature-based solutions), as they provide co-benefits for the environment and recreation. There is strong support for Theme 3 solutions based on emergency response strategies, including flood forecasting and emergency protection of community assets. There is strong support for Theme 4, which includes the use of floodplain management and policy to mitigate flooding, but local conditions should be recognized and there are concerns regarding the potential inequity of these measures.

SPE provides a list of enabling and hindering factors to build support for the recommendations made by the Study Board of the international LCRR Study. The list provides value for this and future IJC studies. Factors include stakeholders' engagement, pressure and perception, political priorities, perceptions of inequity in costs and benefits of mitigation measures, alignment between stakeholder concerns and mitigation measures, sunk costs in prior mitigation efforts, and minimization of negative unintended consequences.

### 5 What are SPE's recommendations for moving forward?

SPE formulates five recommendations for advancing flood mitigation in the LCRR basin. The five recommendations to the Study Board are that governments of the basin should be encouraged to:

1. play an ongoing role in supporting transboundary and trans-jurisdictional dialogue about flooding in the LCRR, as well as promote a whole-systems approach to flood mitigation, adaptation and resilience.
2. create an LCRR flood mitigation capacity building network to facilitate implementation of the study's recommendations.
3. consider flood mitigation within the contexts of geographic, governance and temporal scales.
4. employ adaptive management in the implementation of all recommendations.
5. take an explicit, equity-oriented lens to flood planning, prevention, mitigation and monitoring to facilitate the equitable distribution of resources, benefits and costs.

Based on the economic analysis, SPE also offers two specific recommendations to the Study Board. These recommendations are:

6. Based on the results of the cost-benefit analysis, SPE does not recommend implementing Theme I measures that use any type of diversion (minor or major) at the Chambly Canal. The additional benefits (more specifically, damage prevention) that stem from this type of measure do not justify the cost of building it.
7. SPE recommends the usage of Theme I measures that can mitigate frequent events, instead of focusing mitigation efforts solely on low frequency but extreme events. In short, tailored insurance programs are more efficient and adapted than structural measures in the low frequency/extreme events space.

In addition to these recommendations, SPE offers an eighth recommendation to the Study Board for the Commission's consideration. This recommendation is:

8. SPE recommends that the IJC institutionalize social, political and economic research into current and future IJC references within the LCRR and elsewhere.



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## THE INTERNATIONAL JOINT COMMISSION

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Under the Boundary Waters Treaty of 1909 (the Treaty), the governments of the United States and Canada established the basic principles for managing many water-related issues along their shared international boundary. The Treaty established the IJC as a permanent international organization to advise and assist the governments on a range of water management issues. The IJC has two main responsibilities: regulating shared water uses; and investigating transboundary issues and recommending solutions.





# FIND OUT MORE ABOUT THE STUDY

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Want more information on the Lake Champlain-Richelieu River Study?  
Have a question about the Study?

Email [lcrr@ijc.org](mailto:lcrr@ijc.org)

Access the Study Board's many technical reports, fact sheets and videos on the Study's website: [www.ijc.org/lcrr](http://www.ijc.org/lcrr).

Follow the IJC on social media

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## List of Acronyms

Acronym	Description
CA	Canada
FEMA	Federal Emergency Management Agency
FMMM	Flood Management and Mitigation Measures Technical Working Group
HHM	Hydrology, Hydraulics and Mapping Technical Working Group
HMP	Hazard mitigation plans
IJC	International Joint Commission
IM/IT	Information Management and Information Technology
ISEE	Integrated Social Economic Environmental
LCRR	Lake Champlain-Richelieu River
MAMH	Ministry of Municipal Affairs and Habitation
MCDA	Multi-criteria decision analysis
MSP	Ministry of Public Safety
NGO	Non Governmental Organizations
NWS	National Weather Service
NY	New York State
PAG	Public Advisory Group
PPRLPI	Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains
PSP	Participatory Scenario Planning
QC	Quebec
RCM	Regional county municipality
RR	Resource Response
SADS	Saint-Anne-de-Sabrevois
SB	Study Board
SES	Social-ecological system
SJSR	Saint-Jean-sur-Richelieu
SNA	Social Network Analysis
SPE	AG Social, Political and Economic Analysis Group

Acronym	Description
SPIN	Saint-Paul-de-l'Île-aux-Noix
SWOT	Strengths, Weaknesses, Opportunities and Threats
TOPSIS	Technique for Ordered Preference by Similarity to Ideal Solution
TFN	Transboundary Flood Network
TWG	Technical Working Group
US	United States
VQC	Venise-en-Québec
VT	Vermont



# 1 BACKGROUND - INTRODUCTION

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Following the spring flooding in the LCRR basin in 2011, the governments of Canada and the United States renewed efforts to work together with state, provincial and local governments to identify how flood forecasting, preparedness and mitigation can be improved in the basin. In 2016, the two governments instructed the IJC to convene a study into the causes, impacts, risks, and solutions to flooding along Lake Champlain and Richelieu River. The IJC established a study board to oversee the study and provide recommendations.

This report presents the results of the tasks of the Social, Political and Economic Analysis Group (SPE AG). The Group's primary role was advising the International LCRR Study Board on the complex social, political and economic issues that form an important component of flood mitigation and management in the LCRR social-ecological system's (SES) transboundary context. The integration of the information collected through this study served in the development of a suite of flood mitigation recommendations that considered the wants and needs of the community they would impact, and were politically feasible and economically desirable.

## 1.1 EVOLUTION OF THE THIRD IJC LCRR REFERENCE, AND CREATION OF THE SPE ANALYSIS GROUP

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This study is a component of the third IJC Reference focused on flooding convened on the Lake Champlain-Richelieu River basin in 2016. The first reference was convened in the 1930s following severe flooding in the basin. During that time, the IJC determined that flood control structures would be the most effective way of addressing flooding. The issue of environmental impact was raised by both United States and Canadian partners, although little action was taken on that front. The result of the reference was the construction of the Fryer Island dam, located approximately five miles downstream of Saint-Jean-sur-Richelieu. Construction was completed in 1939. The remedial works required to make the dam functional, however, were delayed due to the outbreak of World War II, and the work was never completed.

A second flood reference was convened for the LCRR basin in 1973 after major regional flooding. The study recommended regulation of water via a dredged channel and gated control structure in the shoal section of Saint-Jean-sur-Richelieu. The ultimate response of the IJC to the report submitted in 1981 stated that:

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*“Although the Commission has concluded that it is technically feasible to operate a gated structure at St. Jean that accommodates the proposed environmental criteria, the Commission was unable to determine the desirability of the gated structure and therefore is unable to make recommendations regarding the regulation of Lake Champlain and the Richelieu River. However, the Commission does recommend that a flood forecasting and warning system be instituted as soon as practicable and that floodplain regulation be implemented by the appropriate jurisdictions as a matter of urgency”*

*(International Joint Commission, 1981: 24).*

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The third reference was convened in 2016, in response to the severe flooding of 2011, and resulted in the current study. This third study of the LCRR basin has three primary objectives: 1) to develop a binational real-time flood forecasting and flood inundation mapping system for the Lake Champlain-Richelieu River basin to help prepare for and mitigate the impacts of floods; 2) to recommend structural and non-structural measures to mitigate flooding and flooding impacts along Lake Champlain and the Richelieu River; and 3) to determine public, community, and stakeholder views on the desirability of the proposed measures. This study was the first time social, political and economic dimensions were explicitly considered and studied in any of the IJC flooding references across the United States-Canada boundary waters.

The study is organized into technical working groups (TWGs) and analysis groups, a ten-member study board, a public advisory group, and an independent review group. The structure of the study’s organization is displayed in Figure 1.

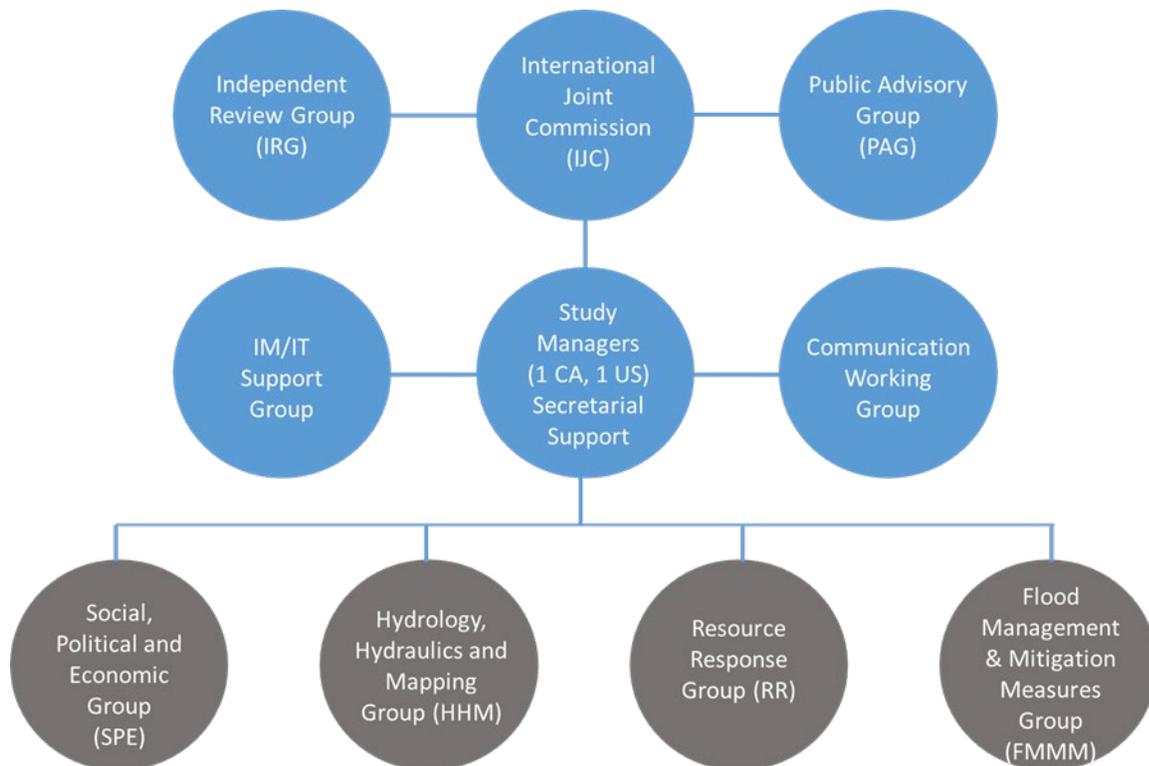


Figure 1. IJC Lake Champlain-Richelieu River study organization.

## 1.2 POLITICAL FEASIBILITY

As discussed above, one of the three main objectives of the study was to determine public, community and stakeholder views on the desirability of the proposed measures. Historically, technical and economic analyses have been used to recommend measures (Jordan and Turnpenny, 2015). However, earlier studies from the IJC have demonstrated the need to analyze the social, political, and economic desirability of measures before making recommendations. SPE was mandated to evaluate the desirability of measures developed by the Study Board. Within the Study, this task has often been referred to as the analysis of the “political acceptability” of mitigation measures. However, the scientific literature makes a distinction between three important concepts related to “desirability” that can influence the success of the study: social acceptability, political acceptability and political feasibility.

While political and social acceptability refer to the support of political actors (e.g. ministers, members of parliament, officials) and the general population to a solution or an alternative, political feasibility is much broader and refers to the plausibility of a solution being accepted and implemented by the political and administrative apparatus (Meltzer, 1972; May, 2005). It is “the relative likelihood that a policy proposal or alternative, and a variety of modifications to that alternative, could be adopted and implemented in such a way that a policy problem is solved or mitigated” (Webber, 1986 p.547). Feasibility is a “way of bridging a gap between the desirable and the possible” (Meltzer, 1972 p.859) by looking not only at the level of support from political actors, but other constraints that can affect the policy and its implementation (Dror, 1969; Majone, 1975). According to the literature, social and political acceptability appear as factors, amongst others, that influence political feasibility.

Political feasibility is influenced by different variables, factors and constraints. The main factors and constraints influencing political feasibility are:

- history, dimensions and importance of the issue (Waterfall, 1982; Jacobsen, 2002);
- political climate and policy window (Dror, 1969; Webber, 1986);
- main actors (and their motivations, resources, beliefs, capacities, intentions and interactions) (Dror, 1969; Meltzer, 1972);
- political acceptability (position and level of support of legislators, decision makers, public officials and key interest groups) (Webber, 1986; Jacobsen, 2002; May, 2005; Skodvin, 2007);
- social acceptability (Dror, 1969; Webber, 1986; Jacobsen, 2002; May, 2005);
- institutional and legislative framework (Majone, 1975; Waterfall, 1982; Jacobsen, 2002; Skodvin, 2007);
- choice of instruments (Henstra, 2016);
- legitimacy (Henstra, 2016; Alexander, 2018);
- economic and resource driven factors (resources available, distribution of benefits and costs, administrative implementation costs) (Dror, 1969; Majone, 1975; Jacobsen, 2002; Skodvin, 2007).

Within the LCRR Study, SPE used the notion of political feasibility as an integrative concept for the different elements of the Study, including social and political acceptability, economic costs and benefits, technical feasibility and ecological sustainability (Figure 2). Figure 2 shows the various factors included in the feasibility evaluation, and notes which analysis groups and technical working groups have addressed each factor.

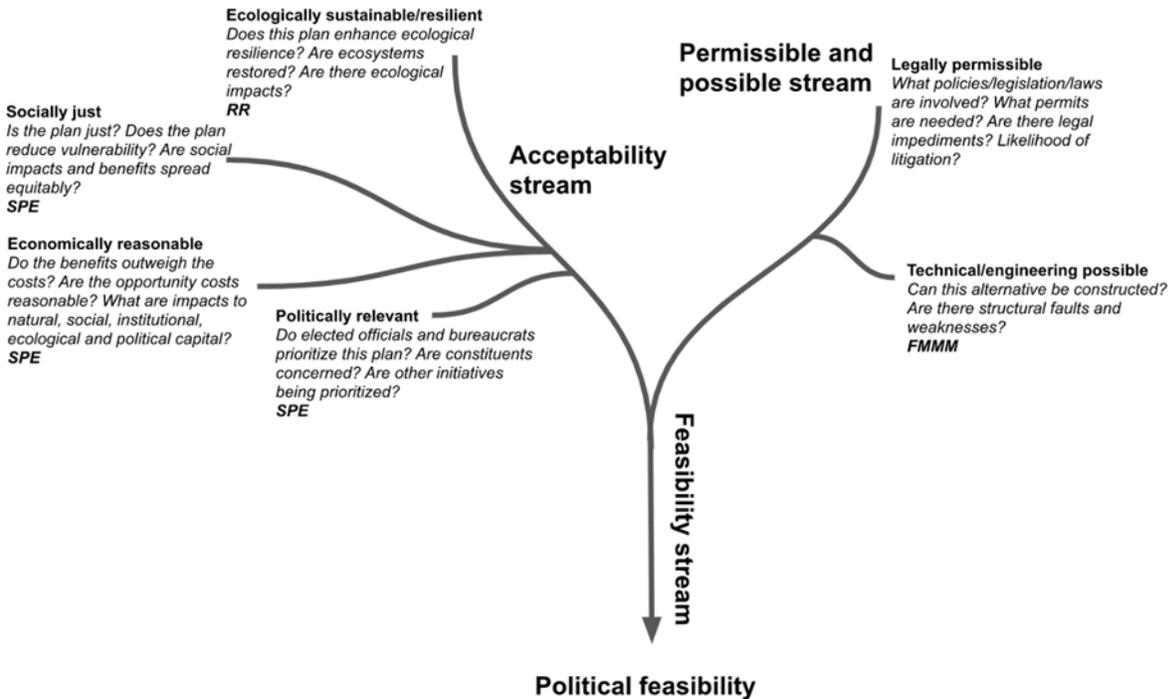


Figure 2. Factors affecting political feasibility.

It is important to underline that the political feasibility of a measure being implemented is time and context dependent. Feasibility represents a “range within which alternatives are politically feasible” (Dror, 1969 p.5). However, as time marches on, and political and social events occur, the feasibility of an alternative may change. Political feasibility therefore differs from probability and its assessment does not pretend to predict whether an action is likely to be implemented within a particular timeframe. The assessment of political feasibility thus tries to determine a “level” of political feasibility in order to help recommend options that have greater chances of being adopted and implemented. At the same time, it tries to get a sense of the “stability” of this level of political feasibility over time. The notion also implies that alternatives or proposals can be modified, improved or adjusted to increase feasibility (Dror, 1969; May, 2005; Webber, 1986). Therefore, it opens a gate to continuous improvement and modification in order to influence the “level” of political feasibility of proposed measures.

SPE's assessment of political feasibility revealed and considered enabling and hindering factors that influence the feasibility of implementing certain recommendations, but did not attempt to determine the probability of these events occurring. Instead, SPE's assessment of political feasibility looked at the enabling and hindering factors influencing political feasibility in order to determine, at this point in time, where the study's recommendations stand on a continuum going from “politically unfeasible” to “politically feasible”. Therefore, the assessment pointed to more or less feasible recommendations, without stating the probability or likelihood of successful implementation. SPE possessed the methods to accurately assess acceptability and feasibility, but could not determine probability in a complex system with many interacting factors beyond its control. By participating in the elaboration of recommendations and giving feedback to the Study Board on possible constraints related to different measures, SPE also contributed to shaping measures to increase their level of feasibility.

### 1.3 THE LCRR AS A SOCIAL ECOLOGICAL SYSTEM

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The LCRR basin is a complex, adaptive social-ecological system (SES) where flood hazards result from a combination of natural and anthropogenic factors (Figure 3). Climate change, extreme weather events, and the natural composition of the region's aquatic and terrestrial system impact, and are impacted by, a wide range of individual and institutional behaviors. The Social, Political and Economic (SPE) Analysis Group of the LCRR flood study was asked to study and model the roles that individual and organizational actions play in the adaptive management and governance of the LCRR basin. The interactions and relationships that exist among the social, political, economic and natural systems of the LCRR create the conditions that influence political and social acceptability and feasibility of flood mitigation measures. Mapping and understanding these interactions was a necessary precursor to data collection in the SPE space, as this step ensured relevant methods and salient questions were asked of stakeholders.

It is critical to understand the social, political and economic factors that shape how agents in the LCRR respond to flooding. These factors are further mediated through the beliefs and behaviors of individuals (e.g. residents of the LCRR basin in both the United States and Canada) and policies and actions of institutions (government agencies across federal, state/provincial, and local scales). Standard means to describe and assess the social system were deployed through data collection and analytical tools that included risk perception surveys, social vulnerability mapping, cost-benefit analysis, social network analysis (SNA), focus groups, source document analysis of hazard mitigation plans and ecosystem service valuation.

Mitigating flood hazards in any SES relies on the ability of organizations and communities to respond to flood hazard threats through the use of structural and non-structural interventions, the alteration of land use and zoning policies, the employment of flood insurance and reimbursement of loss mechanisms, and the use of state-of-the-art mapping and flood forecasting tools. Each mitigation approach is perceived and used by individuals and institutions differently, and no single tool solves the problem in its entirety. Differences in national, provincial, state and local policies and institutional arrangements, such as those found across the transboundary LCRR basin, render it impossible to assume that an institutional "one-size-fits-all" approach will suffice. This is why the SPE AG employed a multi-level governance analysis approach to studying institutional variability and found, not surprisingly, that institutional contexts vary drastically not only between countries, but also between states and provinces. Simple institutional and policy responses to addressing flood hazards within the LCRR basin are not to be found. With that said, a deep and evolving understanding of how institutional regimes are similar and vary across scales and boundaries can allow for better understanding of the political feasibility of specific policy interventions, including structural measures, wetlands preservation, knowledge development and transfer, and advancements in public policy.

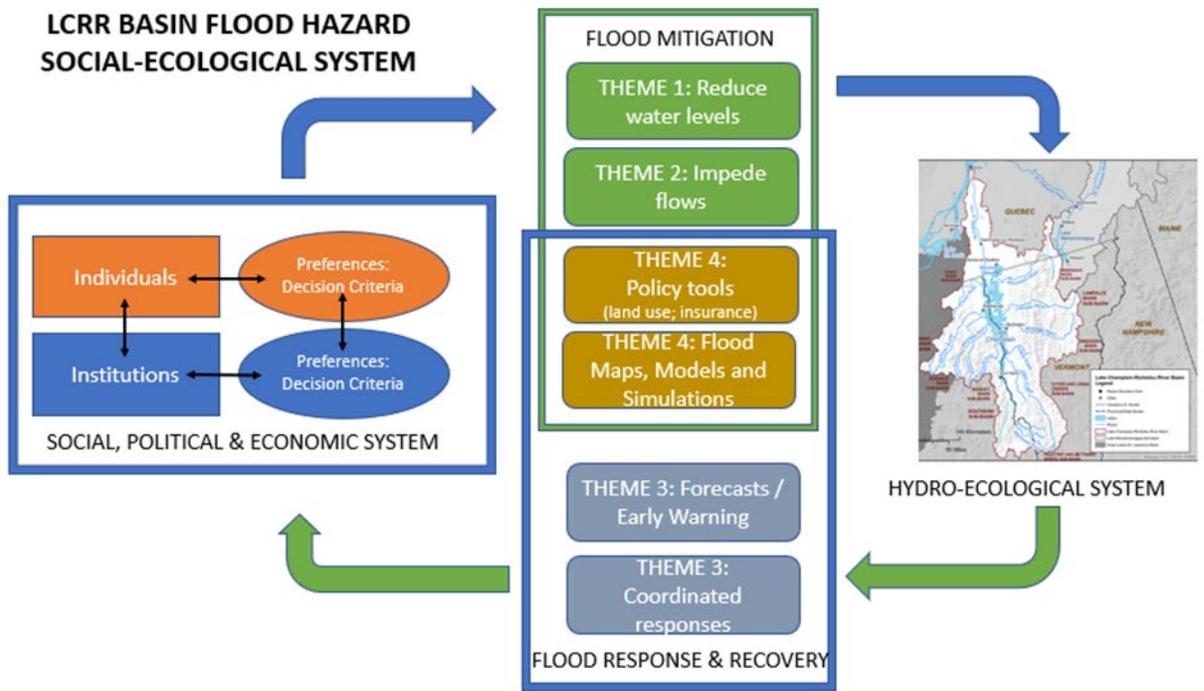


Figure 3. Flood Hazards in the LCRR Basin Socio-Ecological System.

The roles that individual residents of the LCRR basin play relative to flooding are equally complex and heterogeneous, with individual preferences shaped by one’s prior experiences with flooding, political and environmental predispositions, and socioeconomic demographics. In democratic societies, the preferences of individuals, particularly those in positions of power, not only guide personal responses to threats of flooding, but can influence the preferences of the institutions that have the power to design and implement larger scale flood mitigation, response and recovery programs.

Effective flood response and recovery measures can be informed by the development of knowledge management tools including flood maps, models and simulations, early warning systems, more accurate forecasting and improved coordinated responses between governments and residents. The ability of an SES to mount effective flood response and recovery measures is predicated on the ability of individuals and institutions to rely on state-of-the-art knowledge management tools to shape preferences and ultimately, inform coordinated responses. The resiliency of any SES to flood hazards depends on the combined ability to both mitigate flood hazards and respond to flood threats in a timely and effective manner. In order to accomplish such results, it is imperative that regions have flood maps, models and simulations available to anticipate the frequency and severity of flood events, to inform the design of structural and non-structural mitigation measures, and to effectively respond to flood events in-situ.

The LCRR Flood Study was the first IJC flood reference to integrate considerations of the social, political and economic systems into the entirety of the project. Social scientists were involved in collecting empirical evidence of institutional arrangements across the LCRR basin, including mapping institutional arrangements through social network analysis in Canada, and studying the composition of local hazard mitigation plans in the United States (US). In this manner, a great deal was learned about how flood hazard mitigation policies and basin wide tools are developed and coordinated. Social scientists also conducted surveys of the general public, as well as targeted emergency managers and planners, to gauge risk perception, sources of risk communication, flood mitigation behaviors, and a weighted evaluation criterion to assess the costs and benefits of specific flood mitigation recommendations being considered by the Study Board. By doing so, SPE was

able to understand how the public in each region of the basin perceived the risk of lake and riverine flooding, the anticipated impacts on their livelihoods, and their willingness to adopt certain risk mitigation measures and policies, as well as how they received risk communication messages.

Floods impact residents differently and can be particularly shaped by one's levels of social vulnerability prior to the flood event. A strong relationship between prior vulnerability and higher risk from the impacts of floods has been found in the literature (Cutter, Boruff and Shirley, 2003; Wilson, 2012). To capture the disproportionate impacts of social vulnerability on the high risk flood zones in the LCRR, social vulnerabilities were plotted on flood maps and used in flood simulations with the Study's Integrated Social, Economic and Environmental system (ISEE). This process allowed for visualization and analysis of locations where more vulnerable residents of the basin resided, and the risks of flooding in those areas. Emergency responders and planners can use this information to tailor response plans that align social need with geographic realities.

Residents of a region carry personal perceptions and preferences relative to flood risk (personal and communal), willingness to mitigate flood risk (personally and collectively), and criteria for evaluating flood mitigation measures. Residents of Quebec, New York and Vermont were surveyed to assess the variability of these perceptions and preferences. SPE's surveys found areas of commonality and differences among residents of specific jurisdictions, and along specific demographic characteristics. Experiences with prior flooding, political ideology, and trust in science also influence residents' preferences toward flood risk mitigation. Lastly, the sources of information about flood risk, the trustworthiness of such sources and belief regarding the role of institutional interventions in addressing flood risk may be discerned from SPE's work. Understanding the influence of public perceptions and preferences on institutional response is possible and has been considered by SPE in light of institutional assessment of political feasibility.

Focus groups with emergency managers and planners, representatives of elected officials in each region, and meetings with agency leadership across all jurisdictions yielded additional insight into the "political feasibility" of mitigation measures. Matters such as technical feasibility, cost, environmental impact, and public preferences were taken into consideration. These expressions of preference represent particularly salient features of institutional preferences that exist across all complex transboundary water use and environmental agreements. In the context of the LCRR Flood Reference, the political feasibility of options, particularly structural interventions, was considered extensively across all Technical Working Groups (TWGs), the Study Board, and the Public Advisory Group.

Recognizing the complexity of the LCRR basin as an SES and more particularly as having multiple institutional arrangements, the SPE Analysis Group considered that moving institutional actors towards an adaptive management framework could help in addressing the complicating factors presented in the system.

## 1.4 ADAPTIVE MANAGEMENT

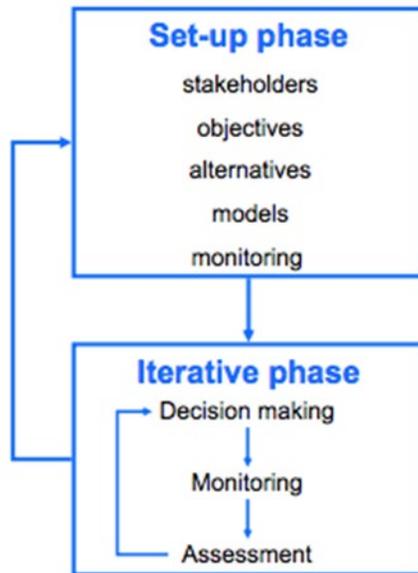
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Adaptive management is a specific approach to manage natural resources that seeks to “purposely and explicitly increase knowledge and reduce uncertainty” (Rist et al., 2013, p.5). There are eight key components of adaptive management, including:

1. Participation of those outside the management institution in order to manage conflict and increase the pool of contributions to potential management solutions,
2. Defining and bounding of the management problem, including the setting of management objectives,
3. Representing existing understanding through system models that include assumptions and predictions as a basis for further learning,
4. Identifying uncertainty and alternate hypotheses based on experience,
5. Implementation of actions/policies to allow continued resource management or production while learning,
6. Monitoring of the effect of implementing new policies,
7. Reflection on, and learning from, monitoring results, and comparison with original expectation in order to revise models and/or management actions based on what has been learned,
8. Iterative repetition of this cycle so that management reduces uncertainties and leads to improved management outcomes over time.

(Rist et al., 2013, p.12).

The adaptive management framework provides insight into best practices for managing the complexities and uncertainties that accompany water management, primarily the need for flexible and adaptive strategies (Brouwer and Biermann, 2011). This framework calls for two phases (Figure 4): a set-up phase, which involves a “framing of the resource problem in terms of stakeholders, objectives, management alternatives, models, and monitoring protocols” followed by “an iterative phase that utilizes these elements in an ongoing cycle of learning about system structures and functions, and managing based on what is learned” (Williams, 2011, p.1348).



*Figure 4. Two-phase learning in adaptive management.*

The implementation of adaptive management strategies in transboundary flood mitigation scenarios has been tested in Europe, where flood risk governance was assessed in six European countries in an effort to build flood resilience. This effort, referred to as Strengthening and Redesigning European Flood Risk (STAR-FLOOD), highlighted that adaptive management can improve resilience by aiding in the “implementation of defense and mitigation measures that can be adjusted to suit changes in circumstances,” in addition to delivering “spatial planning in such a way that consequences are prevented and minimized if floods occur” and improving “systems for forecasting, warning, and emergency response that are proactive, risk-based, and use collaborative approaches” (Hegger, Driessen, Bakker, et al., 2016, p. 12).

The SPE Analysis Group integrated features of the adaptive management framework into its work. SPE developed studies that allowed for stakeholder perspectives to be integrated into research and recommendations, and used the knowledge gained from this research to build relationships and generate recommendations that build capacity for the long-term effective management of the LCRR SES.

## 1.5 GUIDING QUESTIONS AND OVERVIEW OF THE REPORT

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Five guiding questions provide context to the numerous studies carried out by the transboundary Social, Political and Economic (SPE) Analysis Group. These questions home in on the ways that potential flood mitigation measures and recommendations impact the communities, and the political feasibility and social acceptability of those measures.

They include:

1. How is flooding a priority for stakeholders?
2. How do stakeholders prioritize decision criteria?
3. What do we know about social vulnerability?
4. What are stakeholders' reactions and preferences to mitigation measures within each Theme, and what factors hinder and enable the implementation of proposed measures?
5. What are SPE's recommendations for moving forward?

Each of these questions is addressed through a combination of research activities, analytical approaches and data collection tools carried out by the SPE Analysis Group over the course of this study. The SPE work is multi-disciplinary and utilized triangulation to draw conclusions. Multiple data points, based on quantitative and qualitative data, indicating the same finding build the validity and accuracy of this analysis. These analytical approaches and data tools are visualized in Table 1, and indicate the studies carried out in Canada, the United States, or both<sup>1</sup>. Table 1 also provides a breakdown of what studies served which questions. Further details about the methodologies of each of these studies are provided in Appendix A.

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<sup>1</sup> The SPE team decided not to replicate all research studies in both countries, but made sure the data collected through the different studies were sufficient to answer the study's questions both in Canada and in the United States.

Table 1. Research studies conducted by SPE to answer guiding questions.

Research Study	Jurisdiction	Dates	Associated Guiding Questions
Economic studies (including cost-benefit analysis)	United States, Canada	January 2018 – January 2022	Question 4 and 5
Historical analysis	United States	May 2018	Question 5
Media analysis	United States	May 2018	Question 5
Stakeholder focus groups	United States, Canada	US: November 2018 CA: August 2019	Question 1, 4 and 5
Social vulnerability analysis	United States, Canada	2018-2019	Question 3 and 5
Household risk perception survey	United States, Canada	US: September 2019 CA: October 2020	Question 1 to 5
Social network analysis	Canada	February 2020	Question 1, 2, 4 and 5
Emergency responder survey	United States, Canada	February 2020	Question 1, 2, 4 and 5
Hazard mitigation plan analysis	United States	January 2021	Question 1, 4 and 5
Final stakeholder engagement	United States, Canada	US: January-February 2022 CA: December 2021	Question 4 and 5
Public meetings, meetings with stakeholders, meetings with political entities and expert workshops	United States, Canada	Continuously	Question 1, 4 and 5

The results of these analyses operate within the confines of a series of flood mitigation recommendations proposed by the greater IJC LCRR basin flood study, including the “Themes” presented in Figure 5:

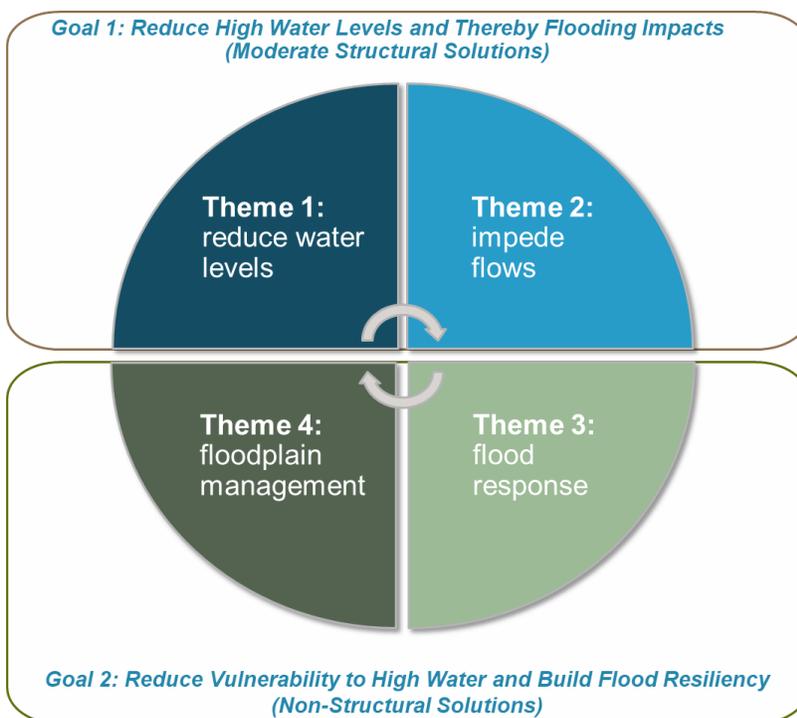


Figure 5. Four flood mitigation Themes of the IJC study.

Theme 1 is representative of structural mitigation measures, including dams and weirs. Theme 2 considers nature-based solutions, including upland water storage and wetland restoration. Theme 3 is emergency responses to flooding, including flood forecasting and early warning systems, and Theme 4 considers policy changes as a tool for mitigating and managing damages to the built environment.



## 2 HOW IS FLOODING A PRIORITY FOR STAKEHOLDERS?

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To assess if flood mitigation measures are feasible, it is important to investigate if stakeholders, such as decision makers, citizens and interest groups, believe it is a priority that needs to be addressed, and at what depth and breadth. Problem definitions by stakeholders set boundaries on the scope of issues to ensure resource availability and constraints, and raise sensitivity to “mission creep” (Adolino and Blake, 2010). Decision-makers typically prefer the status quo to change (Levy, 2000). Moreover, the importance of an issue is not a criterion leading to change. Rather, an issue must be a priority to stakeholders if they are going to invest resources to address it (Howlett et al., 2009) and prioritize it on a political agenda (Kingdon, 1993). For a solution to be accepted and feasible, it must also address the identified problem as it is defined by stakeholders. However, just as there can be different ways to solve a problem, there may be different ways to define it. Citizens, interest groups or decision makers may have divergent ways of defining a problem and thus, considering solutions. To assess the political feasibility of proposed mitigation measures, one important step was to address whether flooding is a priority for stakeholders. This also raised other related questions that SPE addressed in its various studies: Is there a problem, or not? How is this problem a priority considering the other issues stakeholders face? Do all stakeholders define the problem in the same way? Do stakeholders want to address major or minor floods, flooding of the lake, river or tributaries?

This section describes how stakeholders prioritized flooding, first presenting results from Quebec, and then from the United States. The discussion also addresses how climate change perception may affect stakeholder’s priorities and the feasibility of mitigation measures. The understanding of the problem was built on different analyses and data collection methods conducted by SPE in New York, Vermont and Quebec. The analyses conducted in relation to this question are presented in Table 2.

*Table 2. Relevant studies to answer flooding priority questions.*

Guiding Question	Relevant Studies
How is flooding a priority for stakeholders?	Emergency responder survey Hazard mitigation plan analysis Household risk perception survey Public meetings, meetings with stakeholders, meetings with political entities and expert workshops Social network analysis Stakeholder focus groups

## 2.1 CANADA

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This section shows how flooding is considered at the provincial level, by local organizations, authorities, emergency responders and citizens. Results presented in this section show that flooding in the LCRR basin is a priority for stakeholders. However, stakeholders in the LCRR basin also face other issues related to water management, such as erosion, water quality and low water levels. Stakeholders are concerned about multiple water-related problems, and this may influence the acceptability of recommendations and proposed flooding mitigation measures.

Since the 2011 floods, the province of Quebec has faced major floods in 2017 and 2019 (although the LCRR basin faced minor damages compared to other regions). The frequency and severity of flooding have pushed the province to implement several flood-related developments:

1. Special intervention zones (Zones d'interventions spéciales – ZIS) were used to impose a moratorium on development in the floodplain until a new normative framework is developed and adopted.
2. The Ministry of Public Safety (MSP) adopted new plans following the 2017 floods to improve emergency preparedness.
3. The provincial government formed a scientific and a municipal committee to help guide the process towards developing the new normative framework.
4. A "plan for the protection of the territory against floods" has been jointly developed by four ministries (Ministry of Municipal Affairs and Habitation - MAMH, 2020). This plan includes actions to be carried out and sets up "project offices" in 10 watersheds, including the Richelieu River.
5. Changes are underway on the normative level, and a new bill (Bill 67) has been adopted in Quebec (Éditeur officiel du Québec, March 25 2021) to establish a new development regime for flood zones.
6. The policy surrounding the management of the floodplain (Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains - PPRLPI) is being revised and a transitional regime went into effect on March 1, 2022. A new regulatory framework will gradually replace the transitional regime, mainly in terms of flood zone management (measure 5 of the Flood Protection Plan). Rules for the development of these zones, aimed at protecting the environment and the safety of people and property from flooding, will be developed within an appropriate regulatory framework.
7. A revision of the floodplain mapping, the development of methodologies to map the floodplain and efforts to develop flood maps and associated tools throughout the province (notably through the INFO-Crue project) are underway.

Within the realm of Provincial government, flooding is currently an important issue in Quebec. This is mostly due to the major floods experienced in 2017 and 2019. Recent and forthcoming policies and programs to address flooding will impact the entire province. In this context, the political feasibility of the LCRR Flood Study recommendations is influenced by this significant transformation of legislation and tools for flood prevention and management.

Change must also be a priority at the local level as citizens, local governments or organizations advocating for/against change might influence feasibility, including by coalition building (Sabatier, 2014). The studies conducted by SPE surveyed residential stakeholders at the basin scale on how they consider flooding.

In a first data collection carried out by SPE in 2019, interviews were conducted with 24 stakeholders (municipal and regional organizations, NGOs, ministries)<sup>2</sup>. Results showed that 63 percent of those interviewed would like to do more to help citizens face flooding, but they also identified that they were lacking resources, time or knowledge to address the issue. Twenty-eight percent of these respondents stated that they were willing to do more, but it was not their priority.

Later in 2020, SPE conducted a social network analysis (SNA). SNA is a “method for studying relationships between a set of actors” (Therrien, Jutras and Usher, 2019: 2). SNA allows visualization of a formal or informal network based on the links and relations between actors at a specific time, and provides metrics on the centrality and importance of actors. Figure 6 shows the network of the 172 organizations having activities in the watershed related to floods and water management<sup>3</sup>. Organizations were asked to provide their point of view on different issues in relation to the Richelieu River and/or Lake Champlain. Among the 57 organizations who answered the question, 95 percent of the organizations consider floods as an important or very important issue. This could help foster change and the adoption and implementation of mitigation measures. However, while flooding is considered an important issue by organizations, it is not the only issue related to water that respondents perceive: more than 90 percent of organizations also consider water quality, compliance with the guidelines regarding riparian zones, protection of ecosystems, erosion, water level variation and compliance with the guidelines regarding embankment in the floodplain as important or very important. Moreover, as will be seen in the following sections, stakeholders do not have a common vision of the type of solution that should be implemented. Flooding is one challenge among several, and for some respondents it is not their top priority. When asked about their priorities, water quality and the protection of ecosystems appear as the top priorities, as 66 percent of organizations surveyed in the SNA (N=59) consider these issues as priorities. Floods comes next with 61 percent of organizations considering floods as a priority. Other related issues such as compliance with the guidelines regarding riparian zones, erosion, water level variations and economic development are respectively considered as priorities by 51, 48, 44 and 41 percent of organizations. Therefore, this co-existence of multiple priorities must be considered when developing mitigation measures. Solutions that address multiple challenges simultaneously, in an integrative fashion, are likely to be more widely accepted and politically feasible. Stakeholders are unlikely to accept flood mitigation measures that negatively impact other water-related challenges.

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<sup>2</sup> Detailed methodology in Appendix A.

<sup>3</sup> A SNA was conducted in Canada in the fall 2019 and winter 2020. Semi-directed interviews were conducted with 10 organizations to test a questionnaire and identify all organizations in the basin relevant to the study, which resulted in a list of 172 organizations. A questionnaire was then distributed to 153 organizations working and/or influencing the floods and water management in the LCRR basin (SPE was not able to reach 19 organizations. Responses from 67 organizations were collected for a response rate of 43.8 percent. For some questions, respondents withheld information, which results in the variation of the N for the results presented in the following sections. Detailed methodology for the SNA is available in Appendix A.

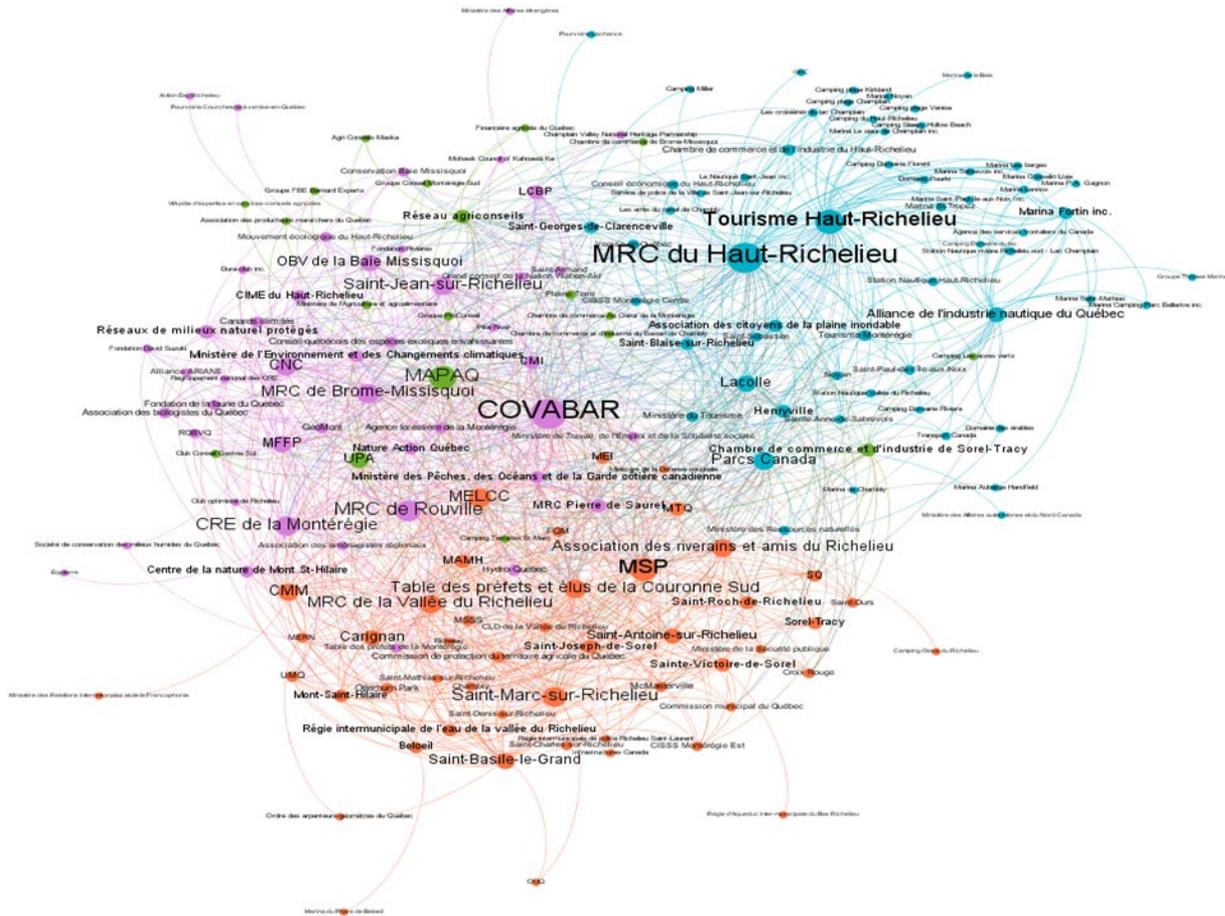


Figure 6. Network of organization related to flooding and water management.

The size of the nodes represents the number of relations an organization has (the degree). The colours are subgroups of organizations that are more related to each other. In blue are organizations that are geographically situated closer to the United States (tourist, municipal, regional and supra-regional organizations), in orange are organizations related to municipal affairs, organizations in green are linked to agriculture and commerce, and organizations in pink are related to the environment.

This co-existence of priorities is also shared by elected officials (Members of Parliament, Members of the National Assembly, or their representatives) for whom water quality, erosion and low water levels are also important<sup>4</sup>. The different studies conducted by SPE (social network analysis, public meetings, expert workshops and focus groups) also highlight that issues (water quality, low water levels, floods, protection of ecosystems, erosion, etc.) are considered as interconnected by stakeholders. Consequently, stakeholders are likely to assess the acceptability of possible solutions in terms of the objective of reducing flooding, but also based on the impacts solutions bring for other water priorities. This should be reflected in the proposed mitigation measures to increase their political acceptability.

<sup>4</sup> Over the course of the Study, SPE participated in different meetings and workshops. For each meeting and workshop, SPE produced observation notes that were included in the analysis. In Canada, SPE participated in 23 meetings with a total of 43 organizations, and 10 public meetings and technical webinars. Some meetings were with more than one organization and some organizations were met multiple times. Meetings were also organized in 2020 with 3 members of parliament or their representatives, one senator and three members of the national assembly of Quebec. Details are available in Appendix A.

Emergency responders from the municipalities situated in the floodplain were also surveyed in 2020<sup>5</sup>. Emergency responders were asked to indicate the probability of a flood occurring in their community, the magnitude of consequences of a flood in their community and the likelihood of a flood occurring in the next ten years. These measures served as indicators to understand the context and perceptions of emergency managers about the urgency to address the risk of flooding. Table 3 presents the results to these three questions. If we aggregate responses, emergency responders were generally equally likely to consider the probability (high risk = 53%, low/some risk = 47%), the consequences (high or very high = 37%, low or very low = 42%), and the likelihood (high or very high = 47%, low or very low = 42%) of floods as low or high. However, there are some contradictions in stakeholders' discourse (especially at the municipal level). Respondents feel more prepared than ever to face floods (this may be due to the adaptation that has taken place in the southern communities since 2011, and the regulatory changes in force since November 2019 on the obligations of municipalities regarding warning, mobilization and minimum rescue services in the event of a disaster), but still think higher level government agencies must act to reduce flooding.

Table 3. Flood risk perception – emergency responders (Canada).

Emergency Responders Survey - Canada (%) N=19		
Probability of community experiencing a lake/river flood	High risk	52.6
	Low/some risk	47.4
	No risk	0.0
	Other	0.0
Consequences of a lake/river flood in your community	Very high	10.5
	High	26.3
	Neither high nor low	21.1
	Low	36.8
	Very low	5.3
	Other	0.0
Likelihood of community experiencing a lake/river flood in the next ten years	Very high	21.1
	High	26.3
	Neither high nor low	10.5
	Low	36.8
	Very low	5.3
	I don't know	0.0
	Other	0.0

<sup>5</sup> The emergency responders survey included questions related to community flood experience, access to information regarding flooding and water levels, local emergency management plan components, flood risk perception and decision criteria preferences. The survey was administrated in February of 2020 to 44 responders in Vermont and New York and 30 in Quebec (all responders from lakeside and riverside communities). 44 responses were collected (23 in the United States and 21 in Canada) for a total response rate of 62.9 percent. Participants were recruited through targeted outreach via relationships built throughout the study and through existing partnerships with study members. Detailed methodology is available in Appendix A.

In the Canadian iteration of the household risk perception survey, 11.3 percent of respondents had experienced flooding in their community and households. Amongst basin residents, results from the household risk perception survey<sup>6</sup> showed that 49.9 percent consider their community to be at risk of flooding (39 percent disagree) but only 5.7 percent indicated a high or very high likelihood of experiencing lake or river flooding at home in the next ten years. The results showed little variation of perceived risk of flooding of the community with flood experience (Table 4). However, results showed some variations in the perceived likelihood of the respondent's home experiencing a lake/river flood in the next ten years; 11.7 percent of those who have experienced flooding rated the likelihood as high or very high, compared to 5 percent of those who have not experienced flooding. Moreover, 21.8 percent of respondents having not experienced flood in the past considered there is no chance of a flood affecting their home in the next ten years, while they were only 5.9 percent amongst respondents having

Table 4. Flood risk perception – residents (Canada).

Household Risk Perception Survey – Canada (QC) (%) N=450			
		Flood Experience N=51	No Flood Experience N=399
I consider my community to be at risk of flooding	Strongly agree	27.5	17.5
	Agree	23.5	32.1
	Neutral	7.8	5.5
	Disagree	21.6	24.1
	Strongly disagree	11.8	15.8
	I don't know	7.8	5.0
Likelihood of home experiencing a lake/river flood in the next ten years	Very high	3.9	1
	High	7.8	4
	Neither high nor low	23.5	14
	Low	19.6	22.1
	Very low	31.4	32.8
	I don't know	7.8	4.3
	There is no chance of a flood	5.9	21.8

The results of the household risk perception survey showed great concern from residents of the basin, with half of respondents considering their community to be at risk of flooding. While the results showed the perception of a lower likelihood of their home experiencing a lake or river flooding in the next ten years (5.7 percent), this perception increased when only respondents with flood experience were considered (11.7 percent). Survey results also showed emergency responders perceived their community to be at risk of flooding. These results, combined with results from the SNA, interviews with organizations and an analysis of the provincial context, led to the conclusion that flooding is still a priority in Quebec. However, stakeholders also face other issues and will assess solutions not only on their ability to mitigate floods, but also on their impact on competing issues such as water quality, erosion, protection of ecosystems or low water levels.

<sup>6</sup> The objective of the household risk perception survey was to assess the socioeconomic and demographic determinants of flood risk perception, and to assess the same determinants of preferences for the decision criteria used to prioritize flood mitigation measures. This survey included questions on risk perception (personal and community flood risk and subsequent impact of flooding), perception of flood risk relative to other hazards, and opinion on different flood mitigation measures. The household risk perception survey was distributed in the United States in September 2019 and in Canada in October 2020. In the United States, the survey was administered to a sample of 3,000 households within the LCRR basin and 150 respondents completed the survey. In Canada, responses were collected from 450 households within the basin. Respondents from the household risk perception survey include representation from the entire Lake Champlain basin, including communities that experience tributary flooding rather than lakeshore flooding. Detailed methodology is available in Appendix A.

## 2.2 UNITED STATES

In the US section of the LCRR basin, flooding is still a major concern, and flooding is indicated as a primary threat to communities across municipal, county, and state hazard mitigation plans in Vermont and New York. Results from emergency first responder surveys and stakeholder meetings also emphasized that stakeholders are often more concerned by tributary flooding than lake flooding, due to its disruptive and fast-onset nature.

In the following sections, findings were drawn from a systematic analysis of Vermont and New York's hazard mitigation plans (HMP) analysis<sup>7</sup>, and from results of the household risk perception survey and emergency responder survey, as well as observations during meetings with organizations and stakeholders (detailed methodologies available in Appendix A).

At the institutional level in Vermont and New York, the HMP analysis showed that numerous jurisdictions do not have active hazard mitigation plans. A visualization of regions with and without HMPs in the United States region of the LCRR basin is provided in Figure 7.

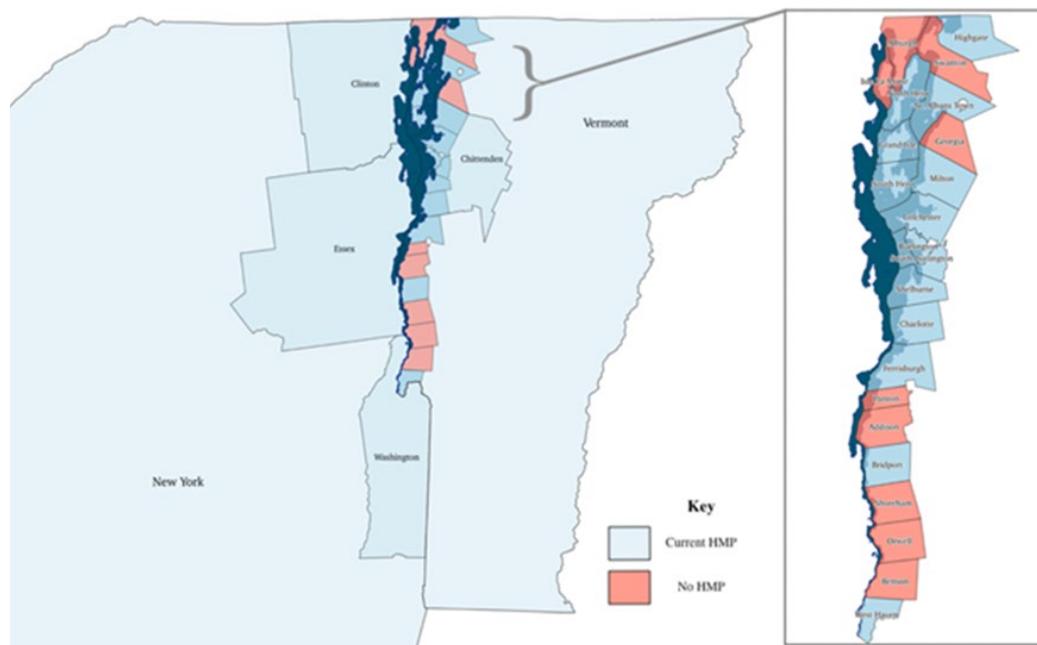


Figure 7. Hazard mitigation plans (HMP) for the US LCRR basin.

Each municipality (in Vermont) and county (in New York) displays either the presence or absence of a hazard mitigation plan. In New York, all counties along the Lake Champlain lakeshore had active hazard mitigation plans. In Vermont, nine of the twenty-four municipalities along Lake Champlain did not have active hazard mitigation plans, as of 2019.

<sup>7</sup> A hazard mitigation plan analysis was conducted in the United States portion of the LCRR basin. The Hazard Mitigation Plans (HMPs) at all levels (municipal, county and state) were analyzed for their content regarding flood risk identification, their description of flood hazards, the content and quality of the mitigation goals, and the number and variety of mitigation actions dedicated to flooding. In total, two state, four county and fourteen local plans were compiled and coded for this analysis. Detailed methodology is available in Appendix A.

There was, however, a disparity between New York and Vermont. In New York, strong state requirements facilitate development of HMPs at the regional level. New York also has a strong county administrative system, and emergency management occurs at the county level, so flood response plans are developed at this level. The counties and municipalities then work together on implementation as floods occur. The plans do not differentiate between lake and tributary flooding. Vermont has strong state support for Hazard Mitigation Planning, due in part to a lack of governance structure at the county level. Additionally, there is a great deal of diversity in the ways that municipalities incorporate flooding into their hazard planning. After 2011, there was a strong push for flood prevention and response planning, but low flood incidence, coupled with low organizational capacity, limits the uptake of innovative measures.

First responders in New York and Vermont saw greater risk of flooding than residents (Tables 5 and 6). Among emergency responders, there was some agreement that future floods are likely in the next 10 years, but there was much less agreement around the consequences. In the household risk perception survey, 10.2 percent of respondents considered the likelihood of their home experiencing a lake/river flood in the next ten years as high or very high. However, the concern of residents varied with flood experience. In the United States iterations of the emergency responders survey and household risk perception survey, 78.3 percent and 19.3 percent of respondents had experienced flooding in their communities and households, respectively.

Table 5. Flood risk perception – emergency responders (United States).

Emergency Responders Survey – United States (%) N=23		
Probability of community experiencing a lake/river flood	High risk	31.6
	Low/some risk	57.9
	No risk	5.3
	Other	5.3
Consequences of a lake/river flood in your community	Very high	5.3
	High	31.6
	Neither high nor low	26.3
	Low	5.2
	Very low	21.1
	Other	5.3
Likelihood of community experiencing a lake/river flood in the next ten years	Very high	21.1
	High	47.4
	Neither high nor low	10.5
	Low	5.3
	Very low	5.3
	I don't know	5.3
	Other	5.3

Table 6. Flood risk perception – residents (United States).

Household Risk Perception Survey – United States (%) N=137		Flood Experience N=29	No Flood Experience N=108
I consider my community to be at risk of flooding	Strongly agree	31.0	13.0
	Agree	44.8	38.9
	Neutral	13.7	11.1
	Disagree	0.0	19.4
	Strongly disagree	3.4	9.3
	I don't know	6.9	7.4
Likelihood of home experiencing a lake/river flood in the next ten years	Very high	13.8	0.0
	High	34.5	0.0
	Neither high nor low	17.2	6.5
	Low	10.3	24.1
	Very low	3.4	46.3
	I don't know	17.2	4.6
	There is no chance of a flood	0.0	17.6

These results showed that perceived risk of flooding increases with flood experience. Respondents who had experienced a flood considered their community to be at risk of flooding (75.8 percent) as opposed to respondents who had not experienced a flood (64.9 percent). This distinction was even more stark when respondents were asked about the likelihood of experiencing a flood at their household in the next ten years. Respondents with flood experience expressed a high perceived threat of future flooding, with 48.3 percent indicating that likelihood being high or very high. None of the respondents who had not experienced a flood expressed that they had a high or very high likelihood of experiencing a flood at their home in the next ten years, and 17.6 percent of respondents indicated that there was no chance of a flood.

Table 7. Comparative analysis of US and Canadian survey responses.

		United States		Canada	
		Flood Experience N=29	No Flood Experience N=108	Flood Experience N=51	No Flood Experience N=399
I consider my community to be at risk of flooding	Strongly agree	31.0	13.0	27.5	17.5
	Agree	44.8	38.9	23.5	32.1
	Neutral	13.7	11.1	7.8	5.5
	Disagree	0.0	19.4	21.6	24.1
	Strongly disagree	3.4	9.3	11.8	15.8
	I don't know	6.9	7.4	7.8	5.0
Likelihood of home experiencing a flood in the next ten years	Very high	13.8	0.0	3.9	1.0
	High	34.5	0.0	7.8	4.0
	Neither high nor low	17.2	6.5	23.5	14.0
	Low	10.3	24.1	19.6	22.1
	Very low	3.4	46.3	31.4	32.8
	I don't know	17.2	4.6	7.8	4.3
	There is no chance of a flood	0.0	17.6	5.9	21.8

In a comparison of flood risk perception across both the United States and Canadian regions in the LCRR basin, and across respondents with and without flood experience, we saw that flood experience was negligible as an indicator of flood risk perception for their community. From the Canadian groups (those who had and had not experienced a flood), about 50 percent of respondents indicated that they agreed that their community was at risk of flooding. In the United States, about 76 percent of respondents in both groups indicated that they agreed at their community was at risk of flooding.

This varied when respondents were asked about the likelihood of experiencing a flood at their current residence in the next ten years. Respondents who had experienced flooding indicated a much higher perceived risk of flooding than the groups without flood experience. Of the respondents from Vermont and New York, 48.3 percent indicated a very high or high likelihood of a flood, while 0 percent of respondents with no flood experienced indicated a very high or high likelihood. This pattern did not persist among Canadian respondents. Of the Canadian respondents who had experienced flooding, 11.7 percent indicated a very high or high likelihood of a flood, while 5.0 percent of respondents without flood experienced indicated the same. In the United States and Canada, respectively, there was also a much higher percentage of respondents who indicated no chance of a flood, while 0 percent of American respondents and 5.9 percent of Canadian respondents indicated such a likelihood.

## 2.3 CLIMATE CHANGE IMPLICATIONS

The potential impact of climate change is also an important consideration of the Study. Climate change influences the ways that stakeholders define the problem of flooding, as well as the political feasibility of flood mitigation. Perceptions and knowledge about climate change may impact how authorities, organizations and citizens look at the problem definition by focusing not only on past events, but also on the future, as the perception of climate change and its impact on water levels may alter how stakeholders bound and scope the problem.

In the household risk perception survey, citizens were asked how they thought climate change would impact flooding in their region. Results (Table 8) show that most respondents from the United States and Canada were concerned about climate change. A majority of respondents in both countries think that flooding will become more frequent because of climate change. A majority of respondents in the United States also think that flooding will become more severe. In Quebec, 42.8 percent of the population of the region think flooding will become more severe. Fewer respondents consider that flooding in the region will become less frequent and severe because of climate change. These results could help increase the feasibility of mitigation measures, as this shows the population thinks climate change will increase flooding.

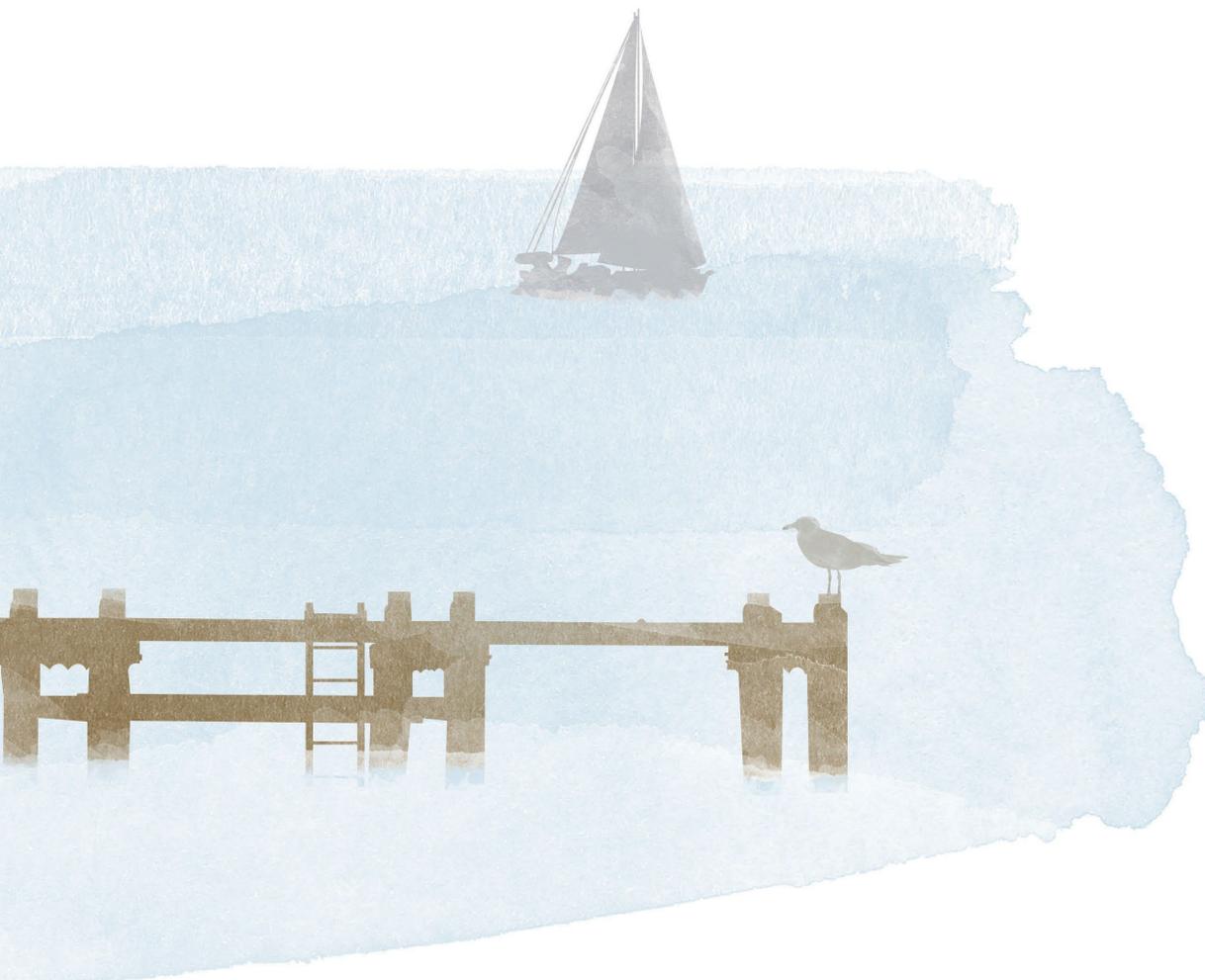
*Table 8. Perception of how climate change will impact flooding – Household risk perception survey.*

Question	Percent YES	
	Canada (QC) (N=450)	United States (N=150)
Are you concerned about climate change	83.1	77.6
Flooding will become more frequent	54.1	59.9
Flooding will become more severe	42.8	51.0
Climate change will not affect flooding in my region	15.1	6.8
Flooding will become less frequent	1.3	0.7
Flooding will become less severe	0.0	1.4

## 2.4 CONCLUSION

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The results of these evaluations displayed a generally high concern for flooding across the LCRR basin amongst public survey participants, particularly considering the disproportionate impacts of flooding across the region, and particularly in Quebec. While the context in Quebec is favorable to change, interviews, focus groups, public meetings and workshops showed it is less so in the United States, and the benefits of flood mitigation will have to be greater to ensure feasibility and acceptability of flood mitigation measures. Priorities and willingness to change depend on personal and community experience with flooding. Based on the results presented here, it appears the question of whether flooding is a priority is evolving and context dependent. Results also suggest that flooding is not the only important issue actors face in the LCRR basin. Individuals, organizations and elected officials will assess the acceptability of mitigation measures in terms of their ability to reduce flooding, but also on their impact on water quality, ecosystems, erosion and other factors.



# 3 HOW DO STAKEHOLDERS PRIORITIZE DECISION CRITERIA?

Considering how stakeholders prioritize decision criteria provides insight into what stakeholders value. Understanding stakeholder values has implications for mitigation recommendations because it suggests what is likely or unlikely to be supported. The study’s decision criteria evolved over time, based on the perceptions of decision-maker concerns, and the criteria used in this study were established at a study board meeting in 2019. There are four broad categories of decision criteria: 1) environment; 2) economy; 3) human health and well-being; and 4) damages and costs/benefits of mitigation measures. This chapter explores the importance of considering stakeholder preferences for decision criteria, and the methodology employed to assess stakeholder preferences in the Lake Champlain-Richelieu River basin. This chapter concludes with an examination of the results of the various studies that assessed stakeholder preferences, and the key takeaways from those results in the context of this study. The analyses conducted in relation to this question are presented in Table 9.

Table 9. Relevant studies to answer questions regarding decision criteria.

Guiding Question	Relevant Studies
How do stakeholders prioritize decision criteria?	Emergency responder survey Household risk perception survey Social network analysis

## 3.1 BACKGROUND

Decision-making has long been aided by analyses of stakeholder preferences of decision criteria (Wang et al., 2009; Ozelkan & Duckstein, 1996), a practice which was employed in this study. Water resource management decisions, for example, are typically guided by multiple objectives measured in a range of financial and non-financial units (Hajkowicz & Higgins, 2008, p.255). Feedback on those objectives can guide policy development and assist decision-makers in considering how best to navigate differing priorities.

In a study carried out in Vermont to assess and evaluate the trade-offs of the costs and benefits of design alternatives for the management of the White River watershed, stakeholders were subjected to a multi-criteria decision analysis exercise. Stakeholders ranked alternatives via an analytical decision framework (Hermans et al., 2007). The authors of this study noted that, “quantifying stakeholder preferences provided a focus for [decision-maker’s] discussion” (Hermans et al., 2007, p.543) and that “the development of criteria and alternatives evaluation provided a basis for future discussions, a way to operationalize the [decision-makers’] vision, and a measure of whether the vision is being achieved” (Hermans et al., 2007, p.544). Another study carried out in Germany noted that “public and stakeholder participation in environmental planning enhanced effectiveness through improving the environmental quality of decisions and enhancing implementation” (Draskiewicz et al., 2015, p. 211). These case studies highlighted how input from the public on decision-making increased the decision-making body’s capacity to produce a decision on a watershed planning issue. Data from the household risk perception survey that deals with respondent preferences of decision criteria provided a basis for discussion for decision-makers within the context of this work, and can guide evaluations of management alternatives from the perspectives of various stakeholders, some of whom would be classified as vulnerable to flooding.

## 3.2 MAIN RESULTS

A key takeaway from the different studies (household risk perception survey, social network analysis and emergency responder survey<sup>8</sup>) that employed this method was that there was some consistency in prioritizations across Quebec, New York, and Vermont (Table 10). For example, each group prioritized human health and safety, including vulnerable residents. Only results from the social network analysis, whose participants were asked the same set of questions, differ, with a priority placed on environmental protection as a high priority for flood mitigation measures. This can be explained by the fact that participants of the social network analysis included groups in Quebec that represented federal, regional, municipal, watershed, and indigenous groups, chambers of commerce, environmental groups, farmers unions, and tourist organizations, rather than members of organizations explicitly concerned with emergency management and flood mitigation. Participants of the SNA and emergency first responder surveys were asked to complete these surveys from the perspective of their roles, rather than their individual priorities.

Generally, mid-level priorities included environmental protection and preventing structural damages, and there was a generally low prioritization for preventing economic harm, protecting historical and cultural sites, and reducing infrastructure impacts (Table 10).

*Table 10. Flood mitigation criteria ranked by importance (1 is the criterion considered as very important by the most responders).*

	Household Risk Perception Survey (CA) N=450	Household Risk Perception Survey (US) N=150	Social Network Analysis (CA) N=45	Emergency Responder Survey (CA) N=19	Emergency Responder Survey (US) N=23
Reduce potential injury, stress, or loss of life due to flooding	1	1	2	2	1
Reduce harm to vulnerable people due to flooding	2	2	5	1	2
Maintain healthy ecosystems, including clean water and thriving biodiversity	4	3	1	3	5
Prevent the spread of aquatic invasive species	6	4	4	6	6
Reduce the number of homes that are impacted by flooding	3	5	7	NA	3
Reduce the financial cost of flood damages	5	6	3	4	4
Reduce harm to economic activity due to flooding	7	7	6	8	7

<sup>8</sup> detailed methodology provided in Appendix A.

	Household Risk Perception Survey (CA) N=450	Household Risk Perception Survey (US) N=150	Social Network Analysis (CA) N=45	Emergency Responder Survey (CA) N=19	Emergency Responder Survey (US) N=23
Reduce harm to historical and culturally sensitive sites due to flooding	8	8	8	7	8
Reduce street closures due to flooding	9	9	9	5	9

Table 10 is a representation of preference results across all five studies that included the flood mitigation decision criteria exercise. Canadian emergency responders were not asked about the criteria for reducing the number of homes impacted by flooding, which is why the response appears as “NA”. Ultimately, the preference information gleaned from this study will influence stakeholders responsible for the development of flood mitigation measures that consider the social and political acceptability of that policy. Stakeholder engagement is defined as a social process working together to find a collective solution for a certain problem (Thaler & Levin-Keitel, 2016, p. 293), and diverse stakeholder engagement is essential to

### 3.3 CONCLUSION

Determining preferences based on how respondents ranked and scored decision criteria can assist in prioritizing the flood management scenarios that are most socially acceptable to the public; such evaluations are essential when considering how to enact policies and programs that are politically feasible, particularly in a transboundary context. Through the assessment of the performance scores based on idealized best and idealized worst solutions, a strong preference for altruistic criteria was displayed. This consistency across Quebec, Vermont, and New York displays the significance of considering social wellbeing in the development of flood mitigation measures, beyond economic and environmental assessment. The quantification of stakeholder preferences also provides focus for research teams in their analysis of measures (Hermans et al., 2007).

A significant output of this study, however, is that it provides space for learning across governance scales, with survey participants representing the public, emergency managers, and decision makers. This research provides insight into the framing of flood mitigation measures for social acceptability. For example, if the public generally prioritizes human wellbeing and population health, it will be helpful to highlight the effect of flood mitigation measures on those criteria. Additionally, it is useful to consider how environmental organizations prioritize ecosystem health, while emergency first responders tend to prioritize other elements of community well-being.

## 4 WHAT DO WE KNOW ABOUT SOCIAL AND COMMUNITY VULNERABILITY?

Vulnerability, according to the definition used by the Ministry of Public Security of Quebec, is "a condition resulting from physical, social, economic or environmental factors, which predisposes elements exposed to the manifestation of a hazard to suffer harm or damage" (Morin, 2008). Vulnerability is the combination of exposure and sensitivity. Exposure to flooding is taken into account through the mapping of flood zones and flooded areas. It is important to note that the elements exposed to a hazard can be both tangible (e.g., people, buildings, ecosystems, etc.) and intangible (e.g., social cohesion, attractiveness, sense of security) (Morin, 2008).

The vulnerability analysis method<sup>9</sup> developed by the ARIACTION research team (member of SPE) in collaboration with the Ministry of Public Security evaluates, calculates and maps the aspect of sensitivity using four thematic indexes: social, territorial, adaptive capacity and infrastructure accessibility. This notion of sensitivity is defined as "the proportion in which an exposed element, community or organization is likely to be affected by the occurrence of a hazard" (Morin, 2008). The analysis of vulnerability, combined with an analysis of the flood hazard, allows the risk to be characterized (hazard x vulnerability = risk) (Figure 8). Knowledge of the risk is an essential element in order to progress towards the choice of appropriate and robust mitigation and adaptation strategies and measures, and better resilience of communities.

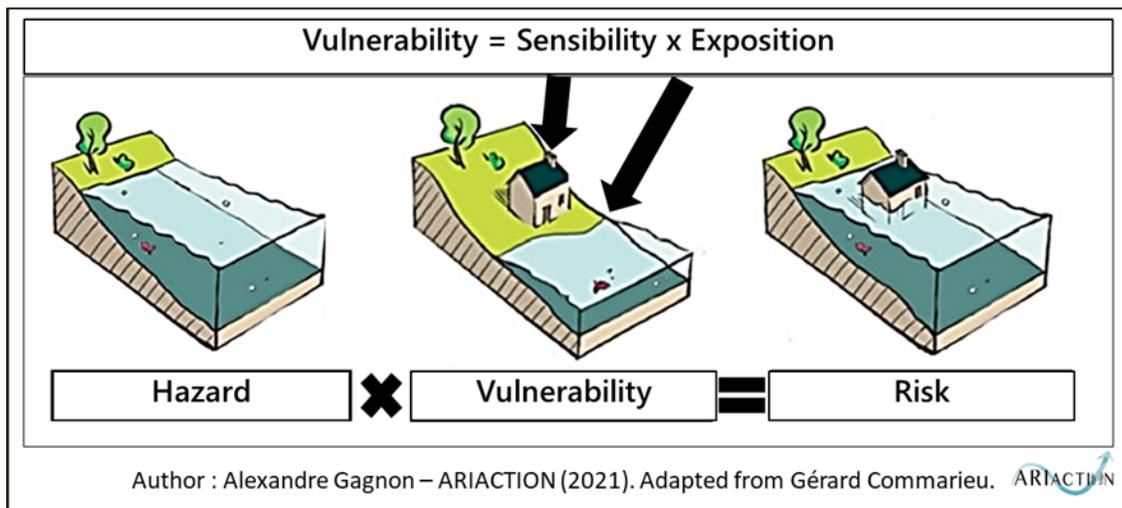


Figure 8. Hazard x Vulnerability = Risk.

<sup>9</sup> A social vulnerability analysis was performed in Canada and in the United States in 2018 and 2019. First developed by the Canadian team of SPE, the methodology was then replicated in the United States. The detailed methodology is available in Appendix A.

## 4.1 OBJECTIVES OF THE VULNERABILITY ANALYSIS

In practical terms, the vulnerability analysis contributed to the objectives of the International Lake Champlain-Richelieu River (LCRR) Study and to enhancing community resilience by 1) establishing an assessment of the situation, 2) forming the basis for performance indicators, and 3) identifying issues and opportunities and guiding recommendations.

### 4.1.1 Establish an assessment of the situation

The first objective achieved by the vulnerability analysis was to carry out an assessment of the situation according to four themes: social sensitivity, territorial sensitivity, adaptive capacity and accessibility (Figure 9). Exposure is also considered. This robust and multi-scale assessment (from neighbourhoods to municipalities to the watershed) helps understand who and what is affected by floods, and also where and how they are affected. It is possible to aggregate indicators into indices or to analyze them individually. Floods affect the watershed, but the impacts vary in intensity across the territory and need to be studied and known with precision. The urban fabric, population characteristics and networks are heterogeneously distributed across the territory, hence the importance of identifying and mapping these differences.

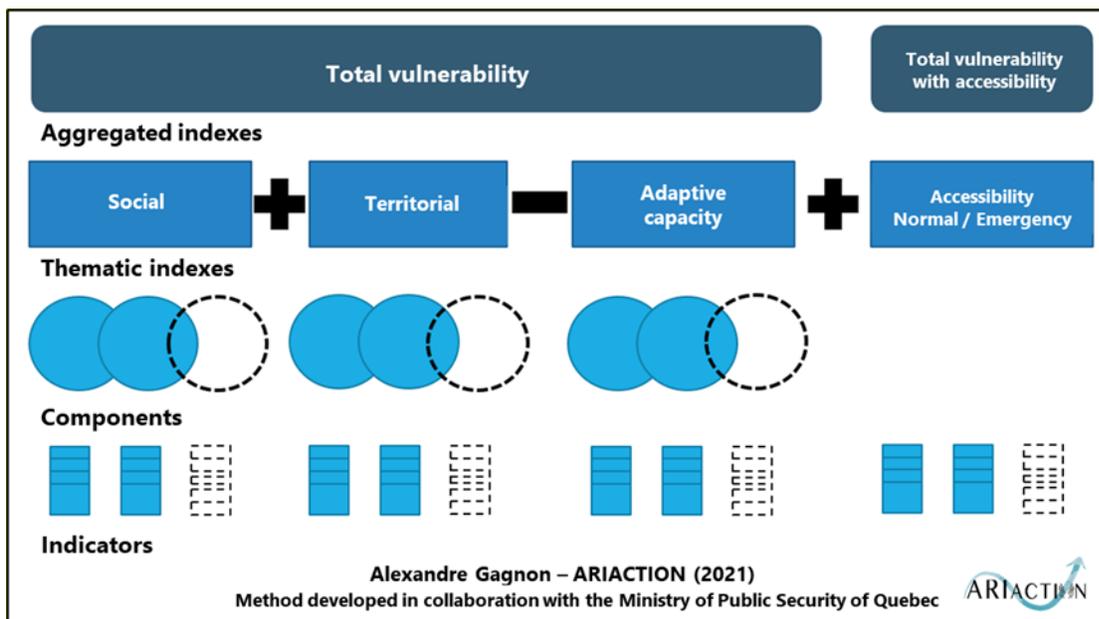


Figure 9. Hierarchical structure of the vulnerability analysis method.

### 4.1.2 Form the basis for the development of performance indicators

The second objective achieved by the vulnerability analysis was to compare different mitigation and adaptation strategies and measures according to their capacity to reduce vulnerability in the territory, using flood scenarios. To achieve this, the indicators used to make the assessment were adapted to fulfill the function of performance indicators. These performance indicators were quantitative in nature and measured the evolution of vulnerability as a function of water level, at the scale of the residential building and by scenario. The ISEE (Integrated Social-Economic-Environmental) modeling platform developed by the Resource Response (RR) technical working group (TWG) was essential for the calculation of performance indicators.

### 4.1.3 Identify issues and opportunities and help create recommendations

The third objective achieved by the vulnerability analysis was to identify issues, problems and opportunities to make communities more resilient. A comprehension of stakeholders' risk perception was essential in understanding how vulnerability was perceived and how actions could be taken. The assessment and performance indicators are thus complementary to field visits, workshops, researchers' expertise and surveys, in order to formulate contextualized recommendations for resilient land use planning and informed and prudent risk management.

In short, vulnerability analysis is essential to risk awareness. As a tool, it produces an assessment of performance indicators and recommendations. As a process conducted in collaboration with stakeholders, it promotes a better understanding and communication of risk. The vulnerability analysis process promotes exchanges about the challenges and opportunities of a territory and the community in the face of flood risk.

## 4.2 VULNERABILITY ANALYSIS IN CANADA

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### 4.2.1 Assessment

The vulnerability assessment in Canada was carried out at the scale of the Quebec municipalities along the Richelieu River, from the American border to the St. Lawrence River. The vulnerabilities of five municipalities, called "pilot municipalities", were analyzed in more detail: Saint-Jean-sur-Richelieu (SJSR), Venise-en-Québec (VQC), Sainte-Anne-de-Sabrevois (SADS), Saint-Paul-de-l'Île-aux-Noix (SPIN) and Noyan. These municipalities were chosen mainly because they have different sizes and urban forms, and different characteristics (large city, tourist town, agricultural area / banks of the Richelieu, nautical town, resort). They were greatly affected by the 2011 floods, are all located in the most affected Regional County Municipality (RCM) (RCM of Haut-Richelieu) and present different situations in terms of vulnerability. The assessment shows the mosaic of possible situations and explains the necessary adaptation of recommendations to local contexts.

#### **Exposure: High exposure upstream of Saint-Jean-sur-Richelieu, but experienced differently depending on the municipality**

The exposure to flooding is much more important in the southern part of the study area (RCM of Haut-Richelieu) than elsewhere in the drainage basin. This area is an expansion zone of the river with generally flat banks and an almost flat river profile, making it vulnerable to flooding. This exposure to flooding presents different forms according to the development framework of the cities and the topographic, natural and hydrological context (Figure 10).

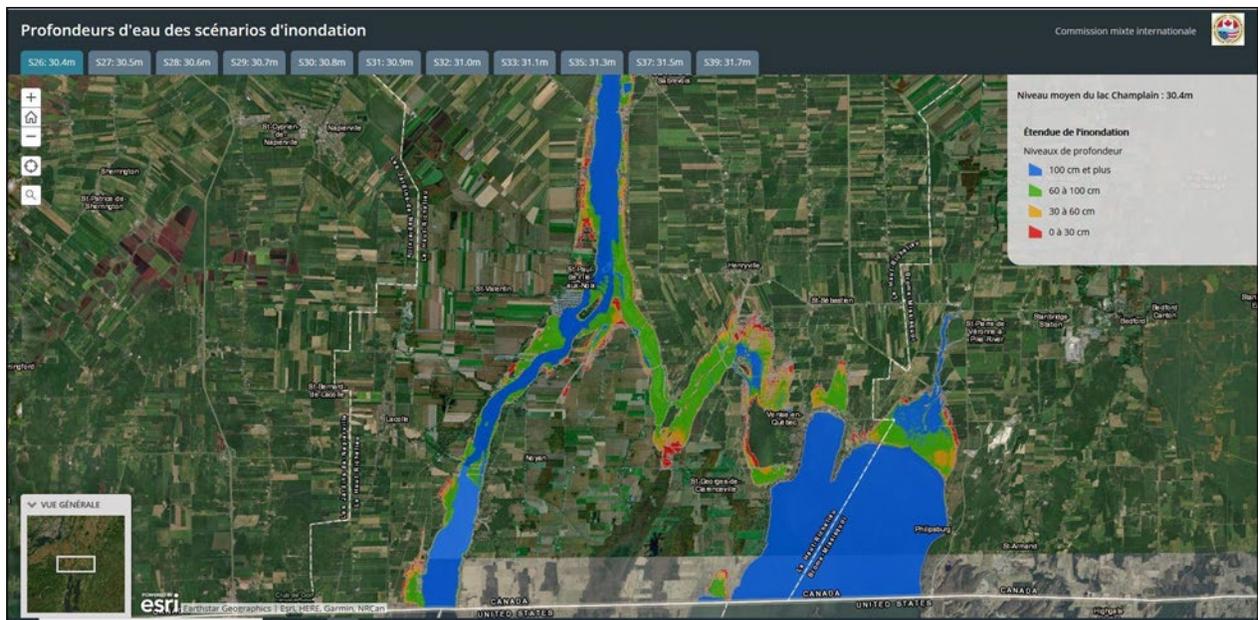


Figure 10. Exposure map example for the Municipal Needs Assessment Workshop.

In Saint-Jean-sur-Richelieu, the downtown area is not really exposed and the neighborhoods greatly affected are rather residential areas south of the Gouin Bridge (notably Saint-Eugène and Saint-Athanase Sud). Sainte-Thérèse Island is also affected. In Venise-en-Québec, the downtown area is also spared, while the campgrounds to the southwest, the central beach, the eastern tip and the campgrounds to the southeast are heavily affected by flooding. Route 202 is at risk. Strong waves can occur on the Mississquoi Bay, causing additional damage. In Sainte-Anne-de-Sabrevois, old cottages converted into residences are in a rather precarious position in case of major flooding, as in 2011. The expansion of the river extends across a wide area of lands, and cuts access to these residences located at the end of dead-end streets. For Saint-Paul-de-l'Île-aux-Noix, the situation can be hazardous for those living on and around the man-made canals. Minor floods do not usually cause problems due to the height of the land. In Noyan, a major expansion zone of the Richelieu is located between Gerard and Emrick Streets and another to the north near Beaver Street.

Exposure analysis is a necessary first step towards understanding vulnerability. The characteristics of the flooding must be studied, as well as the phenomena that result from it, such as shoreline erosion.

### **Social sensitivity: A combination of factors and a need to support sensitive populations**

The composition of the population facing a disaster greatly influences the vulnerability of a municipality (Cutter, Boruff and Shirley, 2003). In order to study this social sensitivity, various socio-economic factors and characteristics of individuals, households and families were separated into components based on the data available in the municipalities studied (Figure 11). When combined, they formed an aggregate social sensitivity index.

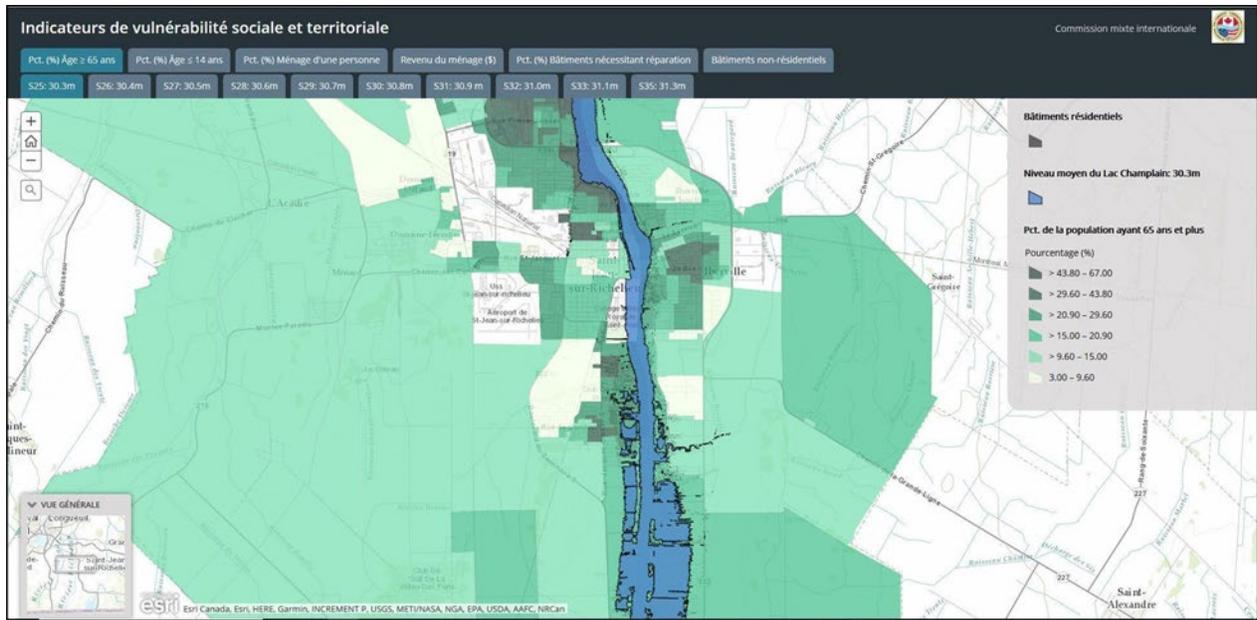


Figure II. Social sensitivity map example for the Municipal Needs Assessment Workshop.

The social sensitivity analysis reveals that while areas classified as "very highly" sensitive in the Canadian study area are not directly affected by flooding, many "highly" and "moderately" sensitive areas are. These areas have large proportions of elderly populations and people who invest a large proportion of their income in their homes. Sometimes these people are in more complicated situations, such as looking for work or living in housing that requires major repairs. So, while some people may be able to cope with a flood and recover quickly, their neighbor, for example, may not be able to recover easily. All the actors concerned must have a preventive approach and support the sensitive populations before, during and after a flood. This knowledge of the sensitive population must be accompanied by a knowledge of the sensitive infrastructures, where people live, work and circulate among others.

### Territorial sensitivity: Adaptation achieved since 2011, but many infrastructures and buildings still at risk

Understanding territorial sensitivity involves an analysis of the structural elements of a community, i.e., the study of infrastructures. By infrastructure, we mean any building, structure, equipment or network necessary for the normal functioning of a community. It is therefore necessary to be able to locate these elements on the territory and to anticipate the risks of a "domino effect" (e.g.: a broken aqueduct or dike complicating the evacuation of residences for the elderly). Special attention should also be paid to essential or critical infrastructures, which are of major importance in emergency management.

The territorial sensitivity is largely influenced by the number of dwellings in the territory. All the pilot municipalities contain hundreds of potentially affected infrastructures, which multiplies the magnitude of the interventions required for prevention, during the emergency and for reconstruction and recovery. The magnitude of the damages is also multiplied. This type of information is useful in establishing mitigation and adaptation strategies and measures developed by the International LCRR Study for local realities. It is important for municipalities and the government to give citizens the tools to organize themselves, adapt their buildings when appropriate and take responsibility.

## Adaptive capacity: Provide tools and information to citizens and strengthen networks

The adaptive capacity index is intended to characterize the ability of a community to absorb the shock of a flood and to adapt, following this disaster, in order to be better prepared for future floods. The higher the adaptive capacity, the lower the vulnerability. Adaptive capacity in the southern municipalities of the Canadian study area varies by situation, but the positive factors generally include the high proportion of homeowners, and the negative factors include the age of the population, technical skills and the proportion of new residents. New residents sometimes do not realize the risk, have little experience with floods and have lower adaptive capacity. Adaptive capacity is a characteristic that can be strengthened overall through community networks, awareness, coaching and risk communication.

## Accessibility: Buildings that become "islands" and several roads at risk

The accessibility of the territory (evacuation of disaster areas, access for rescue workers) should be taken into account when creating an index reflecting the total sensitivity of a city (Demoraes, 2009) (Figure 12). During the response phase (in case of an emergency), accessibility to critical infrastructure is paramount. The inability to get to a hospital or for firefighters to reach a home or business handling hazardous materials can have dramatic consequences. This directly affects the resilience and overall sensitivity of an urban system.

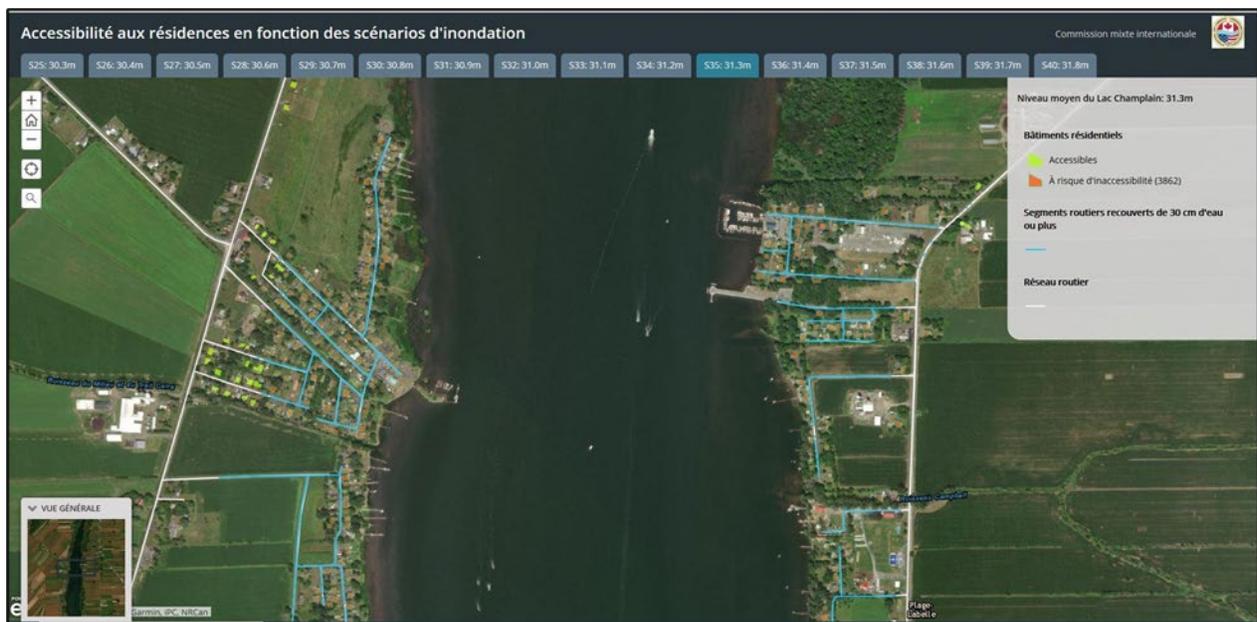


Figure 12. Accessibility map example for the Municipal Needs Assessment Workshop.

For Saint-Jean-sur-Richelieu, accessibility issues are present in the southern part of the municipality, while some areas, such as the northern part of Sainte-Thérèse Island and the area near Mario Street are at risk only in the event of a major event. In Venise-en-Québec, the campgrounds to the east and west are particularly at risk. In the event of a major event, Route 202 may be flooded, which is a significant risk since it is the main east-west axis of the city. In Sainte-Anne-de-Sabrevois, the flood zones are large and isolate many properties located at the end of dead-end streets connected only to the main road. In Saint-Paul-de-l'Île-aux-Noix, the neighborhoods near the riverbanks are at risk, especially the homes that are in the main sector of the artificial canals. In the event of a minor flood, these are minorly affected, but a major flood can create accessibility problems and isolate several residences. In addition, the city came close to a major emergency in 2011 when Route 223, the main north-south route, was almost covered. This would require a flood of exceptional magnitude, but there certainly must be necessary preparations in place in case that happens. In Noyan, the areas that are inaccessible from the fire station are mostly near Gerard Street and to the north near Beaver Street. Accessibility in times of emergency is high in the southern part of the Canadian study area. This is an issue where preparedness is crucial and emergency plans must address it well.

## Synthesis

In summary, the development of the territory and the particularities of the cities mean that vulnerable populations should be provided with assistance in a personalized manner in terms of adaptation. The vulnerability assessment is a snapshot that must be renewed periodically in order to use up-to-date data. It allows for a better understanding of the resilience trajectory of the different municipalities. Collaboration with local stakeholders is essential in order to fully understand the specific characteristics and issues of each territory. Vulnerability can be reduced through direct interventions on the territory, but also through better knowledge of the risk, preparation and communication between all stakeholders, including citizens.

### 4.2.2 Performance Indicators

The indicators used in the vulnerability assessment were adapted to be used as performance indicators. These allow for the comparison of mitigation and adaptation strategies and measures under different flood scenarios and assessment of whether they significantly reduce vulnerability. This exercise lends itself most readily to structural measures that have a direct, quantifiable impact on water levels. This iterative process required close collaboration with the RR TWG to arrive at usable data, a process for calculating performance indicators, and the production of the data in a format suitable for conducting the analysis. Some performance indicators developed by the ARIACTION research team in collaboration with the RR TWG include:

- Number of homes at risk of flooding
- Number of potentially vulnerable at-risk residences: percent of people aged 65 and over (based on Canadian census data)
- Number of potentially vulnerable at-risk residences: percent of residences requiring repairs (based on Canadian census data)
- Number of residences at risk of inaccessibility

Using five available flood scenarios representing different water levels at Rouses Point, namely 30.51 m (100.1 ft), 30.70 m (100.7 ft), 31.02 m (101.8 ft), 31.18 m (102.3 ft) and 31.30 m (102.7 ft), it was possible to evaluate the evolution of vulnerability according to different structural mitigation measures (LCRR Study Theme 1). These measures are 1) selective excavation of the Saint-Jean-sur-Richelieu shoal and human intervention in the river, 2) water diversion through the Chambly Canal, 3) water diversion through the Chambly Canal with selective excavation, and 4) an inflatable weir at the shoal site in Saint-Jean-sur-Richelieu. These were preliminary versions, available in July 2019, of similar measures developed by the Flood Management and Mitigation Measures (FMMM) and the Hydrology, Hydraulics and Mapping (HHM) technical working groups (FMMM/HHM/2021).

Table 11 compares the number of houses at risk of flooding under existing conditions (no mitigation measures) and the four scenarios described above. In summary, the preliminary results show that measures #1 and #3 would be the most effective (highlighted in green font) in reducing vulnerability for the 30.5 m and 30.7 m water level thresholds, and that measure #4 would be the most effective for higher thresholds, especially for a 31.02 m threshold (Table 11). The number of flooded houses, vulnerable people and inaccessible roads decreases as the water level drops with the effect of mitigation measures, but no measure among those studied can reduce vulnerability to zero or even decrease it significantly compared to a reference situation, especially for a major flood event. This situation indicated that a mix of tools and strategies to reduce the risk will be needed and a residual risk will always be present.

*Table 11. Territorial Sensitivity – Comparison Table with Mitigation Measures (based on preliminary results from FMMM).*

Number of houses at risk of flooding with various mitigation measures					
Water level at Rouses Point (m)	30.51	30.70	31.02	31.18	31.30
Number of houses at risk of flooding with no mitigation measure	472	962	2198	2851	3175
Number of houses at risk of flooding with measure #1 (reduction from baseline)	384 (-88)	774 (-188)	1968 (-230)	2648 (-203)	3056 (-119)
Number of houses at risk of flooding with measure #2 (reduction from baseline)	472 (0)	913 (-49)	1853 (-345)	2703 (-148)	3051 (-124)
Number of houses at risk of flooding with measure #3 (reduction from baseline)	384 (-88)	745 (-217)	1730 (-468)	2547 (-304)	2941 (-234)
Number of houses at risk of flooding with measure #4 (reduction from baseline)	472 (0)	881 (-81)	1039 (-1159)	2304 (-547)	2537 (-638)

*Green font shows the most effective measure for each water level scenario.*

*Produced by Alexandre Gagnon (March 2020) – UdeM - ARIACTION. Data: RR TWG. Based on preliminary results.*

### 4.2.3 Risk perception, issues and opportunities

During the study, research was conducted for the vulnerability analysis in parallel to the risk perception analysis. The vulnerability analysis supports the development of recommendations, to be sure that they target the right stakeholders and territories, while being supported by the risk perception analysis to consider “who” is affected and “how” change can be accepted and implemented.

Risk perception is crucial to analyze and understand in this context, because it is related to the concept of vulnerability itself. For example, the non-perception of their own vulnerability by populations is itself a vulnerability factor that will hinder the implementation of preventive measures (Leone and Vinet, 2006). Stakeholders must be aware of their vulnerability and accept it, or else it will be very difficult to take action and adopt mitigation and adaptation measures and strategies. Using questionnaires, semi-directed interviews and discussion groups, SPE analyzed risk perception and identified issues in the basin. This work helps demonstrate that vulnerability is more than just a situation and a collection of facts, but is also interpreted and perceived differently by stakeholders. Issues that affect flood vulnerability are summarized below in abbreviated form and discussed in more depth in the risk perception synthesis report (Thomas et al. 2020).

#### Governance issues

- Decision-making process that is too “vertical”, not inclusive enough
- Lack of time and resources for municipalities
- Potential conflict of interest in the application of the “Politique de protection des rives, du littoral et des plaines inondables” (PPRLPI)<sup>10</sup> by municipalities
- Poor communication between different levels of management
- Lack of incentives to develop resilient practices

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<sup>10</sup> Shoreline, Littoral and Floodplain Protection Policy.

## Risk perception issues

- Relatively low level of risk perception in the study area
- 2011 events considered "exceptional"
- Attention turned to the so-called "usual" spring floods
- Members of the public not encouraged to take accommodation measures
- Population poorly adapted and exposed to a risk that it does not perceive; contributes to maintaining the already existing context of vulnerability
- Selected adaptation measures inconsistent with an aging population
- Backfilling perceived as a "miracle" solution

## Land management issues

- Related to the existing adaptation model
  - Absence of an overall coherent strategy aimed at adapting buildings at the municipal level
  - System based on government tools that, under current conditions, may be too remote from local realities
  - Situation that favors the continued adoption of an unsustainable adaptation model, sometimes an illegal backfilling practice, that does not reduce the existing conditions of vulnerability
  - Preponderance of a particular model of building adaptation: addition of equipment (pumps, generators, first aid kits)
- Social issues
  - Stress caused by the stages of rehabilitation and adaptation
  - Psychological weight related to the "defitting" after a flood (removing materials, floors, etc.)
  - Involvement of physical, emotional and financial resources during the work
  - Extra tasks added to daily activities
  - Significant emotional impact of the feeling of infinite waiting coupled with the feeling of helplessness
  - Larger effects on disadvantaged communities

### 4.3 VULNERABILITY ANALYSIS IN THE UNITED STATES

A version of this methodology employed by the SPE team in Canada was replicated for the United States portion of the LCRR basin, providing a cohesive vulnerability analysis for the entire LCRR basin. The geospatial outputs in Vermont and New York provided insight into understanding the resilience and adaptive capacity of the communities within the region, and assisted in addressing how to best target available resources to assist vulnerable communities. The three social vulnerability indicators include classifications for sensitive populations, precarious situations, and limited resources. Descriptions of these indicators, along with snapshots of the geospatial analyses generated, are provided below.

With respect to sensitive populations, classifications included vulnerable age groups (under 18 and over 65), households with children, individuals inactive in the labor market, and individuals living alone. These metrics are useful for flood hazard mitigation planning, with targeted responses to flooding emergencies. There were concentrations of sensitive populations across the basin, including in New York and Vermont (Figure 13).

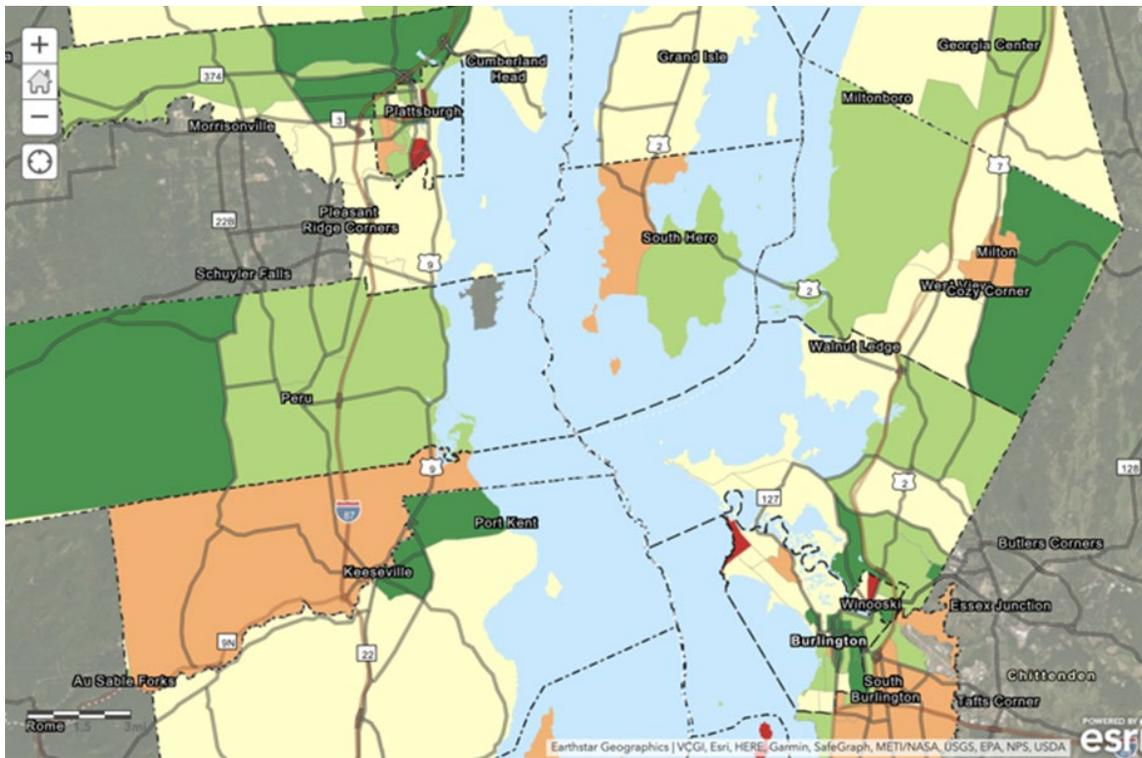


Figure 13. Sensitive population communities in the USLCRR basin. The color scale ranges from dark green (least vulnerable) to red (most vulnerable) at the census block scale.

Precarious situations provide insight into additional social vulnerabilities that impact household capacity to recover from the impacts of flooding. Classifications for precarious situations include single parent families, rental/tenant status, households spending more than 30 percent of income on housing costs, and households with an annual income lower than US\$30,000/year. The national census informed the availability of these classifications, which were then analyzed geospatially. Hubs of communities with high levels of precarious situations are displayed in red in Figure 14.

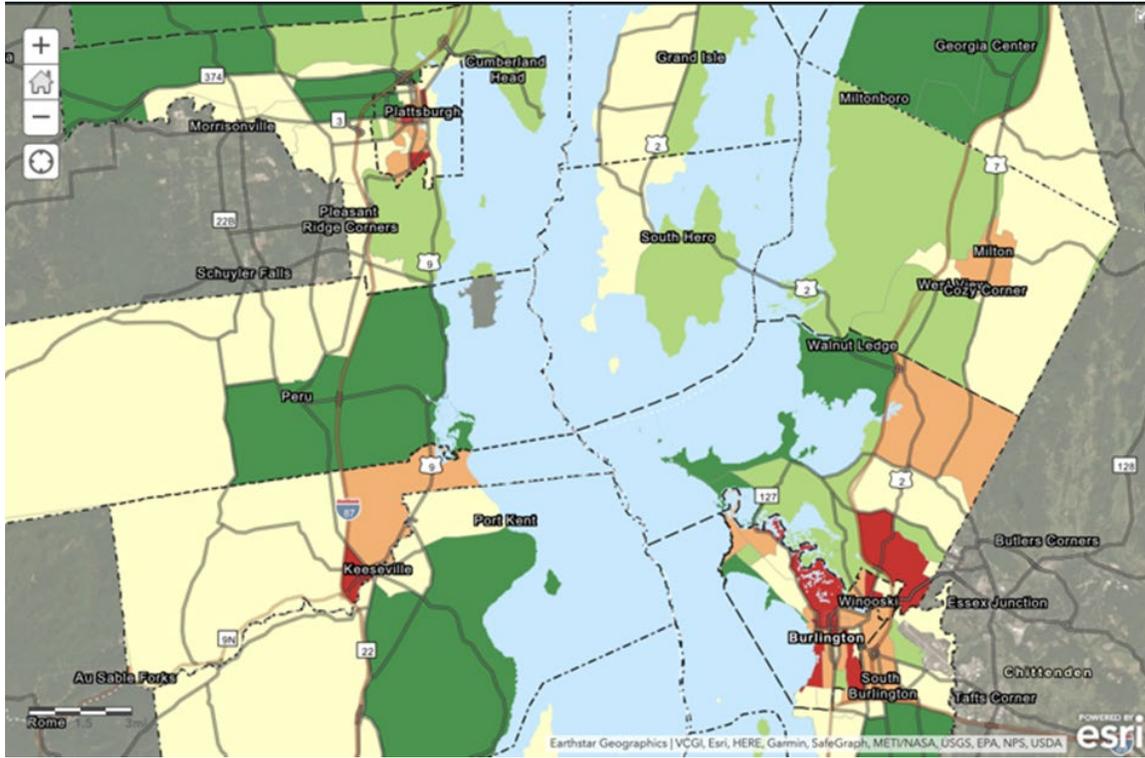


Figure 14. Precarious situation communities in the US LCRB basin. The color scale ranges from dark green (least vulnerable) to red (most vulnerable) at the census block scale.

Finally, mapping households and communities with limited resources provided useful information for how to approach mitigation to future floods. Some of these classifications include houses built prior to 1960, percentage of individuals over the age of 25 without a high school diploma, and households receiving social assistance. Communities with high levels of limited resources are indicated in red in Figure 15.

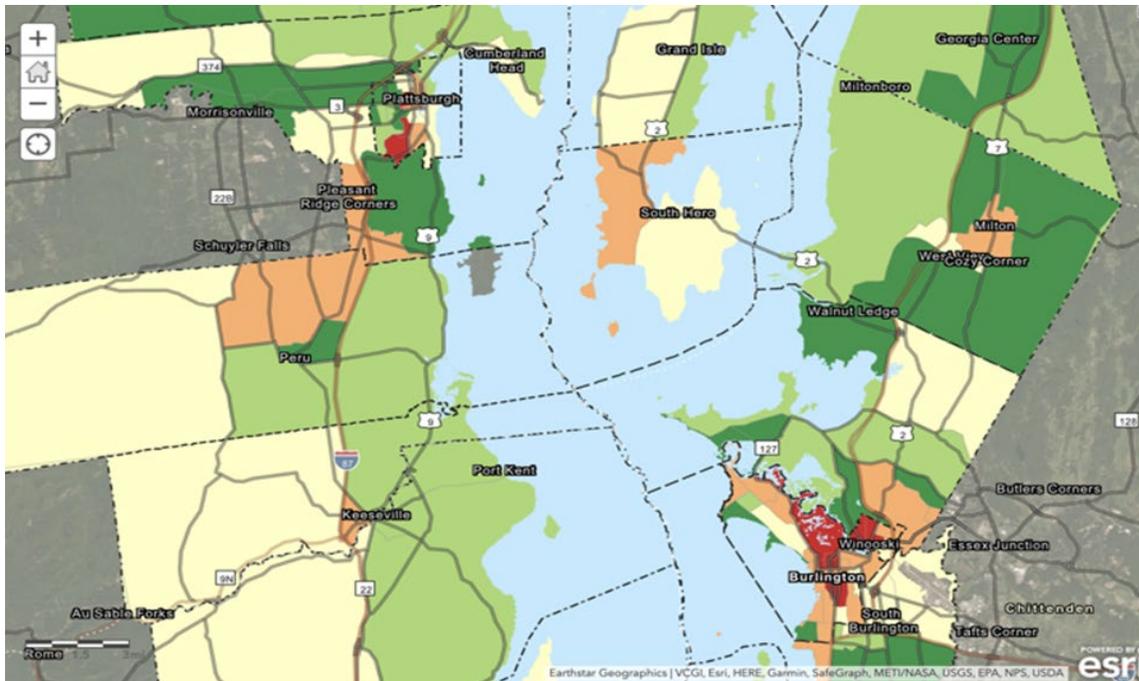


Figure 15. Limited resource communities in the US LCRR basin. The color scale ranges from dark green (least vulnerable) to red (most vulnerable) at the census block scale.

The aggregate scores for the three indicators (sensitive populations, precarious situations, and limited resources) produced a social sensibility score that gave an overview of sensitive areas throughout the US LCRR basin. This information can assist personnel and decision makers with allocation of resources and directed attention towards flood response and mitigation with a focus on equity and targeting the region’s most vulnerable communities.

#### 4.4 JOINT PRINCIPLES AND CONCLUSION

This analysis reveals not only issues related to vulnerability, but also opportunities and areas for improvement. Awareness of the risk is a first step to consider mitigation and adaptation strategies and measures adapted to the context in the long term. Prevention and preparedness must be based on a more solid foundation, and the data and analyses produced help to achieve this. Vulnerability analysis benefits greatly from collaboration with local stakeholders, and their involvement in the process is itself a strategy to achieve greater resilience for all.

In conclusion, vulnerability analysis is multifaceted and multi-scale. It is useful as a diagnostic, a performance indicator and a basis for recommendations for mitigation and adaptation strategies and measures. Vulnerability analysis is relevant to both risk management and land use planning. Different areas could require different mitigation measures, and maps help to identify vulnerable areas.

## 5 WHAT ARE STAKEHOLDERS’ REACTIONS AND PREFERENCES TO MITIGATION MEASURES WITHIN EACH THEME, AND WHAT FACTORS HINDER AND ENABLE THE IMPLEMENTATION OF PROPOSED MEASURES?

As described in section 1, the LCRR Study was divided into four distinct Themes. Theme 1 (reduce water levels) focused on moderate structural measures such as “constructing structures that impact the flow regime, modifications of existing instream structures, dredging or removal of instream obstructions to increase flows” (FMMM and HHM, 2021:33). Theme 2 (impede flows) focused on nature-based solutions such as the “construction of barriers to impede or divert overland flow” (FMMM and HHM, 2021:33), wetlands and water storage. Theme 3 (flood response) focused on emergency preparedness and Theme 4 on managing floodplain occupancy.

The LCRR study occurred over several years, and the recommendations evolved slowly over that period. Early in the study, SPE was limited to inquiring about preferences broadly, and the ability to provide details about the design and consequences of mitigation measures was restricted because these factors were still unknown. For this reason, SPE’s methods of understanding stakeholder preferences also evolved. The risk perception survey, social network analysis and emergency responders survey, for example, which were conducted early in the course of the research, asked broad questions of a wide sample of residents and organizations. As the final recommendations were drafted, multiple feedback sessions in Quebec, Vermont and New York provided far fewer options for mitigation strategies and high levels of details regarding design and consequences.

The research questions and studies presented in Table 12 provided an understanding of preferences regarding the study recommendations that reflected social acceptability, political acceptability and political feasibility, as described below.

*Table 12. Relevant studies to answer questions regarding stakeholder preferences.*

Guiding Question	Relevant Studies
What are stakeholder preferences regarding mitigation, broadly?	Cost-benefit analysis Emergency responder survey Final stakeholder engagement Hazard mitigation plan analysis Public meetings, meetings with stakeholders, meetings with political entities and expert workshops Social network analysis Stakeholder focus groups

Stakeholder engagement meetings were conducted in Quebec, Vermont and New York throughout the Fall of 2021 and Winter of 2022. These meetings included technical experts, government agency personnel, local residents, emergency responders, and representatives of environmental and watershed organizations, and focused specifically on understanding stakeholder preferences for the four Themes. A survey was distributed to attendees of these meetings in the United States and Canada<sup>11</sup>. Additional meetings were organized with officials and assistant deputy ministers of four ministries of Quebec<sup>12</sup>. Data regarding stakeholder perceptions of social and political acceptability and feasibility are also presented. Finally, SPE's overarching conclusions are presented in strengths/weaknesses/opportunities/threats (SWOT) analysis format. The SWOT analysis is based upon SPE's conclusions from studies and interactions with stakeholders in the basin, as well as knowledge of the flood resilience/mitigation literature and the team's professional experiences.

In SWOT analysis, strengths and weaknesses represent positive and negative factors within the study's sphere of influence. Opportunities and threats outline enabling and hindering factors outside the control of the study. Enabling factors are those conditions that facilitate the adoption of recommended actions, and hindering factors are those that pose obstacles or prevent implementation (Therrien, Usher and Matyas 2019).

Understanding the enabling and hindering factors to the implementation of recommendations in environmental management processes is critical (Mukhamedzhanov et al. 2020; Ratcliffe, n.d.). According to Therrien, Usher and Matyas (2019), enabling factors "allow for the actualization of... urban resilience (p. 85)." These characteristics focus attention, facilitate action, direct resources and grow support among stakeholders. They represent factors that exist at different geographic, social, political and temporal scales, and within society, organizations and the environment. When positive steps towards resilience occur, it is often because these factors align. Alternatively, hindering factors "act as barriers... to urban resilience (p. 85)." Assessing enabling and hindering factors, and learning to observe their development, as well as respond to them as they arise, helps to ensure that environmental management plans are successfully implemented, rather than sitting on shelves to gather dust.

Past IJC studies have delayed consideration of enabling and hindering factors until after recommendations were formulated and study work was complete. Consequently, many recommendations may have appeared to have merit on paper and within the confines of the study, but external factors rendered these recommendations inapplicable for a variety of reasons.

The identification of enabling and hindering factors is important because it (Mukhamedzhanov et al. 2020, Ratcliffe, n.d.):

- ensures study recommendations are feasible, given local contextual factors;
- assists the study to rule out unfeasible recommendations, thereby streamlining later review and preventing further reviewers from being distracted by recommendations that sound good on paper, but are irrelevant in reality;
- enhances the relevance of study work in the eyes of stakeholders, who see local realities considered as the study progresses;

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<sup>11</sup> The survey asked respondents to provide general comments on the presentation from the Study as well as specific comments on recommendations. The survey included questions on social and political acceptability, and feasibility of the recommendations. 31 responses were collected in the United States and 18 in Quebec. Detailed methodology is available in Appendix A

<sup>12</sup> In Quebec, the survey was not distributed to representatives from the government, as they planned on sending an official answer to the material presented during the meetings.

- identifies indicators for continual monitoring, and enables nimble implementation in response to changing contextual factors;
- allows implementers to leverage enabling factors and proactively guard against hindering elements, thereby facilitating stronger implementation;
- prevents wasteful spending on the review of recommendations that have little chance of implementation.

Discussion of the primary LCRR Study Themes is presented in this chapter. Summaries of the themes are followed by presentations of data collected at the stakeholder meetings and through the other surveys and engagement activities. In addition to these details, discussion of Theme 1 includes results from the cost-benefit analysis. The final section of this chapter includes a discussion on cross-cutting issues related to Themes 1 through 4 and presents additional enabling and hindering factors for implementation of all, cross-cutting, mitigation measures.

## 5.1 THEME 1 – REDUCE WATER LEVELS

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Measures to reduce water levels have evolved since the beginning of the study, and moderate and less moderate structural measures have been presented to stakeholders. It is important to note that when these measures were presented earlier in the study, information on the effect of the measures on water level, on the environment and on upstream and downstream communities was generally not available. Stakeholders therefore had to express their opinions based on partial information. One of the ways SPE used to assess stakeholders' preferences without having details about the measures was by investigating their preferences more broadly and in relation to decision criteria. As the range and details of measures narrowed, SPE was able to ask more specific questions and provide a higher level of detail. In the final stakeholder engagement meetings conducted in Quebec, Vermont and New York, the LCRR Study Board presented two measures with more details about the influence of mitigation measures on water levels, as well as environmental and social impacts. This allowed SPE to ask specific questions on the perception of feasibility of the measures.

The Theme 1 recommendation, as presented to the stakeholders, was<sup>15</sup>:

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*The Study Board recommends the IJC advise governments that a modest level of flood and drought relief can be achieved by returning the Saint-Jean-sur-Richelieu shoal and the hydraulic regime to a more naturalized state, through the removal of some flow-impeding human artifacts and the installation of a submerged weir (Measure 1).*

*Additional flood relief can be gained through combining this with a modest diversion through the Chambly Canal (Measure 3).*

*The Study Board has determined that both these measures present a viable, moderate structural solution.*

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<sup>15</sup> It is important to note that the recommendations presented in this report are draft recommendations that were presented at the final stakeholder engagement meetings conducted in Quebec, Vermont and New York. These were the latest versions of the recommendations for which SPE conducted data collection prior to writing this report. The recommendations subsequently evolved, which may have an effect on the level of feasibility. The final version of the recommendations is available in Appendix B, but has not been analyzed by SPE.

## 5.1.1 Cost-benefit analysis of Theme 1 solutions

The economic team of SPE produced a cost-benefit analysis of Theme 1 solutions. This subsection presents the results of this cost-benefit analysis for three measures and was excerpted from the report IJC-LCRR Study, Economic Analysis of Structural Measures (Bouchard St-Amant, Dumais, et al., 2022). In addition to Measures 1 (submerged weir) and 3 (submerged weir with a small diversion) presented in the recommendation above, the economic team produced a cost-benefit analysis for a large diversion through the Chambly Canal (Measure 2), which was discarded early on by the Study Board.

Table 13 summarizes the benefit/cost analysis for Theme 1 measures. Because Measure 3 is comprised of Measure 1 with the inclusion of a small diversion, Table 13 presents the accrued costs and accrued expected benefits of Measure 3 compared to Measure 1. The accrued expected benefits (additional prevented damages) of each measure are different. First, the mean additional damage prevention values of Measures 1, 2 and 3 are US\$1.94 million (CDN\$2.59 million), US\$1.61 million (CDN\$2.15 million) and US\$0.29 million (CDN\$0.39 million) for an expected year. At a discount rate of 3%, reflecting United States Government standards (USHS, 2016), and a 50-year project life, the additional benefits are expected at US\$51.85 million (CDN\$69.11 million), US\$43.09 million (CDN\$57.43 million) and US\$7.75 million (CDN\$10.33 million).

Table 13. Expected accrued costs and benefits by mitigation measure.

Additional benefits (M US\$)				Marginal Costs (M US\$)	Marginal B/C ratio
Median (year)	Exp. (year)	97.5 <sup>th</sup> quantile (year)	Exp. (50 yr at 3%)	Value (50 yr at 3%)	(50 yr at 3%)
<b>Measure 1 – Submerged weir (compared to the baseline)</b>					
0.36	1.94	11.22	51.85	6.50	7.98
<b>Measure 2 – Large diversion (compared to the baseline)</b>					
0.33	1.61	9.33	43.09	96.48	0.45
<b>Measure 3 – Submerged weir with a small diversion (compared to Measure 1)</b>					
0.09	0.29	1.59	7.75	11.15	0.69

Source: Bouchard St-Amant, Dumais, et al, (2022).

Note: the median and 97.5<sup>th</sup> quantile are presented for the purpose of yearly comparison, but are not used in the 50 year calculation. Exp.: expected value. US currency values can be converted to Canadian using a factor of 1.333, consistent with other LCRR reports (Moin et al. 2022).

The accrued costs of each measure were the main drivers of the differences in the benefit cost ratios. Accrued costs estimated for Measures 1, 2 and 3 were, respectively, US\$6.5 million (CDN\$8.66 million), US\$96.48 million (CDN\$128.61 million) and US\$11.15 million (CDN\$14.86 million), which led to accrued benefit to accrued cost ratios of, respectively, 7.98, 0.45 and 0.69.

Only the reduction of damages Measure 1 would provide would be cost-effective at a discount rate of 3%. In other words, from a public policy standpoint, paying for damages through a compensation mechanism (insurance, or direct compensation) would be cheaper than paying for the accrued costs of Measures 2 and 3, but more costly than Measure 1.

The total benefits of Measure 3 can be obtained by summing the accrued benefits of Measure 1 and the marginal benefits of Measure 3, which then yields a benefit to cost ratio of 3.33 compared to the baseline. However, the efficiency of Measure 3 should be evaluated in terms of the additional benefits it would generate compared to Measure 1, in light of the additional costs it would generate. Indeed, the remaining benefits can be obtained with the implementation of Measure 1 alone. In particular, using the overall benefit-cost ratio for Measure 3 (submerged weir and the small diversion) obfuscates the added relative inefficiency of the small diversion (the only difference with Measure 1). Hence, from a decision-making standpoint, the relevant information is captured by the marginal benefit to cost ratio.

The USHS discount rate of 3% is lower than the Canada Treasury Board recommendation for cost-benefit evaluations; using a higher rate lowers the overall benefit to cost ratios for all measures. With a higher discount rate of 5%, the recommended rate of the Treasury Board of Canada, the marginal benefit cost ratios would drop to 5.89, 0.34 and 0.52 (not shown in Table 13, but available in Bouchard St-Amant, Dumais, et al., 2022). Based on these results, it seems clear that the high efficiency of measure 1 in reducing flood damages in comparison to its cost, is warranted.

In terms of damage reduction by sector, each measure tends to reduce damages in the residential sector in a greater proportion than in other sectors, which is explained by the greater number of flooded residential properties compared to properties from other sectors. Such analysis can be found in the complete SPE economic analysis (Bouchard St-Amant, Dumais, et al., 2022).

In the non-residential and public sectors, expected damages are lower than in the residential sector, due to the lower number of buildings and higher elevation of buildings in those sectors.

In the agricultural sector, each measure does not tend to have an important impact at reducing damages during extreme floods. This fact is a consequence of agricultural lands being low, flat, and thus, more sensitive to lower water levels. As a result, floods do not need to be high, in comparison to the residential sector, to generate important damages.

### **5.1.2 Summary of final stakeholder engagement**

This discussion presents findings from final stakeholder engagement meetings conducted in Quebec, Vermont and New York throughout the Fall of 2021 and Winter of 2022. In the United States, meetings were conducted with the Lake Champlain Basin Program (LCBP) Technical Advisory Committee (a group of technical experts from colleges/universities, municipal, state and federal government agencies); LCBP's Citizens Advisory Committee (residents of the basin); and a mixed group of political officials that included elected representatives at federal, state and local levels, and emergency responders and planners. In Quebec, two meetings were conducted: one with environmental and watershed organizations, and one with municipalities and regional county municipalities.

#### *Canadian (Fall 2021) Meeting Summaries*

Support for structural solutions was good among attendees at the meetings in Canada. Participants noted that these were modest measures compared to others that had been proposed earlier in the Study. Participants noted that the proposed measure appeared to have low environmental impacts and pointed out that it was a return to a natural state of the river. They also noted that the cost-benefit ratio was favorable. However, comments were made regarding the choice of environmental performance indicators and that some were discarded, as well as the need to carry out further environmental analysis and monitoring of the environmental impacts after implementation of the measure. The structural measure proposed also raised questions regarding the geographical distribution of the impacts avoided, as well as the impact of this structural measure on the mapping of the flood zones.

The implementation of this measure also raised questions and concerns. One stakeholder, for example, highlighted the need to continue engineering and environmental studies, and another pointed out the need to provide pathways to implementation. Respondents also emphasized the need for collaboration between the different levels of government and jurisdictions to enable the implementation of the measures. Finally, the stakeholders emphasized the question of funding for this measure, some considering that the measure should be paid for by the provincial and federal governments. However, the respondents also saw a role for local authorities, particularly with regard to disseminating the results of the study, communicating with the population and building social acceptability.

Similar responses were received regarding the addition of a modest diversion through the Chambly Canal. However, respondents emphasized even more the importance of collaboration, coordination and joint management between the governments on both sides of the border. Stakeholders also pointed out that this measure seems less beneficial from a cost-benefit point of view.

### Canadian Survey Results; Theme 1<sup>14</sup>

Table 14. Perception of Theme 1 recommendation (CA-measure 1).

Measure 1		
	Response	Percentage (%)
I believe that this recommendation will be acceptable to stakeholders in the LCRR basin (N=18 <sup>15</sup> )	Strongly disagree	5.6
	Somewhat disagree	0
	Neither agree nor disagree	5.6
	Somewhat agree	66.7
	Strongly agree	22.2
I believe that this recommendation can be feasibly implemented by all levels of governments (N=18)	Strongly disagree	5.6
	Somewhat disagree	0
	Neither agree nor disagree	16.7
	Somewhat agree	44.4
	Strongly agree	33.3

Table 15. Perception of Theme 1 recommendation (CA-measure 3)<sup>16</sup>.

Measure 3		
	Response	Percentage (%)
I believe that this recommendation will be acceptable to stakeholders in the LCRR basin. (N=16)	Strongly disagree	6.3
	Somewhat disagree	0
	Neither agree nor disagree	12.5
	Somewhat agree	68.8
	Strongly agree	12.5
I believe that this recommendation can be feasibly implemented by all levels of governments. (N=16)	Strongly disagree	0
	Somewhat disagree	6.3
	Neither agree nor disagree	18.6
	Somewhat agree	43.6
	Strongly agree	31.3

<sup>14</sup> In the Canadian survey, separate questions were asked regarding Measure 1 and Measure 3, while in the United States one question inquired about both measures.

<sup>15</sup> Respondents were not required to answer all questions, which results in the variation of the N between questions.

<sup>16</sup> Respondents were not required to answer all questions, which results in the variation of the N between questions.

### *United States (Winter 2022) Meeting Summaries*

Support for structural solutions was mixed among attendees at the United States meetings. The Theme 1 recommendation was met with useful advice and critiques regarding the acceptability and feasibility of structural mitigation measures, largely centered around the need for multi-scale, ongoing collaboration for flood management that includes municipal/local, state, federal, and bi-national participation. One respondent noted that, “protection and restoration of floodplains and shorelines is urgently needed. All levels of government should cooperate” while another added that, “All levels of government should continue to work together, both internationally and inter-governmentally, to mitigate climate change and its impacts. It is also necessary for continued and likely increased financial support and technical assistance to ensure that as hydraulic regimes are restored and diversions occur, they are implemented in the most effective way to ensure long-term success and in the more fair and equitable manner.”

Designated roles for each scale were also addressed, with respondents noting that, “On the State and Federal level funding and partnership with Canada is very important. For State and Local communities’ education and involvement with our residents to inform them of the benefits both ecologically and financially.”

Another piece of feedback involved mapping. The respondent noted that, “The mapping of floodplains needs to be consistent across the board from federal and state governments. It’s very confusing when the information is not the same and makes that data seem less credible.”

Sources of resistance were funding issues and altering of the river. One attendee mentioned that basin infrastructure projects tend to go significantly over budget. However, others were not at all concerned about these areas. Lakeshore flooding is not thought to be of major concern for residents besides those who live very close to the lake. Low water levels in the lake were also brought up as an issue that people may be concerned about. One respondent noted, “Economics show that this is on the cusp of being beneficial...Projects in the basin have gone through the roof due to infrastructure that needs to go in”. Another respondent stated, “I don’t see any obstacles, personally.”

Some felt that the public would understand the need for a structural solution and found it economically acceptable. Contrastingly, there was concern about changing the flow of the river. The cost of maintenance was also raised as a concern that should be considered, as well as the cost of funding the project in general. There was a strong desire expressed for a public comment period and several comments about the need for effective public outreach and education. It was noted that the graphics were hard for the attendees to understand, and the public may have a hard time understanding them as well. Creating clearer diagrams and graphics for future presentations and outreach may help. One participant stated, “This is, of the recommendations, this is the least offensive.” A second member of the group noted, “Education and communication are important.”

Support for structural solutions was vocalized by a few attendees. Concern over whether or not funding would be required from municipalities was expressed, as well as what the impact of lower lake level would be on fishing.

On this point, a respondent stated, “Potentially reducing flooding relieves many of our shoreline properties from flood damages.”. Another stakeholder said, “Thank you. This has been a long haul, but it looks like we have arrived at solidly researched and easily understood conclusions.”

## United States Survey Results; Theme 1

Table 16. Perception of Theme 1 recommendation (US).

	Response	Percentage (%)
I believe that this recommendation will be acceptable to stakeholders in the LCRR basin (N=15)	Strongly disagree	0
	Somewhat disagree	13.3
	Neither agree nor disagree	20.0
	Somewhat agree	46.7
	Strongly agree	20.0
I believe that this recommendation, while located and implemented in Canada, could be supported by local, state and federal agencies in the US (N=15)	Strongly disagree	0
	Somewhat disagree	6.7
	Neither agree nor disagree	33.3
	Somewhat agree	33.3
	Strongly agree	26.7

### 5.1.3 Social and Political Acceptability of Theme 1 Recommendation

SPE's risk perception and emergency responder surveys showed there is some support for moderate structural measures, such as those described in the Theme 1 recommendation, from emergency responders and residents in Quebec. Support is slightly less among residents in the United States, although emergency responders demonstrated stronger support. Among residents on both sides of the border, support was strongest among those that have experienced flooding (Table 17). It is important to note that the risk perception and emergency responder surveys were conducted prior to development of the final Theme 1 recommendations, therefore the survey questions were very general. Respondents were not provided with costs or details about the influence of specific structural designs on water levels and communities.

Table 17. Support for structural measures (household risk perception survey).

		Household Risk Perception Survey Canada (N=450)		Household Risk Perception Survey United States (N=150)	
		Results for respondents that have experienced flooding in the past (%)	Results for respondents that have not experienced flooding in the past (%)	Results for respondents that have experienced flooding in the past (%)	Results for respondents that have not experienced flooding in the past (%)
Flooding should be addressed by building projects (dikes, berms, etc.) that keep water away from development	Strongly agree	34.6	20.1	41.4	31.0
	Agree	46.2	48.1	34.5	38.0
	Neutral/ Indifferent	13.5	16.3	17.2	15.0
	Disagree	5.8	10.3	0	9.0
	Strongly disagree	0	5.3	6.9	7.0

Table 18. Support for structural measures (emergency responder survey).

		Emergency Responder Survey Canada (N=19)	Emergency Responder Survey United States (N=23)
Flooding should be addressed by building projects (dikes, berms, etc.) that keep water away from development	Strongly agree	5.3	10.5
	Agree	26.3	26.3
	Neutral/ Indifferent	21.1	26.9
	Disagree	47.4	26.3
	Strongly disagree	0	0

#### 5.1.4 Political Feasibility of Theme 1 Recommendation

Considerable outreach to government agencies in Canada and the United States has been performed over the course of the study (see Appendix A for a list of outreach activities). Structural solutions proposed early in the study received mixed or negative reactions, which prompted the Study Board to adapt accordingly.

In Canada, SPE’s research on decision criteria, observations during meetings with elected officials and local organizations, and results from the social network analysis revealed more skeptical attitudes towards structural measures. Large, structural measures and intervention in water levels in general have little support from organizations. Large structural measures to reduce water levels raise concerns for water levels in drought conditions, for water quality and ecological impacts. They are often considered as damaging to the environment, yet environmental criteria are highly ranked, especially amongst organizations related to flooding and water management and influential organizations, which could decrease the feasibility of structural measures.

The first Theme 1 solutions proposed also raised concerns about downstream and upstream impact. SPE did not measure the importance of equity as a decision criterion, but it is something that emerged as important from discussions with stakeholders (local organizations, municipal actors and elected officials) and that could be measured in the future.

Structural measures to reduce water levels (should they be moderate or not) would be also more difficult to justify under the new directions of the Quebec government. Indeed, the new flood protection plan explicitly states that structural measures should only be used as a last resort option (MAMH, 2020, p.20). Finally, these recommendations could be subject to further engineering analysis and environmental assessment in Quebec, as the proposed measure involves excavation. While returning the Saint-Jean-sur-Richelieu shoal and the hydraulic regime to a more naturalized state increases acceptability, those social and political preferences hinder feasibility. An official comment from the Government of Quebec has not been received, although a response to preliminary recommendations was received from the Ministère de l’Environnement et de la Lutte contre les changements climatiques. In that letter, it was expressed that Quebec would prefer that possible cross-border collaboration on a structural solution be taken over by the Steering Committee of the Lake Champlain Basin Program, according to the Memorandum of Understanding for the Management of Lake Champlain Among the Government of Quebec, the State of New York, and the State of Vermont, while ensuring that it is done in accordance with the Boundary Waters Treaty of 1909.

The most significant barrier to political feasibility of the Theme 1 recommendation in the United States is the lack of clarity around how management decisions regarding the weir and canal diversion would be made. The recommendation does not provide for a transboundary governance structure that would provide a pathway for US interests to be heard. If this were included in the recommendation, it could enhance the political feasibility of the measure, as it has been requested by representatives of elected officials and agency staff. As currently written, the recommendation is likely not politically feasible in the United States. Beyond governance and decision making, it is unclear what political or governmental intersections exist in the United States with the Theme 1 recommendation. If the measure triggers the Boundary Waters Treaty and its legal restrictions and requirements, political feasibility will be more complicated. It is also unclear if any US funding would be provided to implement the Theme 1 recommendation. If US funding is desired, political feasibility would likely be reduced, since the impacts of the measure on a full suite of economic and environmental indicators, particularly low water, require further study. Finally, it has been voiced by high profile environmental organizations in the United States that insufficient opportunities for environmental groups to learn about and provide feedback on the Theme 1 recommendation have occurred. Consequently, it is difficult to assess whether these groups may oppose the recommendation if it is included. More outreach needs to be done on this point.



## 5.1.5 Theme 1 Strength, Weaknesses, Opportunities and Threat Analysis <sup>17</sup>

Table 19. Theme 1 SWOT Analysis.

INTERNAL FACTORS	
Strengths	Weaknesses
<ul style="list-style-type: none"> <li>• Recommendation is based on strong science and state-of-the-art modeling.</li> <li>• Benefit-cost analysis demonstrates positive return on investment (at least for weir and removal of artifacts).</li> <li>• Resulting influence on water levels will benefit multiple user groups including residents, boaters, etc.</li> <li>• Seamlessly integrates with other measures.</li> <li>• Review of environmental performance indicators shows no significant impact on the ecological indicators that were measured (Roy et al., 2022).</li> <li>• US and Canadian environmental organizations do not strongly oppose this recommendation.</li> </ul>	<ul style="list-style-type: none"> <li>• Recommendation provides only minor flood relief.</li> <li>• Recommendation does not include binational governance.</li> <li>• Recommendation does not address tributary flooding in the United States.</li> <li>• Review of environmental performance indicators is not a comprehensive environmental assessment.</li> </ul>
EXTERNAL FACTORS	
Opportunities	Threats
<ul style="list-style-type: none"> <li>• Binational and intergovernmental collaboration.</li> <li>• Stakeholder pressure- Because flooding in Quebec has become more frequent, there is pressure to address the issue. Structural solutions are seen as a “simple” way to protect structures and property.</li> <li>• Frequent climate-related events will keep the need for mitigation at the top of emergency planners’ and residents’ priority lists.</li> <li>• Theme 1 aligns with other government initiatives including infrastructure development and climate adaptation. It is likely that funding sources within these domains can provide resources for implementation.</li> <li>• Modeling suggests that Theme 1 is a moderate solution with no unintended consequences.</li> </ul>	<ul style="list-style-type: none"> <li>• Historically, infrastructure projects go over budget, reducing the B-C ratio.</li> <li>• Quebec government will require an environmental impact analysis and consultation, which will cause delays.</li> <li>• US environmental groups claim the study has conducted insufficient outreach. This could raise opposition, litigation, delays.</li> <li>• Stakeholder pressure- given past history with structural solutions in the basin, there is skepticism of the ability of governments to successfully implement Theme 1 recommendations. Furthermore, there is a belief that structural solutions bring unintended consequences and exceed their projected budgets.</li> <li>• If the basin experiences several years of mild weather and flood frequency or severity, a decline in momentum may follow.</li> <li>• The COVID pandemic and associated economic challenges have sidelined many initiatives. Emergency responders, especially, are facing new priorities that take attention and resources from flood mitigation. In Quebec, new flood policies and programs prioritize non-structural measures.</li> <li>• Specific concerns relate to environmental degradation and inequities in how the benefits and costs of structural solutions are distributed among residents and taxpayers.</li> <li>• Prior investments in structural measures have failed after considerable resources were already invested. This may reduce the willingness to invest in another structural measure.</li> </ul>

<sup>17</sup> The SWOT analysis is based upon SPE’s conclusions from studies and interactions with stakeholders in the basin, as well as knowledge of the flood resilience/mitigation literature and the team’s professional experiences.

### 5.1.6 Conclusion

An assessment of the different elements that compose political feasibility suggests that the Theme 1 recommendation appears on the feasible side of the continuum, but a number of elements reduce or even jeopardize its feasibility. The recommendation appears to be technically feasible, it lowers water levels during floods while allowing the river to be used for recreational purposes (by avoiding negative impacts on low water levels), it does not present a major environmental risk, and it appears to be acceptable to most stakeholders. Moreover, the benefits outweigh the costs of the measure, at least for Measure 1. However, the lack of a collaborative framework and transboundary governance structure as well as the number of potential barriers and the time it would take to reach implementation reduce the feasibility of the recommendation. This leads us to formulate recommendations on capacity building and transboundary and transjurisdictional dialogue (see SPE recommendations 1 and 2, section 6).

## 5.2 THEME 2 – IMPEDE FLOWS

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The study's Theme 2 recommendation evolved considerably over time. Importantly, the final version of this recommendation was developed in the final weeks of the study and in response to significant feedback from stakeholders in the United States and from the Public Advisory Group. Prior to the Fall 2021 and Winter 2022 meetings, the recommendation was seen as being brief and dismissing the role of wetland conservation in flood mitigation for lakeshore and riverfront communities. This recommendation aligned with modeling projections, but was insensitive to the conservation accomplishments of federal, state and local governments and momentum for additional conservation already underway. SPE's interactions with stakeholders in surveys, public engagement sessions, focus groups and other fora reveal strong support for nature-based solutions such as wetland and floodplain restoration. While the ability of nature-based solutions to play a role in mitigating large scale lakeshore and riverfront flooding is projected to be insignificant unless a large amount of land comes into play, the evolution of this recommendation shows a reinterpretation of research findings and a desire by the study to be responsive to stakeholder feedback. The modifications to this recommendation reflect a commitment to communicate the role of wetlands accurately, and to support the ongoing conservation efforts within the basin.

The Theme 2 Recommendation, as presented to the stakeholders, was<sup>18</sup>:

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*The Study Board recommends that the IJC encourage the governments to continue protection of existing wetlands as they provide some level of flood relief at the basin scale.*

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<sup>18</sup> The recommendations presented in this report are draft recommendations that were presented at the final stakeholder engagement meetings conducted in Quebec, Vermont and New York. These were the latest versions of the recommendations for which SPE conducted data collection prior to writing this report. The recommendations have subsequently evolved, which may have an effect on the level of feasibility.

## 5.2.1 Summary of final stakeholder engagement

### *Canadian (Fall 2021) Meeting Summaries*

The Theme 2 recommendation was very well received among attendees of the meetings and was considered to be consistent with the Quebec legal framework. Comments made by stakeholders, however, suggested that the recommendation did not go far enough. In particular, participants emphasized the need to fund local organizations to protect wetlands and to implement wetland restoration and connection projects. Stakeholders suggested the creation of bi-national conservation agreements. It was also suggested that public awareness on the importance of protecting wetlands be raised.

While this recommendation was in line with the regulation in Quebec, local stakeholders emphasized the need to increase enforcement and inspections, to reject development projects that affect wetlands and to compensate municipalities for the loss of taxation that these regulations could generate.

The stakeholders also showed interest for the data produced within the study.

### Canadian Survey Results; Theme 2

*Table 20. Perception of Theme 2 recommendation (CA).*

	Response	Percentage (%)
I believe that this recommendation will be acceptable to stakeholders in the LCRR basin. (N=16)	Strongly disagree	0
	Somewhat disagree	0
	Neither agree nor disagree	6.3
	Somewhat agree	18.8
	Strongly agree	75
I believe that this recommendation can be feasibly implemented by all levels of governments. (N=16)	Strongly disagree	0
	Somewhat disagree	6.3
	Neither agree nor disagree	0
	Somewhat agree	25
	Strongly agree	68.8

### *United States (Winter 2022) Meeting Summaries*

The Theme 2 recommendation evoked responses calling for increased investment and management of wetland areas. One respondent noted that, “all levels of government should allot funds for acquisition, restoration, and conservation of wetlands” while others indicated support for the inclusion of wetland protection and restoration beyond the confines of the Lake Champlain shoreline. There were also recommendations given that sought more defined funding mechanisms and designations of responsibilities, including engagement with local governments, non-profits, and conservation and environmental organizations.

In the United States, concern was expressed by multiple attendees over the integrity of the wetland data used in the study’s analysis, specifically, that the data used may have resulted in underestimation of the benefits that wetlands provide. More clarity was needed in terms of what was being evaluated and what was being recommended. There was vocal support for

wetlands and the services they provide, as well as potential expansion of wetlands. Interpretation of the recommendation was that it did not echo this attitude. The messaging around the recommendation has since been reworked to avoid understating the role of wetland storage during flooding events. Consideration has been given to the environmental inclinations of both New York and Vermont and their positive views of wetlands, as well as the work that has gone into wetland preservation and protection in both states. The recommendation was made stronger and more explicit to avoid future miscommunication.

Also mentioned by multiple attendees was the need for outreach to local environmental groups. Another comment concerned the difficulty of stopping lakeshore development.

The following comments represent the diversity of concerns expressed by stakeholders in response to Theme 2 recommendations:

- “Wetlands are crucial to water protection and we have lost many wetlands in recent past. Let’s keep wetlands in the mix even if they are not the whole solution.”
- “Save the swamp!”
- “Keep doing what you’re doing”
- “We have a fairly healthy investment from state and federal towards watershed storage. This is a good reason to continue to do that work.”
- “IJC recommendations would incentivize VT to continue to invest in floodplain restoration”
- “No issue with recommending this.”

Several attendees considered this Theme feasible to implement. For example:

- “I live near wetlands...near Rouses Point and continuing to protect wetlands is important to my neighborhood that was hit hard by the 2011 flood.”
- “Is it feasible to say in the report that wetlands restoration can aid at the local level and should be supported?”

## United States Survey Results: Theme 2

Table 21. Perception of Theme 2 recommendation (US).

	Response	Percentage (%)
I believe that this recommendation will be acceptable to stakeholders in the LCRR basin (N=14)	Strongly disagree	0
	Somewhat disagree	7.1
	Neither agree nor disagree	7.1
	Somewhat agree	50.0
	Strongly agree	35.7
I believe that this recommendation can be feasibly implemented by local, state and federal agencies in the United States and/or Canada (N=14)	Strongly disagree	0
	Somewhat disagree	7.1
	Neither agree nor disagree	7.1
	Somewhat agree	50
	Strongly agree	35.7

### 5.2.2 Social and Political Acceptability of Theme 2 Recommendation

Support runs high for nature-based solutions including wetland conservation and restoration. Results from the emergency responder survey showed a strong support for nature-based solutions to address flooding, especially in Quebec (Table 22). The level of support was much higher than it was for structural measures that reduce water levels (Theme 1).

Table 22. Support for nature-based solutions.

		Emergency Responder Survey CA – % N=19	Emergency Responder Survey US - % N=23
Flooding should be addressed through the implementation of nature-based solutions (wetland restoration, freedom space for rivers, etc.)	Strongly agree	68.4	31.6
	Agree	15.8	47.4
	Neutral/Indifferent	10.5	15.8
	Disagree	5.3	5.3
	Strongly disagree	0	0

At the organizational level, nature-based solutions such as wetland restoration and freedom of space for rivers were identified as important in the social network analysis. In the United States, there was also strong support for government funded upstream wetland/floodplain restoration and strong support for ecological restoration. In general, nature-based solutions were seen positively by stakeholders who consider them solutions to also address other issues than flooding, such as water quality. Measures related to Theme 2 are also seen as a way to address tributary flooding and stakeholders expressed a lot of interest in these measures.

Many stakeholders suggested that the Theme 2 recommendation be strengthened to recognize the role of wetlands in reducing damages from recent floods, and the desire of governments to continue expanding conservation. The subsequent revision of this recommendation attempted to meet this request.

It should be noted that there was enough support for pursuing wetland conservation as a flood mitigation strategy that failing to get this recommendation correct could reduce support for the Study overall. In short, the Study may be dismissed as inaccurate or out of touch, in its entirety, if a strong message on the role of wetland conservation is not included.

### **5.2.3 Political Feasibility of Theme 2 Recommendation**

There was a high level of political feasibility around the Theme 2 recommendation. The federal and state/provincial governments already have robust wetland, forest and farmland conservation programs, and the recommendation simply reinforces the continued importance of these programs. Establishing new wetlands or other conservation areas, and increasing funding to existing programs, may be more difficult. However, achievement of the recommendation does not require expansion.

At the local levels, such as municipalities and counties, there is a need for additional capacity building to implement the Theme 2 recommendation. Resources including finances, staff, training and mapping are necessary. A deliberate effort to build capacity for implementation is necessary for successful implementation. Capacity building should address outreach and education, training, and funding.



## 5.2.4 Theme 2 Strength, Weaknesses, Opportunities and Threat Analysis

Table 23. Theme 2 SWOT Analysis.

INTERNAL FACTORS	
Strengths	Weaknesses
<ul style="list-style-type: none"> <li>• Current wetland protection provides flood relief</li> <li>• Wetland conservation/restoration offers co-benefits including water quality, habitat, recreation uses, and agricultural uses.</li> <li>• Seamlessly integrates with other measures.</li> <li>• Federal and state governments have robust wetlands programs.</li> <li>• Wetland conservation aligns with public and local government values.</li> </ul>	<ul style="list-style-type: none"> <li>• As stated when presented to stakeholders, the recommendation did not provide relief to tributary communities.</li> <li>• As stated when presented to stakeholders, the recommendation did not strongly support expansion of wetland conservation programs as some stakeholder groups desire.</li> <li>• Education and outreach are needed, especially locally.</li> <li>• Questions remain about funding.</li> </ul>
EXTERNAL FACTORS	
Opportunities	Threats
<ul style="list-style-type: none"> <li>• Aligns well with the US Bipartisan Infrastructure Bill.</li> <li>• Aligns well with other federal, state, local priorities/plans. Governments of the basin in the United States and Canada demonstrate that conservation is a common goal. Wetland and riparian conservation is written into the main local land use and comprehensive plans. Funding streams exist to channel resources to conservation. These initiatives suggest windows of opportunity exist for further conservation.</li> <li>• High level of public support for conservation of wetlands/floodplains. Local residents and environmental groups sent the loud and clear message that conservation of wetlands, forests and other riparian areas is valued. Pressure to expand conservation may persist, encouraging further development of this recommendation.</li> <li>• Stakeholder support runs strong for wetland conservation. Conservation provides multiple benefits in addition to attenuating floods. Wetlands enhance water quality and provide recreation areas for hunters, anglers, hikers and birdwatchers. Multiple use mitigation measures that provide co-benefits are strongly supported by stakeholders.</li> <li>• There are very few unintended negative consequences of wetland conservation, paving the way for accelerated implementation.</li> </ul>	<ul style="list-style-type: none"> <li>• Failing to message this correctly risks generating distracting opposition.</li> <li>• Weak protection and enforcement allow for development of wetlands, floodplains.</li> <li>• Continued funding</li> <li>• Wetland mitigation banking and destruction of wetlands could allow for trade of LCRR wetlands for wetlands outside basin.</li> <li>• At times the agricultural community resists wetland conservation because it is incorrectly assumed to remove farmland from production. This false assumption may need to be addressed through outreach and development of a robust conservation program that pays farmers for water storage in flood conditions and wetland conservation in dry years.</li> <li>• If weather patterns widen the gap between flood events, they will recede from memory. Furthermore, if other natural hazards become more frequent or severe, they will distract stakeholders and planners from flooding and draw their attention elsewhere.</li> <li>• Lack of consensus on problem definition. This issue relates to the differences between tributary flooding in the upper watersheds of Vermont and New York, and flooding along the shores of Lake Champlain and the Richelieu River. Conservation of wetlands is not projected to provide significant benefits to lake and river flooding. In the upper watershed, however, benefits may be stronger. Communicating the differences in the ways that water moves throughout the basin and the role wetlands may play in reducing flooding in different locations is complicated and may delay progress.</li> <li>• Perceptions about where conservation occurs, and where the benefits are accrued, complicate generating public support for this initiative.</li> </ul>

## 5.2.5 Conclusion

SPE's studies and data collections showed a high level of support and political feasibility around the Theme 2 recommendation. However, the recommendation itself lacked the strength needed for implementation. This report identified elements that could be considered to increase feasibility, such as recommending wetland restoration, recognizing the effect on tributaries and making an effort to build capacity for implementation. It is recognized that the latest version of the recommendations (Appendix B) may address some of these issues.

## 5.3 THEME 3 – FLOOD RESPONSE

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Theme 3 refers to mitigation and adaptation strategies and measures related to emergency preparedness and response. Several options were put forward in the International LCRR Study, including 1) improving flood forecasting tools to improve response time, 2) preparing for emergencies using actions such as sandbagging and floodwalls, 3) reducing risk through effective mobilization and prompt evacuation, and 4) protecting vulnerable populations and maintaining essential services. The study's strategies for addressing these topics have grown more detailed and, ultimately, created several products to achieve these goals. Among these are a new five-day forecasting system, ISEE's social vulnerability tool, and new models for projecting flood regimes under climate change scenarios. At the time SPE completed its work, Theme 3 included the two recommendations presented below<sup>19</sup>:

### Theme 3 Recommendation 1.

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*The Study Board recommends that the IJC advise the governments that:*

*Work to improve the functionality and implementation of coherent risk assessment systems will need to be supported after the Study in both countries.*

*State-of-the-art modelling tools (such as the Integrated, Social, Economic and Environmental system TM) developed for the Lake Champlain-Richelieu River basin can greatly aid flood response planning and should be maintained.*

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### Theme 3 Recommendation 2.

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*The Study Board recommends that the IJC advise the governments that the variety of climate modeling approaches applied by the Study all indicated the potential for larger, more damaging floods than 2011. This information should be shared with communities and its consideration in their floodplain management and emergency plans should be encouraged.*

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<sup>19</sup> The recommendations presented in this report are draft recommendations that were presented at the final stakeholder engagement meetings conducted in Quebec, Vermont and New York. These were the latest versions of the recommendations for which SPE conducted data collection prior to writing this report. The recommendations have subsequently evolved, which may have an effect on the level of feasibility.

### 5.3.1 Summary of final stakeholder engagement

#### *Canadian (Fall 2021) Meeting Summaries*

The work done by the Study group related to Theme 3 was generally very well received by stakeholders. However, the discussions and comments focused more on the tools themselves than on the recommendation. Although one stakeholder showed concerns regarding the accuracy of the data, attendees showed great interest in the tools developed by the Study. Respondents emphasized the need for the provincial and federal governments to provide funding for the maintenance and updating of the systems and tools. Stakeholders also felt that inter-governmental agreements, particularly between Canada and the United States, should be put in place to support and maintain the tools. Partnership and collaboration are considered by respondents as key elements for the implementation of Theme 3 recommendation.

The potential usefulness of the tools for the implementation of effective communication strategies, as well as for the adoption of plans that take into account potential flood scenarios, was mentioned. However, stakeholders emphasized the importance of ensuring that tools respond to real needs and initiatives are not duplicated by different governments.

#### Canadian Survey Results; Theme 3

*Table 24. Perception of Theme 3 recommendation (CA).*

	Response	Percentage (%)
I believe that this recommendation will be acceptable to stakeholders in the LCRR basin. (N=16)	Strongly disagree	0
	Somewhat disagree	0
	Neither agree nor disagree	12.5
	Somewhat agree	31.3
	Strongly agree	56.3
I believe that this recommendation can be feasibly implemented by all levels of governments. (N=16)	Strongly disagree	0
	Somewhat disagree	0
	Neither agree nor disagree	6.3
	Somewhat agree	50
	Strongly agree	43.8

#### *United States (Winter 2022) Meeting Summaries*

The Theme 3 recommendation related to emergency response is, as noted by respondents, not a solution to flooding, but rather, “it’s just going to improve communication and preparedness at all levels of government.” Another respondent advised the study that, “there are a number of ways that governments at all levels can work together to increase the potential for success of these recommendations. Coordination in response to model outputs is one example, and would happen at Federal, State and Local levels. There would be a need for consistent messaging about the results of the model. And continued, sustainable funding to ensure that the model is updated with accurate and up-to-date information and is run consistently would benefit from funding, as well. Coordination across governments would be necessary for the implementation of risk assessment systems and for the implementation of model outputs and planning efforts.” The idea of increased federal oversight appeared multiple times.

Stakeholders supported the new tools for forecasting and modeling, but raised the issue of the responsibility of maintenance of the tools. The need for coordination among various agencies was expressed, as well as addressing the capacities of many government agencies, especially on the local level. Specific recommendations to various agencies would help make that possible. A comment suggested that a current increase in capacity will allow progress to be made, especially if recommendations and the roles of agencies are defined. These points are highlighted in the following statements from stakeholders.

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*“Will the final report build on these bulleted recommendations and make specific, operational recommendations to state and federal agencies on both sides of the border as to how they can best use and coordinate tools and flood forecasting generally?”*

*“There is a significant increase in capacity across the board right now. Strong recommendations coming forward as soon as possible...can make significant progress.”*

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Respondents were supportive of the tools that have been developed over the course of the study, particularly the forecasting tools. Few obstacles to implementation were thought to exist.

For the Theme 3 recommendation related to climate change, a key message from respondents was to focus on improved communication, stakeholder engagement, and floodplain regulation. Funding was also cited as a key implementation issue. One respondent noted that, “the federal and state governments can put greater sums of money towards infrastructure planning and implementation and local governments can use it to protect their communities.” Another backed up this claim, calling for “continued financial support from varying levels of government, and consistent messaging to stakeholders throughout the basin. Also, Federal and State governments should strive to provide technical assistance wherever feasible to implement floodplain management and emergency plans.”

Regarding climate change, one attendee mentioned that they felt states are in a better position to respond to flooding than they were in 2011. However, Canada may have a more significant interest in lakeshore flood preparedness than the United States because of how much more strongly they were affected.

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*“While they were not built for the purpose, these new modeling tools are really cool and will be of interest to multiple lake user communities. This will help in the future with cyanobacteria forecasting and other measures, very nice products”*

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One concern expressed was regarding what is included in the recommendation, and the capacities of local governments to fund things like fixing roads. Another attendee asked about the discrepancy between the maps produced by the study and those used by FEMA to assess flood insurance. There were also a number of questions about the specific information, predictions and recommendations that can and will be made as a result of the study. This included general lake level predictions as well as smaller scale events, not just major floods.

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*“If we have another 2011 flood, in spite of everything we put forth, we’re going to have lots of damage. We can use this study to more likely manage a 102 flood, or 103 flood.”*

*“We wouldn’t be able to fund a project as big as this. Although very interesting, we will help and support requests to provincial and federal governments.”*

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## United States Survey Results: Theme 3<sup>20</sup>

Table 25. Perception of Theme 3 recommendations (US).

	Response	Percentage (%)
I believe that this recommendation will be acceptable to stakeholders in the LCRR basin (N=14)	Strongly disagree	0
	Somewhat disagree	0
	Neither agree nor disagree	7.1
	Somewhat agree	42.9
	Strongly agree	50.0
I believe that this recommendation can be feasibly implemented by local, state and federal agencies in the US and/or Canada (N=14)	Strongly disagree	0
	Somewhat disagree	0
	Neither agree nor disagree	7.1
	Somewhat agree	57.1
	Strongly agree	35.7

Table 26. Perception of Theme 3 recommendations (US – Climate change).

	Response	Percentage (%)
I believe that this recommendation will be acceptable to stakeholders in the LCRR basin (N=13)	Strongly disagree	0
	Somewhat disagree	0
	Neither agree nor disagree	7.7
	Somewhat agree	61.5
	Strongly agree	30.8
I believe that this recommendation can be feasibly implemented by local, state and federal agencies in the US and/or Canada (N=14)	Strongly disagree	0
	Somewhat disagree	0
	Neither agree nor disagree	14.3
	Somewhat agree	57.1
	Strongly agree	28.6

### 5.3.2 Social and Political Acceptability of Theme 3 Recommendations

In the Canadian portion of the LCRR basin, flood response was a popular Theme, particularly for municipal stakeholders. As part of the risk perception analysis (see methodology in Appendix A), participants were asked their opinion on the most relevant mitigation and adaptation measure/strategy among five choices. For measures related to Theme 3, "improve the flood response plan, both in terms of forecasting and mapping", was the most popular choice in Saint-Paul-de-l'Île-aux-Noix (26 percent), it came in 3<sup>rd</sup> place in Saint-Jean-sur-Richelieu (19 percent) and Venise-en-Québec (19 percent) and in 4<sup>th</sup>

<sup>20</sup> During stakeholder engagement meetings in Quebec, Theme 3 recommendation did not include the climate change component, which explains why we do not present the same results for Quebec.

place in Sainte-Anne-de-Sabrevois (16 percent) and Noyan (14 percent). Twenty-four stakeholders from four pilot municipalities (one municipality decided not to participate), MRCs, government and non-governmental organizations (NGOs) were also interviewed (see methodology in Appendix A). The measure/strategy related to Theme 3 was the most popular (27 percent), tied with the strategy related to Theme 4 (floodplain management). Stakeholders interviewed downstream of Saint-Jean-sur-Richelieu shared this preference for the measures and strategies of Themes 3 and 4.

Discussion groups with local actors from the four pilot municipalities (see methodology in Appendix A) also show measures related to Theme 3 were deemed highly relevant, but many have already been implemented, which could explain why observations from other SPE studies showed that stakeholders feel better prepared than in 2011. The local actors had to assess the relevance of different measures to reduce high water levels in the event of flooding or to reduce the consequences of flooding in the context of their municipality. Table 27 shows how the measures related to Theme 3 were ranked. In general, measures were considered as relevant or very relevant. Participants were already developing or using these tools and say they help improve response and citizen safety. One measure that was not as highly rated was dynamic flood maps. Participants wanted to be sure that these maps would be truly useful, easy to use and interpret. Other measures were suggested by two groups. The SADS group 1 reiterated the importance of helping people in need and the VQC group noted that preventive visits could be helpful. These data may help local decision makers and emergency responders prioritize forecasting, planning, education and communication tools.

Table 27. Relevance of Theme 3 measures to local actors in pilot municipalities.

Theme 3: Enhancing Emergency Preparedness					
Mitigation or adaptation measures	Saint-Jean-sur-Richelieu	Saint-Anne-de-Sabrevois (group 1)	Saint-Anne-de-Sabrevois (group 2)	Saint-Paul-de-l'Île-aux-Noix	Venise-en-Québec
Emergency Response Plan	1	1	2	1	1
Alert system	1	3	2	1	1
Detailed weather forecasts	1	1	3	1	1
Dynamic flood maps	2	3	4	2	1
Protection of populations and sensitive infrastructures	1	1	2	1	1
Communication tools and awareness-raising	1	3	2	1	1
Other ?	x	1	x	x	1
© UdeM / ARIACTION / Alexandre Gagnon (2019) in Thomas <i>et al.</i> (2020).					
1. Very relevant	2. Relevant	3. Moderately relevant	4. Not very relevant	5. Not at all relevant	

Observations during the *Municipal Needs Assessment Workshops*<sup>21</sup> also showed support from municipal stakeholders for Theme 3 measures, and, more particularly, a need for early forecast and practical map products. Participants underlined the relevance of a flood forecast five days in advance in order to better prepare the population, especially the vulnerable population. A need for a longer-term forecast (three weeks – based on snowpack and long-term weather forecast) even emerged as a way to make inexpensive preparations and to communicate the risk to the population so that they are engaged in the preparation. Mapping products were found to be useful for such things as better distribution of sandbags, determining which routes to mark, communicating risk in a personalized way by neighborhood, and determining when to evacuate. Municipal stakeholders perceived that they were generally well prepared. Since 2011, the situation on the territory

<sup>21</sup> The "Municipal Needs Assessment Workshop" consisted of four working sessions between December 2020 and March 2021, with municipal and regional actors, as well as the ministry of public safety (MSP) (details in Appendix A).

has changed: roads have been raised and several buildings have been modified. These data are not always present in the tools provided and it is therefore important to update them periodically to reflect the reality on the ground.

The *municipal needs assessment workshops* provided a better understanding of the tools and information needed by stakeholders. However, this raised the question of how the different tools and mapping products could be transferred from the IJC and other relevant agencies to municipal, regional, and provincial actors that may use them. It would be important to include the Ministry of Public Safety (MSP) in the process, as it is a highly central actor of the network of organizations related to flood management in the Canadian portion of the LCRR basin. The social network analysis showed that the MSP is an important actor for the dissemination of information, coordination and collective action on flood management, but also has the power to control the network and potentially block an innovation.

In Canada, there is general support from municipal and regional actors for Theme 3 measures. However, observations and interviews also highlighted that flood mitigation measures only relying on flood response will not be acceptable and that those measures should be combined with others.

In the United States, preferences for Theme 3 adaptation measures and strategies were identified primarily through interviews with actors involved in local and regional planning and decision making, and emergency management<sup>22</sup>. The following topics emerged from the stakeholders:

- There exists a need for education and outreach for local planning and emergency management professionals, the property development/real estate community (engineers, architects, real estate agents), and property owners;
- There is interest in holding a culminating, summative conference covering the Study for scientists, regional/local planners, emergency management professionals and nongovernmental organizations;
- Recommendations for flood prevention and recovery within Theme 3 must spread the risks and benefits of flood mitigation equitably across residents of the Lake Champlain basin;
- There is potential for long-term solutions in planning and zoning on the local level, through comprehensive land use planning, zoning codes and building codes/inspection;
- There is interest in mapping/forecasting products to supplement the Federal Emergency Management Agency (FEMA) and the National Weather Service (NWS), especially regarding waves and wind.

These interviews identified potential measures and strategies, and also showed that stakeholders are primarily focused on mitigating flooding along tributaries. Lake Champlain flooding is a secondary concern, and this should be taken into account in the shaping of measures and strategies.

Generally speaking, there is a high degree of social acceptability for the Theme 3 recommendations. These recommendations provide substantial public benefits and add value for multiple interest and user groups. The joint Canada/United States principles related to adaptation and mitigation measures and strategies in Theme 3 are relevant for improving risk awareness among stakeholders and citizens. The different tools of forecasting (preferably longer term) and mapping can help to better prepare and complement the local experience of stakeholders. In conclusion, significant

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<sup>22</sup> See methodology in Appendix A.

prevention and response efforts have been made since the 2011 floods, although this is a process that needs to be renewed and sustained over the long term. Local stakeholders find mapping and forecasting tools useful. Risk communication is a key element and would benefit from being more personalized at the municipal level, with efforts being made to reach out to citizens and provide contextualized information. The acceptability of the measures and strategies of Theme 3 is high among municipal and regional actors. Municipalities feel better prepared than in 2011 and are using a greater number of tools.

### 5.3.3 Political Feasibility of Theme 3 Recommendation

The Theme 3 recommendations are feasible, if capacity is built within the federal, state and local agencies involved. Stakeholders raised questions about funding and coordination among the agencies responsible for hosting new forecasting and modeling tools. Further questions were raised about the degree of coordination required among agencies, and how modeling outputs would be communicated to other agencies, local authorities and public users. Finally, political actors recognized the need to strengthen floodplain policies and enforcement. This is a component of Theme 4, but intersects with Theme 3. A deliberate program of capacity building can assist to raise the political feasibility of Theme 3 recommendations.

### 5.3.4 Theme 3 SWOT Analysis

Table 28. Theme 3 SWOT Analysis.

INTERNAL FACTORS	
Strengths	Weaknesses
<ul style="list-style-type: none"> <li>Forecasting advancements rely on robust data sets and models.</li> <li>New forecasts are multi-use and provide additional value, such as to boaters, recreators, anglers and others.</li> <li>ISEE's vulnerability analysis facilitates targeted flood planning and response where it's needed most.</li> </ul>	<ul style="list-style-type: none"> <li>Recommendation does not describe dissemination pathways.</li> <li>Recommendation does not describe training for use, updating and ongoing maintenance.</li> <li>Funding streams are unclear.</li> <li>It is not a solution to flooding and should be combined with other solutions.</li> </ul>
EXTERNAL FACTORS	
Opportunities	Threats
<ul style="list-style-type: none"> <li>Aligns well with US Bipartisan Infrastructure Bill (<a href="https://www.whitehouse.gov/bipartisan-infrastructure-law/#resilientinfrastructure">https://www.whitehouse.gov/bipartisan-infrastructure-law/#resilientinfrastructure</a>).</li> <li>Aligns with and supports evolution of Quebec flood policy (MAMH, 2020).</li> <li>More frequent flooding, and an increase in severity, will increase the need and support for improved flood forecasting.</li> <li>Theme 3 recommendations take place, primarily, within federal agencies. Modeling outcomes are communicated to state and local authorities. Political initiatives around climate and resilience can directly accelerate the implementation of this recommendation.</li> </ul>	<ul style="list-style-type: none"> <li>If no communication program is developed, the tools will not be used effectively and credibility will be limited.</li> <li>Ongoing maintenance and funding of data, models and updates required.</li> <li>Competing forecasting and modeling systems exist and may provide different, confusing results.</li> <li>Perceptions of the need for this recommendation will recede if weather patterns widen the gap between flood events.</li> <li>Several other modeling and forecasting programs already exist and residents/governments in the basin are accustomed to using them. Encouraging adoption of a new tool may be challenging. Furthermore, if multiple models are in use, and provide differing results, users may become confused.</li> </ul>

### 5.3.5 Conclusion

The Theme 3 recommendations are politically feasible, as they raise a lot of interest from stakeholders, answer needs from local actors and involve tools and data that are already available, can be transferred and can be used for decision-making, communication and action. However, various elements pull the recommendations toward the “not feasible” side of the continuum: there is no plan for updating the data and there is no link being made for a potential use of these tools for floodplain management. Feasibility would require answers to those issues as well as building capacity for use, maintenance and upgrading these tools among federal, state, provincial and local organizations and agencies.

## 5.4 THEME 4 FLOODPLAIN MANAGEMENT

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Theme 4 refers to better management and use of the floodplain and is often associated with actions and strategies in Theme 3. Theme 4 included actions and strategies such as 1) establishing more accurate flood impact measurement and flood boundary maps; 2) improving flood risk communication; 3) strengthening floodplain development and occupancy regulations, primarily at the local level through zoning and building codes; and 4) flood insurance. These four strategies were first identified in a February 2020 workshop organized by the Study Board with experts from Canada and the United States. The Study Board then commissioned four White Papers, each of which focused on one of these topics. The White Papers compiled best management practices based on a literature review and interviews with experts and inform the current state of these strategies (Alberti-Dufort, 2022a, b; Henstra & McIlroy-Young, 2022; Shabman, 2022). Like the other Themes, progress on Theme 4 has occurred over the course of the study. Details were included in the four white papers and were the starting point for the recommendation.

### Theme 4 Recommendation<sup>25</sup>

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*The Study Board recommends that the IJC encourage the governments to work with the jurisdictions, private sector and communities to explore the ideas and analytical modelling approaches presented in the Study’s Integrated Flood Risk Management Strategy for the Lake Champlain -Richelieu River basin.*

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### 5.4.1 Summaries of final stakeholder engagement

#### *Canadian (Fall 2021) Meeting Summaries*

Support for this recommendation was good among attendees and they showed interest in the insurance model. However, respondents pointed out the need for collaboration and coordination between the different levels of governments. One stakeholder also pointed out the need to clarify the recommendation.

To fully understand the comments received on Theme 4, it is important to take into consideration that major changes are currently occurring in Quebec within the normative and regulatory framework related to flood management. This may explain the fact that during the meetings, the material on the insurance model aroused interest and raised the most questions and feedback. Indeed, this is an element that is not often discussed in Quebec compared to the other Themes (risk communication, mapping) explored by the Study Board.

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<sup>25</sup> The recommendations presented in this report are draft recommendations that were presented at the final stakeholder engagement meetings conducted in Quebec, Vermont and New York. These were the latest versions of the recommendations for which SPE conducted data collection prior to writing this report. The recommendations have subsequently evolved, which may have an effect on the level of feasibility.

## Canadian Survey Results; Theme 4

Table 29. Perception of Theme 4 recommendation (CA).

	Response	Percentage (%)
I believe that this recommendation will be acceptable to stakeholders in the LCRR basin. (N=16)	Strongly disagree	0
	Somewhat disagree	0
	Neither agree nor disagree	12.5
	Somewhat agree	37.5
	Strongly agree	50
I believe that this recommendation can be feasibly implemented by all levels of governments. (N=16)	Strongly disagree	0
	Somewhat disagree	0
	Neither agree nor disagree	12.5
	Somewhat agree	50
	Strongly agree	37.5

### United States (Winter 2022) Meeting Summaries

For the Theme 4 recommendations, respondents indicated support for increased regulations on floodplains, and noted that key barriers would be government capacity, funding, and the need for technical assistance. One respondent noted that, “Governments would need to be open to implementing recommended strategies (i.e. insurance, floodplain designation, etc.) and would need financial and technical assistance to do so.” Another respondent noted that floodplain management should be a top-down approach. They wrote that, “Generally I'm not a fan of more regulations, but within floodplains right now there really aren't adequate regulations. It may be possible to create an online state level floodplain map that local building inspectors can use to input a GPS location for a proposed structure that will indicate whether that location is within a floodplain or at least needs more review. Local governments will be reluctant to regulate floodplains since it is the prime real estate for lakefront housing - it probably has to start with federal / state level.”

Questions were raised about how the maps would integrate with FEMA maps and whether that might be confusing for the public if they do not match. There were also questions about the recommended flood insurance program, including why there was no recommendation for buy-out or property elevation, and how it would integrate with FEMA Flood Insurance Rate Maps. One attendee noted the potential of state and local governments to take advantage of an inflow of funding with FEMA and put it towards implementation of recommendations. One participant stated “I think it will be confusing to communities that FEMA and the study highlight different areas subject to flooding.” Another Stakeholder mentioned that “wind/wave forecast will be very helpful for people utilizing the lake for recreation AND emergency response teams.”

Discussion of Theme 4 centered around the challenges that exist with the differences between different communities and their responses to floodplain and lakeshore development. Certain communities have interest in updating floodplain land use regulation, while others do not. One source of these differences is in the way that different types of flooding affect them. In places where there is already development on the floodplain, there is incentive to maintain it because of the taxes that come from such expensive properties. However, one stakeholder argued that flood insurance costs may be enough to prevent further development in high-risk areas.

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*“If they were in a floodplain and impacted, they may not advocate for additional land use regulations.”*

*“The whole system isn’t set up to actually push development out of those areas without a lot of policy and planning work upfront. Flood insurance can make it too expensive possibly. A potential way to steer development out of those areas.”*

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There were several reactions to the recommendation for flood insurance in Canada. The first was that if a flood insurance program is adopted, it should not necessarily model that of the United States. One reason for this is that planning policies for the floodplain are different now in Quebec than they were before 2011, and they are different than in the United States. One attendee questioned why flood insurance was being recommended rather than prevention of building in the floodplain at all. Similarly, another said that it doesn’t make sense to insure buildings that lie within the floodplain.

Issues with this recommendation pertained to local government and their capacities for addressing lakeshore development. They would need to be very engaged for it to be effective. It was also felt that the recommendation may be too gentle to affect real change:

- “This is the recommendation I’m most excited about”
- “Wealthy people are well connected to political leadership. It’s hard to have serious conversations about areas we shouldn’t develop or insure. The report is a little too gentle with that message because of fear of politics”
- “Intended to be flood damage in the LCB, significant missed opportunity if the IJC doesn’t include a broader set of recommendations”
- “Lots of engagement at this level will be needed to see real progress”

#### United States Survey Results: Theme 4

*Table 30. Perception of Theme 4 recommendations (US).*

	Response	Percentage (%)
I believe that this recommendation will be acceptable to stakeholders in the LCRR basin (N=14)	Strongly disagree	0
	Somewhat disagree	0
	Neither agree nor disagree	14.3
	Somewhat agree	57.1
	Strongly agree	28.6
I believe that this recommendation can be feasibly implemented by local, state and federal agencies in the United States and/or Canada (N=14)	Strongly disagree	0
	Somewhat disagree	0
	Neither agree nor disagree	14.3
	Somewhat agree	71.4
	Strongly agree	14.3

## 5.4.2 Social and Political Acceptability of Theme 4 Recommendations

In Canada, early interviews and questionnaires conducted in 2018 and 2019 as part of the risk perception analysis showed that Theme 4 (floodplain management) was the most popular Theme (detailed methodology in Appendix A). Amongst measures related to Theme 4, the "modification/strengthening of policies and regulations in flood-prone areas" was the most popular in questionnaires distributed in Saint-Jean-sur-Richelieu (28 percent), Noyan (28 percent) and Sainte-Anne-de-Sabrevois (24percent), and in third place in Saint-Paul-de-l'Île-aux-Noix (22 percent) and Venise-en-Québec (22 percent). Interviews show the strategy related to Theme 4 was the most popular (27 percent), tied with the strategy related to Theme 3.

In 2019, discussion groups with local actors from the four pilot municipalities also showed a need for more adaptation measures. The local actors had to assess the relevance of different measures to reduce high water levels in the event of flooding or to reduce the consequences of flooding in the context of their municipality. Table 31 shows how the measures related to Theme 4 were ranked. In general, participants felt that they already had a set of ground rules for floodplain management, but would like more adaptation options. The relevance of each option varied, but they were generally classified as relevant. Participants were unanimous on the high relevance of building and plot adaptation. They would like to see changes in construction techniques, more resilient renovation, and clearer regulations. Some also suggested a grant to help protect buildings or allow backfilling to protect residences. Removing residents from the floodplain was the least relevant option for participants, the concerns being that it is not a realistic option, that there have not been many houses that had to be destroyed following 2011 and that an intervention of this scale and significance is not the responsibility of the municipality. The SADS Group 1 also mentioned the relevance of creating a physical file with relevant information for elected officials and for feedback. The VQC group stressed the importance of empowering residents living near water by making them more autonomous.

Table 31. Relevance of Theme 4 measures to local actors in pilot municipalities.

Theme 4: Better floodplain management (adaptation)					
Mitigation or adaptation measures	Saint-Jean-sur-Richelieu	Saint-Anne-de-Sabrevois (group 1)	Saint-Anne-de-Sabrevois (group 2)	Saint-Paul-de-l'Île-aux-Noix	Venise-en-Québec
Adaptation of the building and the plot	1	1	1	1	1
Buffer zones and non-constructible zones	2	3	2	1	4
Zoning, urban planning by-laws	2	2	2	1	3
Removal of residents and/or buildings from the floodplain	4	2	3	4	5
Floodplain mapping	1	2	2	5	1
Government Policies	1	x	3	2	5
Training for stakeholders and elected officials	2	2	4	1	2
Other?	x	1	x	x	1

© UdeM / ARIACTION/ Alexandre Gagnon (2019) in Thomas *et al.* (2020).

1. Very relevant	2. Relevant	3. Moderately relevant	4. Not very relevant	5. Not at all relevant
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During the numerous studies, observations and interviews conducted by SPE with stakeholders of the LCRR basin, floodplain management appeared as an important issue underlying the whole LCRR Study. Ongoing changes in the normative and regulatory framework in Quebec highlight the current importance of this issue. Stakeholders also highlighted that most flood mitigation measures will be somehow related to this Theme.

In the United States, floodplain occupancy also appears as an important Theme. In the household risk perception survey, respondents were asked to engage with Theme 4 through a question on willingness to pay for the development of policy to better manage floodplains and adapt communities to flooding. Of the 136 respondents, 66.7 percent indicated a willingness to pay out of pocket in support of this mitigation measure (this proportion was 54.3 percent in Canada). Additionally, respondents were asked to agree or disagree with a statement “government funds should be used to reduce vulnerability before a flood,” of which 67.3 percent of respondents either agreed or strongly agreed, showing support for intervention in floodplain management. In Canada, 67.6 percent agreed or strongly agreed.

The responses from the first responders survey also provided interesting insight into their priorities across the LCRR basin. As far as considerations of government responsibility by means of addressing flooding and social vulnerability to flooding, there was substantial variation in both the United States and Canada. For example, when asked whether government funds should be used to help repair damage after floods, US respondents strongly agreed with this use of government funds to cover flood damages, while Canadian respondents strongly disagreed. When asked about the use of government funds to address flooding on private property, again there was more support within the US than Canada.

Additional questions asked more specifically about opinions of different flood mitigation measures. Statement 4 asked about whether respondents believed floodplain residents should be required to purchase flood insurance, which received strong support from both US and Canadian respondents. Statement 6 asked about keeping development out of the floodplain, and was met with strong support from both Canadians and Americans. Additionally, some stakeholders saw floodplain insurance as a subsidy for building in an irresponsible location.

Findings from Theme 3 interviews with planners and emergency managers also provided insight into perspectives on floodplain management in the United States portion of the basin. They include:

- There is a need for education and outreach for local planning and emergency management professionals, property development and the real estate management community, and property owners
- There is potential for long term solutions in planning and zoning on the local level, through comprehensive/land use planning, zoning codes and building codes/inspection
- There will consistently be overlap in the planning and management of floodplains and emergency response.

### 5.4.3 Political Feasibility of Theme 4 Recommendations

In Quebec, the characterization of flood-prone areas is being modified using a risk-based approach. Law 67 was passed in March 2021 and introduced a new regulatory framework in flood-prone areas with a provincial regulation, replacing the PPRLPI. The new transitional regime began March 1, 2022 and will be implemented over the coming years. In the United States, the implementation of "Risk Rating 2.0" will change insurance premiums and risk assessment. Theme 4 recommendations reinforce these developments and indicate political acceptability.

However, respondents also expressed the need for stronger floodplain occupancy regulations and enforcement of these policies. Because floodplains, lakeshore and riverfront properties are often high value properties for residential development, there is not always an appetite for stronger policies and enforcement at the local level. Local governments are also under pressure to reduce obstacles to development in building codes, and flood resilient codes may come up against this pressure. Furthermore, the real estate development and sales community may resist these strategies because they are perceived to slow or prevent residential development.

In summary, Theme 4 brings together diverse and evolving adaptation and mitigation strategies and measures that address both flooding and long-term resilient community development. However, because the recommendations are new, or significant expansions of existing programs, there is considerable outreach and training necessary for implementation. Over time, a robust capacity building program can enhance the political feasibility of these measures.



#### 5.4.4 Theme 4 SWOT Analysis

Table 32. Theme 4 SWOT Analysis.

INTERNAL FACTORS	
Strengths	Weaknesses
<ul style="list-style-type: none"> <li>• Strong public support.</li> <li>• Seamlessly integrate with other recommendations.</li> <li>• Co-benefits with other environmental goals such as adaptation to climate change, improved stormwater management, and generating recreation opportunities.</li> <li>• Reduce loss of life, injury and structural damages.</li> </ul>	<ul style="list-style-type: none"> <li>• Need for education to local governments.</li> <li>• Resistance from real estate developers and professionals.</li> </ul>
EXTERNAL FACTORS	
Opportunities	Threats
<ul style="list-style-type: none"> <li>• Aligns well with US Bipartisan Infrastructure Bill.</li> <li>• Aligns well with Quebec advancements in flood policy and resilience measures.</li> <li>• Supported by flood risk ratings developed by national real estate companies in the United States.</li> <li>• Municipal comprehensive planning processes and updates provide a targeted opportunity for action on local floodplain development policies.</li> <li>• Some residents in the basin voice concern that floodplain development regulations, such as zoning and building codes, are not strong enough or enforced well at the local level. There is some support for stronger programs and policies. If this continues, it may create a window of opportunity for expanding development regulations.</li> <li>• Frequent floods will increase local concern and desire for solutions, as well as acceptance of solutions that may have been unacceptable in the past.</li> <li>• There is considerable support for climate resilient policies and programs from state and federal agencies. Flood resilience is a common feature and may provide additional motivation for local level programming and policies around flooding.</li> <li>• Theme 4 recommendations occur at the local level, where stakeholder concerns are strongest. Theme 4 measures also show co-benefits for quality of life at the local level. Alignment between stakeholder concerns and Theme 4 recommendations is high.</li> </ul>	<ul style="list-style-type: none"> <li>• Resistance from real estate developers and professionals.</li> <li>• Local governments lack resources to stay up to date on floodplain regulations and advancements.</li> <li>• Local governments lack geospatial technologies and training.</li> <li>• Communication and coordination to maintain focus at local level is lacking.</li> <li>• Some professional communities, such as real estate developers and sales professionals, may resist enhanced floodplain communication and the removal of high value residential property from the market.</li> <li>• Pressure exists from local homeowners to reduce regulations on property development, including zoning and building codes. Local elected officials sometimes succumb to this pressure and offer variances to homeowners that request exceptions.</li> <li>• There is a perception that wealthier and politically-connected property owners located in floodplains receive exceptions to development regulations more frequently than less well-off residents. Additionally, flood resilient greenspace and wetlands are more often located in wealthier neighborhoods. This real and perceived inequity perpetuates skepticism of Theme 4 recommendations at the local level.</li> </ul>

### 5.4.5 Conclusion

There are four Theme 4 recommendations, and each has varying levels of political feasibility. It is technically feasible to develop more accurate inundation maps, including elements such as first floor elevations of structures in floodplains. Pilot projects are underway in Quebec. Mapping advancements are also politically feasible, as there appears to be little resistance to these technologies. However, mapping improvements can be expensive and time consuming, and flood mitigation professionals must be trained to use these tools. It is not clear if mechanisms for these essential elements are present in the LCRR, and if there is commitment to carry them out. Capacity building and outreach to targeted staff within government agencies at all levels can increase the feasibility of this Theme 4 recommendation.

The second recommendation under Theme 4 is the development of an improved and targeted risk communications program. This recommendation appears technically feasible. At the national level, improvements in flood risk communication are occurring. These developments include FEMA's Risk Mapping 2.0, and real estate flood ratings on national real estate websites. Within the LCRR basin there are challenges to political feasibility. First, the LCRR study has not determined key communicators and target audiences for this initiative. Therefore, it is very difficult to gauge feasibility. Second, while national real estate companies can implement general risk ratings at broad scales, local real estate professionals may resist risk communication requirements because it may be perceived to hinder sales. Furthermore, real estate professionals must be trained in the meaning of risk ratings and how to accurately communicate flood risk to buyers and sellers.

The third recommendation embedded in Theme 4 is strengthening management of floodplain occupancy through local level planning, zoning and building codes. This proposal is technically feasible, as local jurisdictions commonly manage floodplains through zoning and building codes and consider development and use of these areas in comprehensive and land use planning. Furthermore, governance mechanisms exist for amending and updating these policy and planning instruments. SPE assessed moderate and mixed motivations for political feasibility of these tools. Local governments in the LCRR basin appear to support the need for flood planning and resilience, but fear hurdles to implementation and enforcement of policy tools to achieve these goals. Exceptions are often granted to zoning and building code requirements, for example, and comprehensive plans and land use plans are guidance documents only. In order to enhance the political feasibility of these tools, significant capacity building and outreach to local elected officials, planning and zoning board members, and local property developers must occur. At present, it appears that local governments in the LCRR basin do not have the commitment and knowledge to enforce strong floodplain development and occupancy rules.

The final Theme 4 recommendation is development of more robust insurance programming. In the United States, FEMA recently promulgated Risk Mapping 2.0. SPE assessed political feasibility of this program to be high, as it improves on several historical problems with FEMA's prior insurance program. In Quebec and Canada, there is movement towards the development of a flood insurance program, though technical and political feasibility are less certain, as the program is in proposal phases.

## 5.5 CROSS-CUTTING ISSUES IN THEME 1-4

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The organization of the International LCRR Study around four Themes has resulted in the compartmentalization of analyses according to these four Themes. In this section, SPE presents some cross-cutting issues in the four Themes. First, general comments are presented regarding the recommendations and the desire expressed by the stakeholders to see the recommendations combined. Second, the findings of the economic team regarding the role of the public and private sectors in flood mitigation and damage prevention are summarized. Finally, the enabling and hindering factors for implementation of Theme 1-4 mitigation measures are discussed.

### 5.5.1 General reactions and support for diversification

Following the final stakeholder engagement meeting in the United States, there was a mix of comments from respondents regarding the appropriateness of the presented recommendations. Some respondents found the recommendations appropriate and feasible, particularly with respect to the weirs and controls of water levels. One respondent noted that, “[the recommendations] seem to be the least invasive measure with positive results. Any relief from flood lake levels affects our community.”

From the more critical perspective, respondents noted that, “the hope to regulate floodplains through local zoning will probably not be popular or be accepted by most local towns. [It] would require either a good level of convincing or state level regulations.” It should be noted that many jurisdictions in the LCRR already regulate floodplain development through zoning, or have the ability to regulate floodplains. This comment highlights the perception that municipalities lack the capacity to enforce regulations already on the books, or that the regulations in place are ineffective. There were concerns about the capacity issue with respect to management and implementation, as evidenced by the respondent comment: “The recommendations as presented appear to provide adequate and appropriate relief for lakeshore flooding if the necessary funding, long-term partnerships, and implementation by local, state, and federal governments is fully supported. Without these mechanisms, it is difficult to gauge how successful the strategies would be.”

Respondents also noted that environmental concerns were top of mind. One respondent urged “ecological restoration and reliance on natural structures where possible,” while another noted that, “man-made infrastructure such as the proposed weir creates a management hassle and an environmental concern that impacts aquatic organisms and natural sediment transport as well as water quality within Lake Champlain.”

In Quebec, the recommendations received good feedback and stakeholders found them appropriate and adequate. However, respondents also pointed out that it was only the beginning, and that each recommendation was only a partial solution to flooding. Respondents raised the question of implementation, funding and collaboration between governments in reaction to each Theme, and also highlighted the need to combine recommendations.

This is consistent with results from other SPE studies. The social network analysis highlights that when asked about the flood mitigation measures they consider as ideal, 70 percent of organisational respondents prefer a combination of measures, rather than just one individual solution. This is also consistent with the international trend towards diversifying mitigation measures to flooding (Challies et al., 2016), which is considered as ultimately leading to the creation of more resilient urban areas (Alexander et al., 2016; Driessen et al., 2018; Hegger, Driessen, Wiering, et al., 2016; Hegger et al., 2014). It also reflects the paradigm shift taking place in Quebec and the new way of looking at the issue of flooding: the “Plan de protection du territoire face aux inondations” includes actions to be taken under four different axes and carried out jointly by four ministries (MAMH, 2020).

The use of diversified strategies and combination of recommendations also make solutions more acceptable. This implies that more actors are involved in the development and implementation of measures and can increase their success (Dieperink et al., 2016; Hegger et al., 2018). Diversified solutions can become more acceptable by building a sense of equity and a belief that everyone is doing their part to address flooding. This principle of equity was directly expressed as important by local stakeholders.

### **5.5.2 Role of the Public and Private Sectors<sup>24</sup>**

There are strong theoretical results for a public/private separation of the damage prevention scheme in the context of floods. Such separation can be understood as the public sector fully insuring low to mild (frequent) damages, with the private sector covering the remaining less frequent mild to high damages. Such separation is efficient for two reasons. First, the cost of public interventions is cheaper than insurance in the low to mild range (Bouchard St-Amant, Tchokouagueu, & Dumais, 2022). Second, the low to mild range is more consensual, in a perceived value of benefits sense, than the higher but less frequent damage space. This is because the individual's preference for insurance starts to differ in the higher range of damage: an individual's risk-aversion starts to differ with less frequent risks.

Separation is a consequence of efficient public intervention (Bouchard St-Amant, Tchokouagueu, & Dumais, 2022). If the public sector fully prevents damages in the low range, there is then a crowding out effect, as there is nothing left for the private sector to insure. The remaining high damage range is then left to the private sector. In that range, the private sector is more efficient, as it can provide insurance schemes tailored to heterogeneous individual preferences for insurance (a form of damage compensation).

The structure of public intervention should be in accordance with those who benefit from the damage prevention. As such, a floodplain based approach is relevant to structure not only how to think about benefits, but also how to think about the tax burden (in a general sense of mandatory payments). Flood-based mandatory contributions would provide the most efficient approach to fund projects (regardless of national boundaries).

Those principles are qualitative (as opposed to quantitative). High and low ranges of damages should be quantitatively assessed against a measure of an individual's preferences for insurance, the likelihood of events, and how the cost structure of public interventions changes with the extent of damage prevention. This will fix a numerical delineation, separating "low" and "high" range damages, or the public and private separation.

### **5.5.3 Enabling and hindering factors**

Tables 33 and 34 present holistic enabling and hindering factors that can influence implementation of the study recommendations. SPE encourages decision makers at all levels to be aware of and observe these dynamics as they work to seize opportunities for implementation of mitigation measures.

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<sup>24</sup> This subsection is a summary from the research paper Public Private Flood Management (Bouchard St-Amant, Tchokouagueu, & Dumais, 2022).

Table 33. Enabling factors for implementation of Theme 1-4 mitigation measures.

Enabling factors	Description
<i>Stakeholder pressure</i>	Local government officials and emergency responders engaged through focus groups, public meetings and interviews indicate that stakeholder pressure to enhance flood management is among the stronger enabling factors to alter mitigation practices.
<i>Frequent flooding and other flood related climate/weather events</i>	Through Risk Perception Surveys, focus groups and public meetings, stakeholders indicated that their concern for flooding is directly tied to recent flood events. As major flood events recede in time and memory, interest in flood management dissipates. If weather patterns bring flood events more regularly, stakeholder interest in enhanced mitigation may grow.
<i>Political initiatives such as maximizing climate and resilience planning in flood prone areas</i>	Governments at all levels in the LCRR are engaged in a number of urban/regional planning initiatives. Many of these dovetail with climate adaptation planning and natural hazard resilience. Stakeholders involved in the LCRR study take interest in these, and demonstrate support for aligning flood mitigation with efforts that achieve additional community and environmental goals.
<i>Media attention</i>	The media plays a large role in developing and sustaining interest in flood mitigation. Media reporting after the 2011 floods helped to focus funding and relief efforts.
<i>Alignment between stakeholder concerns and mitigation measures, including those indirectly related to flooding</i>	Stakeholders indicate interest in several concerns indirectly related to flooding, including water quality, ecology and recreation of the lake and river. Mitigation measures that support these interests will garner more support from stakeholders.
<i>Minimization of negative unintended consequences</i>	Past mitigation measures in the LCRR have had unintended and negative consequences that directly and indirectly created damage and/or loss for stakeholders. Developing mitigation measures that avoid these past mistakes is critical to success.

Table 34. Hindering factors for implementation of Theme 1-4 mitigation measures.

Hindering factors	Description
<i>Entrenched perspectives and positions</i>	Enhancing flood mitigation in the LCRR basin demands new ideas. Past efforts have not always been successful and the skeletons of these measures scar the landscape. Repeating past mistakes by relying on the same logic will not be successful.
<i>Frequent drought or other non-flood related climate/weather events</i>	If weather patterns widen the gap between flood events, they will recede from memory. Furthermore, if other natural hazards become more frequent or severe, they will distract stakeholders and planners from flooding and draw their attention elsewhere.
<i>Shifting political priorities and distractions</i>	Over time, political attention shifts from one topic to another. Implementation of LCRR recommendations should take advantage of moments when attention is focused on flooding, and patiently avoid pushing implementation when attention is focused elsewhere. Attention is likely to shift away from flooding as flood events grow less common, and memories of floods grow distant.
<i>Lack of consensus on problem definition</i>	Flooding is a wicked problem, with no single cause, a variety of damage and loss and no single solution. Stakeholders, emergency responders and planners disagree on the causes of flooding, and on how to address flooding. If these disagreements become the focus of dialogue, they will fragment planning efforts and create disjointed solutions with unintended consequences.
<i>Real and/or perceived inequity in costs and benefits of mitigation measures</i>	If stakeholders perceive that flood mitigation measures only serve to benefit select stakeholders and/or community members, support will decline. Furthermore, if stakeholders perceive that the costs of mitigation are borne by select stakeholders, support will decline. Fairness in costs and benefits must be spread and felt equitably.
<i>Sunk costs in prior flood management/mitigation measures</i>	Prior investments sometimes limit current and future planning. Relying on sunk costs as an excuse for suboptimal planning will result in suboptimal outcomes and unintended consequences.

## 6 RECOMMENDATIONS AND CONCLUSIONS

### 6.1 SPE RECOMMENDATIONS

This section describes SPE’s recommendations for advancing flood mitigation in the LCRR basin, as well as recommendations for future IJC flood references throughout its binational jurisdiction. The recommendations represent the activation of findings from the studies SPE conducted over the course of the study, as well as best practices and knowledge from scholarship.

SPE offers five high level recommendations for improving flood mitigation in the LCRR basin.

Table 35. SPE Recommendations for improving flood mitigation in the LCRR.

SPE recommends to the Study Board that governments of the LCRR are encouraged to...	Key findings that support this recommendation
<p>play an ongoing role in supporting transboundary and trans-jurisdictional dialogue about flooding in the LCRR, as well as promote a whole-systems approach to flood mitigation, adaptation and resilience.</p>	<p>SPE studies revealed that flooding and its associated impacts are the outcome of a complex system of interactions and feedback loops that includes climate and weather, basin-level ecological functions, and economic, social and political activities. Thus, the causes and impacts of flooding in the LCRR are multidimensional. While spring flooding in the LCRR basin is caused by strong winter/spring precipitation and temperature fluctuations, and summer/fall flooding is caused by severe storms, the risks of floods are exacerbated by environmental, land use and other social/political decisions and actions. Through this lens, SPE’s research demonstrates that there are diverse perspectives on the need for risk reduction and mitigation, as well as on the acceptability of specific mitigation strategies. Professional and nonprofessional flood stakeholders are aware of the complexities in transboundary environmental management, and illustrate a diverse and multidimensional set of objectives, concerns, priorities and perspectives.</p>
<p>create an LCRR flood mitigation capacity building network to facilitate implementation of the study’s recommendations.</p>	<p>SPE data illustrates a great deal of heterogeneity among the federal, state/provincial, and local level governments within the LCRR basin. Furthermore, relative to flooding, the planning and response capacities of local governments are varied and, in some cases, divergent. The heterogeneity of governance structures in place may inhibit or limit flexibility and innovation, as well as uniform implementation of flood mitigation measures. Capacity building is a necessary component in cases where diverse governments share common but differentiated interests and responsibilities for environmental damages and progress.</p>

SPE recommends to the Study Board that governments of the LCRR are encouraged to...	Key findings that support this recommendation
consider flood mitigation within the contexts of geographic, governance and temporal scales.	<p>SPE’s research demonstrates that the social and economic impacts of flooding are not uniform throughout the basin. In Vermont and New York, residents show a higher level of concern for tributary flooding than lakeshore flooding, for example. This means that quick-rising floods, high rates of flow, road washouts and the possibility of loss of life to humans and livestock may be priorities for mitigation in New York and Vermont.</p> <p>Quebec, on the other hand, faces slower rising water levels that impact a wider range of residents and for longer periods of time. In the context of lakeshore flooding, the long-term economic losses in Quebec are more severe than in the United States. Differences in impacts are visible at the community and neighborhood levels, as well. There exists social-demographic variation across the basin that influences the risk profile and vulnerability of particular communities, neighborhoods and even at the scale of streets. Additionally, the levels of government planning, emergency preparation, and response capacities of local governments vary.</p>
employ adaptive management in the implementation of all recommendations.	<p>The LCRR basin is dynamic. Ecological, social, economic and governance systems change. The data collected by SPE and others involved in the LCRR study represent a snapshot of the LCRR. Knowing that conditions change, it is vital for successful implementation of LCRR study recommendations that future data are able to be compared to the data collected in 2017-2022, and that data can be used to set benchmarks and track progress. Furthermore, as implementation occurs, new variables for change are inserted into the LCRR system. These changes will have intended and unintended consequences that need to be tracked, and in some cases addressed through amplification or remediation.</p>
take an explicit, equity-oriented lens to flood planning, prevention, mitigation and monitoring to facilitate the equitable distribution of resources, benefits and costs.	<p>SPE data illustrated a lack of uniformity in the vulnerability and risk profiles of regions and communities in the LCRR basin. Vulnerability is increased when residents with atypical health and medical needs, reduced resources, infant and senior age classifications, and inadequate housing live within flood inundation zones. Furthermore, the planning and response capacities of municipalities and counties are not uniform. Therefore, there is a need for considering the ways that the benefits and costs of flood management are spread among residents and communities in the basin, and to ensure that these are spread equitably.</p>

Based on the economic analysis, SPE also offers two specific recommendations to the International LCRR Study Board.

Table 36. SPE recommendations specific to the Theme 1 analysis.

Regarding Theme 1, SPE recommends	Key findings that support this recommendation
Discarding measures that include a diversion (minor or major) at the Chambly Canal.	Based on the results of the cost-benefit analysis, the additional benefits and prevention that stem from this type of measure do not justify the costs of building it.
Implementation of Theme 1 measures that mitigate frequent events instead of focusing mitigation efforts solely on low frequency but extreme events.	Tailored insurance programs are more efficient and adapted than structural measures in the low frequency/extreme events space.

SPE offers a final recommendation to the IJC Board of Commissioners in particular.

Table 37. SPE recommendation to IJC Board of Commissioners.

SPE recommends that the Study Board recommend for the Commission's consideration that they ...	Key findings that support this recommendation
institutionalize social, political and economic research into current and future IJC references within the LCRR and elsewhere.	SPE's work played a valuable role in shaping the LCRR study and final recommendations. It is demonstrated in the literature and the LCRR study that the upfront inclusion of social, political and economic research in water resource management results in stronger study outcomes and improved opportunities for implementation.

## 6.2 CONCLUSIONS

Between 2017 and 2021, the SPE Analysis Group carried out eleven research studies to inform the social, political and economic feasibility of flood mitigation measures in the LCRR basin. This has been done through team effort and working with researchers with complementary expertise. It is the first time an SPE Analysis Group has been part of an IJC study, and the team has started setting the path for more inclusion of social, political and economic factors in the development of flood mitigation measures and recommendations to governments.

Through mixed methods, SPE has explored the LCRR basin as a social ecological system. This report presents the work of SPE and answers questions that inform the feasibility of flood mitigation measures. This report highlights that flooding is still a priority in the region, but that the LCRR basin and its stakeholders also face other competing issues, such as erosion, water quality or drought, that need to be addressed simultaneously for flood mitigation measures to gain more acceptance. Stakeholders also recognized the multi-dimensionality of causes and impacts of flooding and the multi-dimensionality of mitigation measures needed to answer this issue. SPE provided some insights on what stakeholders thought of mitigation measures developed within the four Themes of the LCRR study. Data collected through a variety of methods were used to triangulate around concepts of social acceptability and political feasibility. Conclusions were conveyed through SWOT Analysis and identification of enabling and hindering factors to implementation. Through mixed data collection, SPE also investigated the prioritization of flood mitigation decision criteria. There was some consistency amongst different stakeholders, and they prioritized human health and safety as well as environmental criteria. This knowledge can assist in prioritizing the flood management scenarios that are most acceptable. Finally, SPE performed vulnerability analysis to include vulnerability as a performance indicator of the mitigation measures developed by the Study Board and to consider along with other indicators (i.e. environmental, hydrologic, etc.).

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# APPENDIX A – Study Methodologies

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This appendix presents the various data collection methods and tools that were used by SPE and whose results were used in this report. It is important to note that these methods and results have sometimes been the subject of separate reports, of which only part of the results are presented in this report.

## Risk perception analysis – Household Risk Perception Survey

This household risk perception survey was developed through an exhaustive review of literature on risk perceptions of natural hazards, with a specific focus on flooding. Questions related to risk perception made up a significant portion of the survey, with respondents being asked to gauge their perception of personal and community flood risk, the likelihood of flooding at their home and in their community, and the subsequent impact of flooding. They were also asked questions that gauged their perception of flood risk relative to other hazards (natural and man-made), their opinions on different flood mitigation measures, and what actions they had taken to prepare themselves and their households for floods. The household risk perception survey had the following objectives: to assess the socioeconomic and demographic determinants of flood risk perception, and to assess the socioeconomic and demographic determinants of preferences for the decision criteria used to prioritize flood mitigation measures.

Questions from this survey were divided into five categories: 1) natural hazard risk perception, 2) governance, 3) cost-benefit analysis, 4) flood mitigation measures, and 5) demographics. Natural hazard risk perception and governance questions were developed following extensive literature review and input from experts on risk perception, emergency management, and resilience. Cost-benefit analysis questions were provided by the economic team from this study, Ouranos. The flood mitigation measures section utilized a multi-criteria decision analysis (MCDA) technique to assess preferences and priorities through three exercises, which, when considered in tandem, provided weighted preferences from each respondent and the opportunity to develop weighted ranks of each criterion. Demographic questions were asked in order to glean the socioeconomic and demographic characteristics of participants.

There are an estimated 672,831 households in the LCRR basin; 3,000 surveys were distributed to households within the basin in Vermont and New York, and an additional 820 surveys were administered in Quebec. Increased sampling was carried out within counties in Vermont and New York that were considered “lakeside,” although surveys were sent to households across the extent of the LCRR basin in order to consider all of the communities that would be impacted by potential flood mitigation measures. This sample was purchased from ASDE Survey Sampler, Inc. Each addressee was mailed a postcard in August 2019 with a brief description of the study, and a link to the online survey platform. This was followed by a physical survey and a pre-stamped envelope for easy return two months after the initial mailing date, in October 2019. Survey participants were incentivized with a chance to win a \$100 Amazon gift card, if they opted into the drawing.

In order to geographically code responses and consider perceptions of risk and flood mitigation preferences with respect to location, each respondent was assigned a number that corresponded to their survey response.

The response rate for the United States iteration of this survey was just over 5 percent, with 150 respondents completing a survey administered to 3,000 households. It is not uncommon for studies of this nature to make inferences about public perceptions of natural hazard risk with this degree of response (Feldman et al., 2016; Kellens et al., 2012; Lindell et al., 2009; Lindell & Perry, 2000). In Canada, 450 responses were collected by Léger 360 (a survey data company).

In order to assess the respondents' perceptions of different mitigation measures across a consistent standard, nine decision criteria were collaboratively and iteratively developed by the multidisciplinary study board, and are provided below in Table A-1. These criteria were provided to respondents, where they carried out a ranking exercise. These ranks were aggregated to establish common ranks across various stakeholder groups, the results of which are provided in section 4 of this report.

*Table A-1. Flood Mitigation Decision Criteria.*

Criteria
Reduce the financial cost of flood damages
Reduce harm to economic activity due to flooding
Reduce the number of homes that are impacted by flooding
Reduce street closures due to flooding
Reduce potential injury, stress, or loss of life due to flooding
Reduce harm to vulnerable people due to flooding
Maintain healthy ecosystems, including clean water and thriving biodiversity
Prevent the spread of aquatic invasive species
Reduce harm to historical and culturally sensitive community sites due to flooding

The full version of the household risk perception survey, which was amended and administered as the emergency responder survey, is provided here. It was culturally and linguistically translated to French by the Canadian SPE team.

1. Do you certify that you are 18 years of age or older, have read the above information and agree to take part in this research?
  - Yes
  - No
2. Please type your 5-digit zip code in the space provided below:
3. Have you experienced flooding at your current residence?
  - Yes, major flooding
  - Yes, minor flooding
  - No
4. If you experienced flooding, please provide the years when flooding occurred:

5. If you experienced flooding, during any of these events, did you and/or any of your household members experience any of the following during or as a result of flooding? (Please check all that apply)

- Loss of personal property/belongings
- Structural damage to residence
- Water damage to residence
- Evacuation from residence
- Loss of income
- Physical injury
- Mental health concerns (stress, anxiety, depression, PTSD, etc.)
- Long term health concerns (respiratory infections, toxic exposure, skin rash/infection, cancers, etc.)
- Other:

6. I consider my community to be at risk of flooding:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree
- I don't know

7. I consider my home to be at risk of flooding:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree
- I don't know

8. Do you opt in to flood insurance?

- Yes
- No
- I don't know

9. If you opt in to flood insurance, what is your average annual premium?

- \$0-\$200
- \$201-\$400
- \$401-\$600
- \$601-\$800
- \$801-\$1000
- \$1001-\$1200
- \$1201-1400
- \$1401-\$1600
- More than \$1600

10. How far in advance do you typically hear about flooding in your community?

- One week
- Three days
- One day
- Twelve hours
- Five hours
- One hour
- After the flood occurs
- I have never heard about flooding in my community

11. What do you estimate is the likelihood that you will experience a flood at your home in the next ten years?

- Very low
- Low
- Neither high nor low
- High
- Very high
- There is no chance of a flood
- I don't know

12. Do you consider flooding when there is a heavy rainstorm?

- Yes
- No

13. Do you consider flooding when the snow melts in the spring?

- Yes
- No

14. Do you consider the risk of flooding when you buy a home?

- Yes
- No

15. How far is your home from a lake or river?

- 0-1 miles
- 1-5 miles
- 5-10 miles
- More than 10 miles
- I don't know

16. Is your home located in a flood zone?

- Yes
- No
- I don't know

17. If you do not live in a flood zone: How far do you live from a flood zone?

- 17.1. 0 to 1 miles
- 17.2. 1 to 5 miles
- 17.3. 5 to 10 miles
- 17.4. More than 10 miles
- 17.5. I don't know

18. If you live in a flood zone: what is the designation of your home's flood zone?

- Moderate or low risk area (Zone B, Zone C, Zone X)
- High risk area (Zone A, Zone AE, Zone AI-30, Zone AH, Zone AO, Zone AR, Zone A99)
- Undetermined risk area (Zone D)
- I don't know the designation of my home's flood zone

19. In the past ten years, which, if any of the following problems have you experienced at your primary residence?  
(Please check all that apply)

- Flooding around property
- Flooding on property
- Basement flooding
- Impacts to you/your family's health due to flooding
- Flooding, erosion, or washouts of driveway or road to your house
- Flooding, erosion, or washouts of roads in your community
- Flooding to residences in my neighborhood/immediate surroundings
- Other:

20. Have you taken any of the following steps to protect your household from flooding? (Please check all that apply)

- Raised the foundation of my home
- Landscaping for storm water management
- Building flood walls
- Placed sand bags prior or during a flooding event
- Raised house onto stilts
- Enrolled in the National Flood Insurance Program (For US program)
- Keep sentimental belongings on upper floors
- Sealed basement windows
- Relocated critical systems (heating, electrical, hot water) from flood prone levels
- Purchase private flood insurance
- Nothing
- Other:

21. How would you rate your flood risk compared to your neighbors?

- I have an average flood risk
- I have a higher than average flood risk
- I have a lower than average flood risk
- I have no risk of flooding
- I don't know

22. How much financial damage do you expect that a single flood would cause to your home and belongings?

- \$0
- \$1-100
- \$101-1,000
- \$1,001-10,000
- \$10,001-\$100,000
- \$100,001-1,000,000
- More than \$1,000,000

23. How high do you estimate the probability that you or someone in your household will experience the following? Rate each possible event on a scale from 1 to 10, with 1 being impossible, and 10 being extremely likely.

\_\_\_My residence gets flooded, damaging property

\_\_\_The roads around my home get damaged due to a flood, causing disruptions to my routine travel patterns

\_\_\_I am laid off from my job

\_\_\_I am injured in a car accident

\_\_\_My house is burglarized

\_\_\_My car is stolen

\_\_\_I have a house fire

\_\_\_A storm causes a power outage

24. Please indicate the probability of you or someone in your household undertaking the following flood mitigation measures. Rate each measure on a scale from 1 to 10, with 1 being no probability (“I will never do this”) and 10 being extremely high probability (“I will absolutely do this”)

\_\_\_Support additional taxes to prevent flooding

\_\_\_Contribute money for an early warning system to better prepare my household for floods

\_\_\_Move to a safer region where flooding is not an issue

\_\_\_Contribute money to recovery efforts after a flood

\_\_\_Take measures to fortify my house against flooding

\_\_\_Volunteer to assist in recovery efforts after a flood

\_\_\_Take time to understand the best ways to mitigate the impacts of flooding

\_\_\_Store dry goods and water in case of emergency

25. Are you concerned about climate change?

- Yes
- No
- I don't know

26. What effect do you think climate change will have on flooding in your region? (Please check all that apply)

- Flooding will become more frequent
- Flooding will become more severe
- Climate change will not affect flooding in my region
- Flooding will become less frequent
- Flooding will become less severe
- I don't know
- Other:

27. Addressing the issue of flooding requires the development of policies and programs meant to protect households, communities, and the environment. Please indicate how much you would be willing to pay for the following flood protection, in the form of government tax:

Flood mitigation measure	\$0	\$0-100	\$101-500	\$501-1000	\$1001-5000	More than \$5000
Reduce water levels during flooding events						
Reduce flooding severity by storing or impeding the flow of water coming from contributing watersheds						
Development of better response plans for emergency preparedness						
Development of policy to better manage floodplains and adapt communities to flooding						

28. Please note whether you agree or disagree with the below statements about flood mitigation:

Flood mitigation measure	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
<b>Government funds should be used to address flooding on private property</b>					
<b>Government funds should be used to reduce vulnerability before a flood</b>					
<b>Government funds should be used to help people repair damage after a flood</b>					
<b>Floodplain residents should be required to purchase insurance that would reimburse them for flood damage</b>					
<b>Flooding should be addressed by building projects that keep water away from development</b>					
<b>Flooding should be addressed by keeping development out of the floodplain</b>					

29. In your opinion, does the benefit of living near the water outweigh the financial cost of flooding?

- Yes
- No
- This does not apply to me
- Other:

30. Have you ever had to stay home from work or school due to flooding?

- Yes
- No

31. Imagine an activity you had planned (camping, hiking, boating, eating at a lakeside restaurant, etc.) is disrupted due to flooding. How are you most likely to react, as a consumer?

- I would cancel the activity
- I would postpone the activity
- I would do something else that has not been impacted by flooding
- I would do the same activity in a nearby area not impacted by flooding
- I would do the same activity in another region not affected by flooding
- Other:

32. Where do you get information about flood hazards? (Please select your top three)

- Neighbors and community members
- Local fire/police
- Twitter
- Facebook
- Instagram
- Front Porch Forum or similar platform
- Town/municipality website
- Local television news
- Local print news
- Local radio
- Scientific literature
- Other:

33. Who do you trust when getting information about flood hazards? (Please select your top three)

- Neighbors and community members
- Local fire/police
- Twitter
- Facebook
- Instagram
- Front Porch Forum or similar platform
- Town/municipality website
- Local television news
- Local print news
- Local radio
- Scientific literature
- Other:

34. Rank in order from 1 to 6 which of the following should bear the responsibility for flood management in your community (1 bears the most responsibility; 6 bears the least responsibility)

\_\_\_ The federal government

\_\_\_ State government

\_\_\_ Regional or county government

\_\_\_ Local government

\_\_\_ Non-governmental organizations

\_\_\_ Individuals

35. Below are a series of criteria that policymakers are using to consider what flood mitigation measures are best suited to the needs of the communities within the Lake Champlain and Richelieu River basin. Please rank order the following criteria from 1 to 9.

Criteria	Rank (1- most important to 9- least important)
Reduce the financial cost of flood damages	
Reduce harm to economic activity due to flooding	
Reduce the number of homes that are impacted by flooding	
Reduce street closures due to flooding	
Reduce potential injury, stress, or loss of life due to flooding	
Reduce harm to vulnerable people due to flooding	
Maintain healthy ecosystems, including clean water and thriving biodiversity	
Prevent the spread of aquatic invasive species	
Reduce harm to historical and culturally sensitive sites due to flooding	

36. For each flood mitigation criteria, please check the box for your sense of the importance of the issue:

Criteria	Unsure	Not Important	Slightly Important	Moderately Important	Very Important
Reduce the financial cost of flood damages	1	2	3	4	5
Reduce harm to economic activity due to flooding	1	2	3	4	5
Reduce the number of homes that are impacted by flooding	1	2	3	4	5
Reduce street closures due to flooding	1	2	3	4	5
Reduce potential injury, stress, or loss of life due to flooding	1	2	3	4	5
Reduce harm to vulnerable people due to flooding	1	2	3	4	5
Maintain healthy ecosystems, including clean water and thriving biodiversity	1	2	3	4	5
Prevent the spread of aquatic invasive species	1	2	3	4	5
Reduce harm to historical and culturally sensitive sites due to flooding	1	2	3	4	5

For questions 37-46, pick the answer that is more important to you:

37. Would you rather have a flood mitigation measure in place that:

- Prioritizes the economic wellbeing of communities
- Prioritizes the environmental health of our lake and river ecosystems

38. Would you rather have a flood mitigation measure in place that:

- Prioritizes the economic wellbeing of communities
- Prioritizes the health and wellbeing of community members

39. Would you rather have a flood mitigation measure in place that:

- Prioritizes the economic wellbeing of communities
- Prioritizes the protection of homes, roadways, and other infrastructure

40. Would you rather have a flood mitigation measure in place that:

- Prioritizes the economic wellbeing of communities
- Prioritizes the protection of historical and cultural sites in your community

41. Would you rather have a flood mitigation measure in place that:

- Prioritizes the environmental health of our lake and river ecosystems
- Prioritizes the health and wellbeing of community members

42. Would you rather have a flood mitigation measure in place that:

- Prioritizes the environmental health of our lake and river ecosystems
- Prioritizes the protection of homes, roadways, and other infrastructure

43. Would you rather have a flood mitigation measure in place that:

- Prioritizes the environmental health of our lake and river ecosystems
- Prioritizes the protection of historical and cultural sites in your community

44. Would you rather have a flood mitigation measure in place that:

- Prioritizes the health and wellbeing of community members
- Prioritizes the protection of homes, roadways, and other infrastructure

45. Would you rather have a flood mitigation measure in place that:

- Prioritizes the health and wellbeing of community members
- Prioritizes the protection of historical and cultural sites in your community

46. Would you rather have a flood mitigation measure in place that:

- Prioritizes the protection of homes, roadways, and other infrastructure
- Prioritizes the protection of historical and cultural sites in your community

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47. What type of residence do you live in?

- Single family
- Multi-family
- Apartment
- Condominium

48. Do you own or rent your home?

- Own
- Rent
- I prefer not to answer

49. How long have you lived in your current home?

- Less than one year
- 1-5 years
- 6-10 years
- 11-15 years
- More than 15 years

50. What is your gender?

\_\_\_\_\_

51. What year were you born?

\_\_\_\_\_

52. What is the highest level of education you have completed?

- Less than 9th grade
- 9th grade to 12th grade, no diploma
- High school graduate (including GED)
- Some college, no degree
- Associates degree
- Bachelor's degree
- Graduate or professional degree
- Other:

53. How many people live in your home?

54. How many people in your home are under the age of 18?

55. How many people in your home are over the age of 65?

56. What is your household income?

- Less than \$10,000
- \$10,000 to \$14,999
- \$15,000 to \$24,999
- \$25,000 to 34,999
- \$35,000 to \$49,999
- \$50,000 to \$74,999
- \$75,000 to \$99,999
- \$100,000 to \$149,999
- \$150,000 to \$199,999
- \$200,000 and up
- I'd rather not say

57. What is your usual political ideology?

- Consistently conservative
- Mostly conservative
- Mixed
- Mostly liberal
- Consistently liberal
- I'd rather not say
- Other:

Please feel free to include any additional comments in this space. Thank you for your participation.

## Vulnerability Analysis and Risk Perception Analysis

### Vulnerability analysis

The vulnerability analysis method was developed by the ARIACTION research team in collaboration with the Ministry of Public Security of Quebec. Its hierarchical structure allows for a portrait and analysis of vulnerability using four thematic indices, social sensibility, territorial sensibility, adaptive capacity and accessibility, themselves broken down into components and then indicators. From an adaptation perspective, knowledge of the sensitivity of the territory (physical elements) and communities (the population) is crucial, as reducing the sensitivity of exposed elements is, in many situations, the only real way to reduce vulnerability and even risk (Morin, 2008).

The mathematical method used to identify components of the social sensitivity is principal component analysis (PCA). Cutter, Boruff and Shirley (2003) popularized PCA in the field of vulnerability assessment. They used this analysis to develop a Social Vulnerability Index (SoVI) in the United States. Several other researchers have used the method in different contexts and at multiple scales. For example, Thomas et al. (2012) conducted a vulnerability study of the south shore of the Rivière-des-Prairies on the island of Montreal; Guillard-Gonçalves et al. (2015) applied it to characterize and map social vulnerability in Greater Lisbon, Spain; and Tate, Cutter, and Berry (2010) used it to construct a social vulnerability index at the scale of Charleston County, South Carolina. This method was later replicated in vulnerability analyses conducted with the Ministry of Public Security of Quebec (Thomas et al. 2020). This method was first applied on the Canadian side. Then, a knowledge transfer workshop with the US SPE colleagues made it possible to reuse the method in order to obtain a comparable picture of the situation in the United States. Other methods were used to complement the vulnerability analysis: field visits, focus groups with local stakeholders (summer 2019) and a literature review about risk perception. These methods helped to confirm and update certain elements.

### Discussion groups

Discussion groups were conducted in July 2019 and August 2019 with four pilot cities (Saint-Jean-sur-Richelieu, Venise-en-Québec, Sainte-Anne-de-Sabrevois, Saint-Paul-de-l'Île-aux-Noix). The fifth pilot municipality, Noyan, was unwilling to participate in a discussion group. This activity consisted of a meeting of no longer than three hours. The participants targeted for these discussion groups were municipal actors; for example, the director general, the urban planner, the person in charge of fire safety. Elected officials (councillors and the mayor) were not directly targeted but could participate if they were interested.

Participants and dates for these discussions were as follows:

1. Saint-Jean-sur-Richelieu (SJSR): Luc Castonguay (Director of the Urban Planning Department), Daniel Dubois (Emergency Measures Coordinator), Brigitte Cérat (Director of Communications). August 30, 2019.
2. Saint-Anne-de-Sabrevois (SADS): Teresa Gagnon (resident and involved in the project) and Jean Vasseur (urban planning department) for Group 1 (SADS 1). For group 2 (SADS 2), Jacques Lavallée (mayor), Freddy Serreyn (general manager), an anonymous participant. August 7, 2019.
3. Saint-Paul-de-l'Île-aux-Noix (SPIN): Jacques Daigle (urban planning department) and one anonymous participant. September 11, 2019.

4. Venise-en-Québec (VQC): Patrick Sauriol (Director of Fire Safety), Gérard Bouthot (City Councillor), Frédéric Martineau (Director General), Jacques Landry (Mayor). July 30, 2019.

The discussion sessions were divided into two parts: the first part dealt with vulnerability and risk perception, and the second with preliminary mitigation and adaptation measures proposed by the FMMM TWG. During the first part, stakeholders were asked questions to understand how they perceived their vulnerability and why. Results from the vulnerability analysis were shown and discussed. In the second part, participants were presented with preliminary results discussing Themes 1, 2, 3 and 4 and discussed the pertinence of mitigation actions. The discussion groups were part of a process of collaboration with local stakeholders and evaluation of the social acceptability of adaptation and mitigation measures and strategies

### **Risk perception analysis**

For the risk perception analysis, questionnaires were distributed door-to-door during the summer of 2018 to citizens in areas that were flooded in 2011 in the five pilot municipalities. Thirty-two citizens responded in Sainte-Anne-de-Sabrevois, 35 in Venise-en-Québec, 32 in Saint-Paul-de-l'Île-aux-Noix, 42 in Saint-Jean-sur-Richelieu and 17 in Noyan. Citizens were asked about their flood risk perception, access to information, priorities around information and reach, adaptation measures and resources to develop.

Twenty-four interviews were conducted between 2018 and 2019 with municipal, regional, departmental and agency stakeholders. Participants were asked about the situation before the 2011 floods and after, about key tools for communication, risk perception, needs for adaptation and needed adaptation strategies. Three government agencies were contacted (MAMH, MSP, MELCC), as well as two regional organizations (Haut-Richelieu RCM and Brome-Missisquoi RCM), local municipalities, NGOs and municipalities downstream (Carignan, Saint-Mathias-sur-Richelieu). The complete list is available on [www.ariaction.com](http://www.ariaction.com) in the SPE5 public summary report (Thomas and Gagnon, 2020).

### **Social network analysis**

This section presents the methodology used for conducting the Social Network Analysis. It was presented in the April 2020 report SPE 8 & 9 Social Network Analysis –Preliminary results. and in the October 2020 report SPE 8 & 9 Social Network Analysis and Political Feasibility. The methodology was divided into three parts: first, semi-directed interviews were conducted with some of the organizations working in the basin. Second, a questionnaire was distributed to all the organizations working and/or influencing the floods and water management in the LCRR basin. Third, the quantitative results were analysed.

### **Semi-directed interviews**

First, organizations working on floods or water management in the Quebec part of the basin were identified. Ten organizations that appeared as central (based on their activities and the number of organizations they appeared to be linked to in available online documentation) were selected and the research team conducted interviews with them (Table A-2). The first objective of these interviews was to complete the questionnaire for the social network analysis and test some questions. The second objective was to identify all the organizations in the basin relevant to the study by asking them to list the organizations they have relations with. The third objective was to collect qualitative data from the organizations on the issues they face in the basin (related to floods and water management), as well as their idea of the mitigation measures they would rather see implemented. SPE made sure that the people interviewed were representative and were able to voice the positions of their organizations. The research was conducted under the Ethics certificate on responsible ethics in research.

Therefore, the names of the organizations are presented, but never the names of the people interviewed. Interviewees were guaranteed anonymity by explaining that their names would not be tied to the information that they gave. Only the researchers had access to the transcription, and these were kept on a secure server. Interviews were semi-structured and lasted between 25 and 80 minutes. The interviews were recorded, transcribed, and coded according to SPE's analytical grid with NVivo software.

*Table A-2. List of organizations interviewed.*

Organization	Type of organization	Date
Tourisme Haut Richelieu	Tourist organization	October 4, 2019
COVABAR	Watershed organization	October 4, 2019
Table des préfets et élus de la Couronne-Sud et des préfets de la Montérégie	Regional organization	October 4, 2019
MAMH	Provincial organization	October 8, 2019
MAMH - Montérégie	Provincial organization	October 25, 2019
MRC du Haut-Richelieu	Regional organization	October 25, 2019
MRC de la Vallée-du-Richelieu	Regional organization	October 28, 2019
UPA Montérégie	Farmers' union	October 28, 2019
Chambre de commerce et de l'industrie du Haut-Richelieu	Chamber of commerce	November 4, 2019
OBV de la baie Missisquoi	Watershed organization	November 5, 2019

When conducting a Social Network Analysis, the first important step is to consider all the relevant organizations, 1) from different sectors and 2) acting at different levels (e.g. local, regional, provincial and national). For this purpose, interviewees were asked to list all organizations they have contacts with on issues related to floods and water management. The interviews were stopped once no new organizations were named, which indicated that the saturation criterion had been reached for this question. This led to a list of 172 organizations (Table A-3). COVABAR, the interviewed organization with the most relations, was asked to review the list in order to make sure no organization was missing. The questionnaire was sent to 153 organizations, as all the 172 organizations from the list could not be reached.

Table A-3. Number of organizations identified by type.

Type of organization	Number of organizations	Number of contacted organizations
Federal organizations	14	12
Provincial organizations	19 <sup>25</sup>	16
Regional organizations	10	10
Municipal organizations	34	29
Watershed organizations	4	3
Indigenous groups	2	2
Chambers of commerce	7	8
Environmental groups	17	16
Associations and farmer's unions	14	12
Tourist organizations	42	33
Consultants	9	12
Total	172	153

### Quantitative questionnaire

The questionnaire consisted of a five scale Likert scale question regarding the importance of different issues related to floods and water management, as well as a question on the issues considered as a priority by the organization. These questions were asked to see if the status quo was preferred or if flooding was still a priority for them. Respondents also had to identify in a list all the organizations they have links with and provide the type of relations, in order to map the network. Finally, organisations were asked about nine different flood mitigation decision criteria elaborated by SPE. Responders had to state how important each criterion was for their organization on a five ranks Likert scale. The criteria can be categorized in “environmental”, “material”, “economical” and “social” categories. Organizations were also asked an open-ended question on the mitigation measures they considered as ideal. These questions were elaborated to provide information on what organizations think about the mitigation measures without having to wait for the solutions to be fully developed and to include impact and cost-benefit analyses as they were not completed at that time.

### Response rate

Of the 153 organizations surveyed, the research team collected 95 responses from 67 different organizations. Therefore, 43.8 percent of organizations responded to the questionnaire; this is a good percentage in a survey where 153 organizations were contacted, each of them with varying levels of interest in flooding. At least one organization in each of the categories identified answered the questionnaire.

The questionnaire was first sent by email on February 6, 2020. An email reminder was then sent on February 18. From February 25 until March 5, 2020, more than 50 organizations that didn't respond to the emails were contacted by phone. Emphasis was placed on types of organizations that did not have a big response rate and organizations that were more directly touched by the issue of flooding in the LCRR basin. The email reminders and the calls were efficient in raising the response rate. Indeed, on February 13, the organizations' response rate was 19.6 percent and on February 21, before the calls, the answer rate reached 34.0 percent. It reached its actual rate of 43.8 percent a few days after the last calls were

<sup>25</sup> Ministries and other public and parapublic organizations.

made on March 5. The decision was made to stop the reminders at the beginning of March to allow analysis of the results.

It is important to mention that the Cité-ID team conducted another survey at the same time in the LCCR basin (the emergency responders survey). This survey targeted the same municipalities that were reached for the social network analysis. Some municipalities were confused, and this may have impacted the response rate from municipalities for both questionnaires. However, the response rate from municipalities for the social network analysis questionnaire remained satisfying, with 65.5 percent of municipalities responding to the questionnaire.

As shown in Table A-4, the types of organizations directly concerned with water management and flooding have a very high response rate of over 50 percent (municipal, regional, provincial and watershed organizations). Consultants, federal agencies, Chambers of commerce and tourist organizations are underrepresented. The low response rate for federal agencies can be explained by the distance of the federal level with the field, as most of the issues related to the basin are under local or provincial jurisdiction. The low response rate for consultants and tourist organizations can be explained by the fact that the list included organizations for which it was uncertain if their activities were related to water management. It was then necessary to contact a high number of organizations from this category in order to include their point of view.

*Table A-4. Response rate by type of organization.*

Type of organization	Number of contacted organizations	Response rate (%)
Federal organizations	12	16.7
Provincial organizations	16	50.0
Regional organizations	10	70.0
Municipal organizations	29	65.5
Watershed organizations	3	100.0
Indigenous groups	2	50.0
Chambers of commerce	8	25.0
Environmental groups	16	43.8
Associations and farmers' unions	12	41.6
Tourist organizations	33	30.3
Consultants	12	16.7
Total	153	43.8

SPSS was used to analyse quantitative data, Gephi was used for the network modeling and metrics and the open question regarding ideal mitigation measures was analysed with NVIVO.

The full version of the social network analysis survey is provided here.

1. Please identify your organisation (*select from the scroll-down list*)
2. What type of organisation are you? (*Public, private, association, non-profit*)
3. Roughly, how many employees is there in your organization? If not applicable write 0.
4. Roughly, how many volunteers is there in your organization? If not applicable write 0.
5. Roughly, how many members is there in your association? If not applicable write 0.

### Questions on the organization

6. Generally, what are the strengths of your organisation? (Several answers possible)
  - a) Number of employees
  - b) Number of members
  - c) Financial resources
  - d) Political weight
  - e) Ability to produce data
  - f) Expertise
  - g) Capacity to carry out actions in the field
  - h) Coordinating capacity
  - i) Ability to influence other organisations
  - j) Other (please specify)

7. What is your organisation's mission ? (Several answers possible)
- a) Protect the environment
  - b) Ensure the safety of citizens
  - c) Contribute to the economic development of the region
  - d) Defend the interests of a group of actors
  - e) Map the flood zones
  - f) Ensure the application of laws and of the regulatory framework
  - g) Preserve and/or improve water quality
  - h) Ensure consultation between stakeholders
  - i) Contribute to tourism development
  - j) Contribute to the region's attractiveness
  - k) Support the municipalities
  - l) Facilitate tourism
  - m) Contribute to urban and regional planning
  - n) Others, please specify

8. What is the point of view of your organisation on the following issues in relation to the Richelieu River and/or Lake Champlain? (Likert scale: Not important, Midly important, Important, Very important, No opinion)
- a) Water quality
  - b) Protection of ecosystems (biodiversity, etc.)
  - c) Urban/real estate development in the floodplain
  - d) Tourism development
  - e) Floods
  - f) Erosion
  - g) Economic development
  - h) Compliance with the guidelines regarding enbankment in the floodplain
  - i) Conflicts related to nautical activities
  - j) Residents' financial difficulties because of their location in the floodplain
  - k) Public access to the river, the bay and shorelines
  - l) Preservation of farming lands
  - m) Landslides
  - n) Water levels variation
  - o) Compliance with the guidelines regarding riparian zones

9. Which of these issues are priorities for your organisation? (Several answers possible)
- a) Water quality
  - b) Protection of ecosystems (biodiversity, etc.)
  - c) Urban/real estate development in the floodplain
  - d) Tourism development
  - e) Floods
  - f) Erosion
  - g) Economic development
  - h) Compliance with the guidelines regarding enbankment in the floodplain
  - i) Residents' financial difficulties because of their location in the floodplain
  - j) Preservation of farming lands
  - k) Landslides
  - l) Water levels variation
  - m) Compliance with the guidelines regarding riparian zones
  - n) None
  - o) Other (please specify)

## Mapping the network and relationship characteristics

10. With which of the following organisations does your organisation have links related to the Richelieu River and /or Lake Champlain? (regarding water management, floods, economic or touristic activities). (scroll-down list)
11. For each of the selected organisations, identify the types of links maintained with them (Checkboxes) -1/2
  - i. Coordination for advocacy
  - ii. Collaboration (you work together on common projects and/or goals)
  - iii. Funding – you receive
  - iv. Funding – you provide
  - v. Sharing of information, knowledge, and/or capabilities
  - vi. None of these type of relationship
12. For each of the selected organisations, identify the types of links maintained with them (Checkboxes)-2/2
  - vii. Access to a different level of action (e.g. access to a more local level, or the government level / access to levers of action)
  - viii. Crisis management in case of flood
  - ix. Other of relationship
  - x. None of these type of relationship

In this section, we would like you to assess the validity of each statements for the selected organisations. (1 = Strongly disagree, 5 = Strongly agree)

13. trust this organization.
14. We share common goals.
15. We share the same values.
16. I rely on this organization for one or more aspects of my activities.
17. Select the statement that best describe the frequency of your contact with this organization :
  - a) Often
  - b) Occasionnaly
  - c) Rarely

18. For each selected organization, what is the strength of your relationship? (Likert 1=weak, 5=strong)
19. If you only have one contact in this organisation, are there mechanisms in place to maintain the relationship if this contact were to leave?
- a) Yes, there is such mechanisms.
  - b) No, there is no such mechanisms.
  - c) I have many contacts within this organization
  - d) I don't know
20. Is there any organization with whom your organization does not voluntarily maintain contact regarding water management and flooding?
- a) Yes
  - b) No
  - c) I don't know
21. What is/are the reason(s) behind your organization not maintaining contact with this/these organization(s)? Without targeting any specific organization, answer by sector. (Public, Private, Non-profit/Association)
22. Are there organizations with which you do not work, but with which you feel that you should work regarding water management and flooding? Which ones? Why have you not developed a relationship yet?

#### Questions on floodings

23. In which phases of flood management are you involved? (Several answers possible, see definitions bellow)
- a) Prevention
  - b) Preparation
  - c) Intervention
  - d) Recovery
  - e) We are not involved in flood management.

24. For each flood mitigation criteria, please check the box for your sense of the importance of the issue (likert scale: Unsure, Not important, Mildly important, Important, Very important)

- a) Reduce the financial cost of flood damages
- b) Reduce harm to economic activity due to flooding
- c) Reduce the number of homes that are impacted by flooding
- d) Reduce street closures due to flooding
- e) Reduce potential injury, stress, or loss of life due to flooding
- f) Reduce harm to vulnerable people due to flooding
- g) Maintain healthy ecosystems, including clean water and thriving biodiversity
- h) Prevent the spread of aquatic invasive species
- i) Reduce harm to historical and culturally sensitive sites due to flooding

25. In an ideal world, what mitigation measures should be implemented?

#### **Sociometric Data**

26. How long have you been with your organisation? (allow two answers)

- Less than a year
- between 1 and 2 years
- between 2 and 5 years
- More than 5 years

27. On a scale of 1 to 5, how well do you think you are placed to answer the questions above on behalf of your organisation? (1 = in a bad position, 5 = in a good position)

28. Before ending this survey, do you have any comments or suggestions?

## Emergency responders

The first iteration of this survey was developed by Ben Rose, Director of Emergency Management for the State of Vermont and a study board member on the IJC LCRR flood study during the summer of 2019. Questions on that survey included those related to community flood experience, access to information regarding flooding and water levels, local emergency management plan components, and flood mitigation experience, specifically related to the deployment of sandbags.

The survey was refined by members of the IJC LCRR flood study's social, political, and economic analysis group. Questions were included from a survey developed to gauge public perceptions of LCRR basin households with respect to flood management, flood risk perception, and decision criteria preferences. Additional questions were included related to early warning systems, emergency management protocol, and other interventions including sandbags and aquadams. The survey was then adapted to be culturally appropriate for its intended audience, with input from the Ministry of Public Safety in Quebec, and the Department of Emergency Management in Vermont.

This survey was administered in February of 2020. Surveys were administered via email, and respondents filled out surveys via the online platforms Lime Survey (in the United States) and Survey Monkey (in Canada).

The survey was sent to 44 first responders in Vermont and New York, and 30 first responders in Quebec. In the United States, 26 individuals participated in the survey, and yielded 23 usable surveys, bringing the response rate to 52.3 percent. Of these, 43.4 percent of responses were from first responders in Vermont, and 56.5 percent of responses were from first responders in New York. In Canada, 21 individuals participated in the survey, with a response rate of 70 percent. Overall, 74 surveys were sent to first responders within the transboundary LCRR basin, and 44 responses were collected, for a total response rate of 62.9 percent. For certain questions, respondents withheld information, which accounts for a decreased response rate in some instances for both the United States and Canadian surveys. The sampling for this survey was confined to first responders from lakeside communities in Vermont and New York, and riverside and lakeside (Missisquoi Bay) communities in Quebec, to focus on the places directly impacted by LCRR flooding, rather than other instances of tributary flooding.

Generally, the analyses carried out on this data were descriptive.

## Hazard mitigation plan analysis

In the United States, the Hazard Mitigation Plans (HMPs) at all levels were analyzed for their content regarding flood risk identification, flood hazards description, the content and quality of the mitigation goals, and the number and variety of mitigation actions dedicated to flooding. Mitigation actions were analyzed using the mitigation Theme categories predominant in the LCRR Study, to encourage integration of this analysis to others within the Study. Through the iterative process employed with coding the source documents, two more categories were added to the four Themes: *emergency response and preparedness*, and *education and outreach*. The source documents were first analyzed using MaxQDA, using the same methods established in *A Comparison of the State Hazard Mitigation Plans of New York and Vermont*. The coding framework developed for MaxQDA was based off the Disaster Resilience of Place (DROP) model developed by Cutter et al. (2008) and intended to complement the geospatial analysis method developed to identify areas of social vulnerability. Building upon the coding method, a scoring of HMP documents was introduced for this analysis, to overcome some of the limitations encountered with MaxQDA. The scoring method developed by Godschalk et al. (1999) intended to facilitate comparison amongst the various levels (state, county, and local) of HMPs within the LCRR.

Source documents were collected from a variety of sources, including municipal websites, county websites, and state databases. In total, two state, four county and fourteen local plans were compiled and coded for this analysis. Nine lakeside jurisdictions lacked a current HMP in either official or draft form. Documents that were in official draft form (meaning that they are in the process of being reviewed and approved by FEMA) were coded and scored alongside the others as long as all sections were present.

The coding process in MaxQDA followed the method developed for the coding of the state plans. The coding framework branches in a hierarchical manner, with each “lower” level increasing in specificity. Four of the coding categories were taken directly from the DROP model; two categories to help illustrate scale (geographic, governance) were added to help identify the level of the responsible government agency and the focal area of the mitigation action (Cutter et al., 2008). The coding focused on three main sections within the HMP documents, the Hazard Identification and Risk Assessment (HIRA) Section, the Mitigation Goals, and Mitigation Actions. As this project is focused on flood hazard risk and mitigation, the analysis was further focused on the flood profile located within the HIRA. All codes for a section were linked to a single word at the beginning to eliminate the possibility of artificially inflating the number of codes within a single document. When a section described conditions in the community as they were prior to a hazard event they were coded for Antecedent Conditions. The descriptions of hazard events were coded for Impacts and Response and Recovery depending upon the content and detail of the narrative of the event. All actions regarding mitigation were coded using the various codes nested within Mitigation Actions. Finally, all sections were coded with the particular Governance and Geographic Scale to illustrate the focus of the action or description. From this coding process, counts were produced that were used to compare the content of the mitigation actions.

It was discovered through the use of the MaxQDA visualization tools that certain aspects of analysis highly favored the longer state plans. Previously, in *A Comparison of the State Hazard Mitigation Plans of New York and Vermont*, codelines were used to help demonstrate the content of the HMP documents. The codeline, however, was less useful for the shorter Local HMPs, and therefore did not facilitate comparison between the various levels of HMPs that were responsible for managing the shoreline Lake Champlain. To assist with comparisons amongst the various levels, the Guide for Describing and Evaluation Section 409 Plans developed by Godschalk et al. (1999) was adapted for use with plans at the local, county, and state level. The tool was adapted by removing specific questions that would only pertain to state-level HMPs, such as questions pertaining to high level coordination and authoritative power. It is important to note that although the tool was developed in 1999, requirements for HMPs have not changed significantly in that time period, and thus, the tool is still relevant today.

The guide has six different sections, and a total number of points able to be awarded for each section, which was transformed into a proportion to allow for comparison amongst the various plans. This differs from the approach taken by Godschalk et al. (1999), as they produced a composite average score from all of the plans that they reviewed to demonstrate what could be expected from a “typical” state level HMP. The intention of this analysis was to identify strengths and opportunities within the HMPs of the lakeshore communities, and therefore the documents were given individual scores. The first part of the tool gives a score based upon the content of the HIRA in the HMP. The second part of the assessment focuses on the analysis of the capabilities of the hazard mitigation programs and policies. The third scores the variety of goals and objectives in the plan. The fourth focuses on the description of the proposed mitigation actions. The fifth part further explores the content of the mitigation actions, to determine their likelihood of implementation. The sixth looks at overall aspects of the plan, such as readability, comprehensiveness, and the plan for public participation.

After the HMPs were coded and analyzed, a small number of key informant interviews were used to provide specific and targeted knowledge regarding various findings from the coding and scoring. Individuals were contacted from county and local levels in New York and Vermont in jurisdictions that both focused on flooding and did not focus on flooding. In total, ten individuals were contacted and asked to participate in 1:1 phone interviews. Two individuals agreed to participate and were contacted in July of 2020 to discuss some intricacies of flood hazard mitigation and the creation of a hazard mitigation plan.

Overall documents were coded and scored based upon both items that were present and items that were missing. The combination of these two analytic approaches allowed for insight into the planning capacity, the types and extent of hazard mitigation described within HMPs, and the areas in which documents were particularly lacking. The Cutter et al. (2008) analysis focused on the ways in which the plan addresses both flood hazard as well as social vulnerability, while the Godschalk et al. (1999) tool was focused on plan content related to FEMA regulations as well as aspects of HMPs that facilitate greater hazard resilience. The two approaches complement each other and allowed for a more thorough image of the contents of the plans in both New York and Vermont.

## Public meetings, meetings with stakeholders, meetings with political entities and experts

### Observations

The SPE team participated in different meetings organized by the outreach coordinators and the Study Board with organizations of the basin and political entities. During those meetings, notes were taken and analysed. Table A-5 shows the list of meetings held with different organizations.

Table A-5. Meetings with organizations.

Organization	Date
Ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC)	September 17, 2019
Ministère des Affaires municipales et de l'Habitation (MAMH)	September 17, 2019
Parks Canada	September 18, 2019
Municipalité régionale de Comté (MRC) de la Vallée de Richelieu	December 5, 2019 <sup>26</sup>
MRC de Rouville	December 5, 2019
MRC Pierre de Saurel	December 5, 2019
Comité de concertation et de valorisation du bassin de la rivière Richelieu (COVABAR)	December 5, 2019
Nature-Action Québec	December 5, 2019
Conseil Régional de l'Environnement de la Montérégie (CRE Montérégie)	December 5, 2019
Centre d'interprétation du milieu écologique (CIME) du Haut-Richelieu	December 5, 2019
Mouvement Écologique du Haut-Richelieu (MEHR)	December 5, 2019

<sup>26</sup> At the meetings held in December 2019, organizations were asked to answer four questions regarding the acceptability of the measures proposed.

Organization	Date
Conservation de la nature Canada (CNC)	December 5, 2019
Organisme de bassin versant (OBV) de la baie Missisquoi	December 5, 2019
Ville de Saint-Jean sur Richelieu	December 6, 2019
MRC du Haut-Richelieu	December 6, 2019
MRC Brome-Missisquoi	December 6, 2019
Union des producteurs agricoles (UPA)	December 6, 2019
MRC du Haut-Richelieu	February 6-7, 2020 <sup>27</sup>
MRC de Brome-Missisquoi	February 6-7, 2020
Communauté métropolitaine de Montréal (CMM)	February 6-7, 2020
MELCC	February 6-7, 2020
Environnement Canada	February 6-7, 2020
CNC	February 12, 2020
Pêche et Océans Canada	February 12, 2020
MAMH	June 2, 2020
Ministère de la Santé et de Services sociaux (MSSS)	June 2, 2020
Ministère de l'Énergie et des Ressources naturelles (MERN)	June 2, 2020
MELCC	June 2, 2020
Ministère des Transports du Québec (MTQ)	June 2, 2020
Ministère de la Sécurité publique (MSP)	June 2, 2020
Ministères des Forêts, de la Faune et des Parcs (MFFP)	June 2, 2020
Ministère de l'Agriculture, des Pêcheries et de l'Alimentation (MAPAQ)	June 2, 2020
Ressources naturelles Canada	July 10, 2020
Agriculture et agroalimentaire Canada	July 10, 2020
Parks Canada	July 10, 2020
Affaire Mondiale Canada	July 10, 2020
Travaux publics Canada	July 10, 2020

<sup>27</sup> The workshop on Theme 4 was held in February 2020 at Ouranos' offices in Montreal. Local and regional stakeholders and experts in floodplain management were invited to discuss, among other things, the capacity to implement certain adaptation and mitigation strategies and measures. The effectiveness and equity of strategies and measures was also discussed. This workshop on Theme 4 laid the groundwork for four "White Papers" on the current state of four important dimensions of risk management and resilient land use planning.

Organization	Date
Agence d'évaluation d'impacts du Canada	July 10, 2020
Pêche et Océans Canada	July 10, 2020
Environnement Canada	July 10, 2020
Justice Canada	July 10, 2020
Transport Canada	July 10, 2020
Sécurité publique Canada	July 10, 2020
Parks Canada	October 29, 2020
Parks Canada	November 12, 2020
Parks Canada	November 26, 2020
Parks Canada	December 10, 2020
MELCC	January 27, 2021
Parks Canada	April 1, 2021
MELCC	May 12, 2021
MAMH	May 12, 2021
MSP	May 12, 2021
MERN	May 12, 2021
MAMH	November 3, 2021
MSP	November 3, 2021
MELCC	November 3, 2021
MERN	November 3, 2021
MAMH	November 16, 2021
MSP	November 16, 2021
MELCC	November 16, 2021
MERN	November 16, 2021
Canard Illimité	December 1, 2021
OBV de la baie Missisquoi	December 1, 2021
CRE de la Montérégie	December 1, 2021
COVABAR	December 1, 2021

Organization	Date
CNC	December 1, 2021
CIME du Haut-Richelieu	December 1, 2021
MRC du Haut-Richelieu	December 2, 2021
MRC Pierre de Saurel	December 2, 2021
MRC Rouville	December 2, 2021
Venise-en-Quebec	December 2, 2021
Saint-Blaise-sur-Richelieu	December 2, 2021
Saint-Paul-de-l'île-aux-noix	December 2, 2021
Saint-Anne-de-Sabrevois	December 2, 2021
Saint-Jean-sur-Richelieu	December 2, 2021
Saint-Georges-de-Clarenceville	December 2, 2021
Henryville	December 2, 2021
Saint-Blaise-sur-Richelieu	December 2, 2021
Chambly	December 2, 2021
MAMH	December 9, 2021
MELCC	December 9, 2021
MERN	December 9, 2021
MSP	December 9, 2021
MTQ	December 9, 2021
MAMH	December 14, 2021
MELCC	December 14, 2021
MERN	December 14, 2021
MSP	December 14, 2021

Table A-6. Meetings with Canadian political entities.

Riding or municipality (MNA, MP, Senator or representant, Mayor)	Level	Date
Beloeil-Chambly (representative)	Federal	May 8, 2020
Saint-Jean (MP)	Federal	May 8, 2020
Brome Missisquoi (representative )	Federal	May 8, 2020
Senateur	Federal	May 8, 2020
Brome Missisquoi (representative )	Provincial	May 20, 2020
Chambly (representative )	Provincial	May 20, 2020
Iberville (representative )	Provincial	May 20, 2020
Saint-Georges-de-Clarenceville (Mayor)	Municipal	May 27, 2020
Saint-Jean-Sur-Richelieu (Mayor)	Municipal	May 27, 2020
Henryville (Mayor)	Municipal	May 27, 2020
MRC du Haut-Richelieu (two employees)	Regional	May 27, 2020

Table A-7. Public meetings and webinars.

Event	Date
Public information session – Saint-Jean-sur-Richelieu	November 7, 2018
Public information session – New York	November 8, 2018
Public Officials Focus Group- Vermont	November 28, 2018
Public Officials Focus Group- New York	November 29, 2018
Community Meeting- Shoreham, VT	August 12, 2019
Community Meeting- Westport, NY	August 13, 2019
Community Meeting- Burlington, VT	August 14, 2019
Community Meeting- Plattsburgh, NY	August 15, 2019
Political Entity Meeting	August 24, 2020
Political Entity Meeting	August 25, 2020
Virtual public meetings	September 29, 2020
Virtual public meetings	September 30, 2020
Technical webinars - watershed storage	November 5, 2020
Technical webinars - overview of performance indicators	November 12, 2020
Technical Webinar - Improvements in forecasting	November 18, 2020
Technical Webinars - Development of a performance indicator for damages to residential buildings and its use in economic analysis	November 24, 2020
Technical Webinar - How the LCRR study is assessing Climate Change	December 2, 2020
Technical Webinar - Chambly Canal diversion	December 9, 2020
Technical Webinar - Floodplain management considerations	December 16, 2020
Technical Webinar - Risk perception surveys, vulnerability and other social science studies	January 13, 2021

## Municipal Needs Assessment Workshop on Theme 3

The "Municipal Needs Assessment Workshop" consisted of four working sessions between December 2020 and March 2021, with municipal and regional actors, as well as the ministry of public safety (MSP). Participants were first familiarized with the project and then given a mock flood event forecast with online mapping tools. Questions were asked to better understand how these actors would prepare for this potential mock flood event. The forecast was revealed and feedback was given on the relevance of the forecasting tools and mapping, as well as their needs for preparedness, emergency management and risk communication. In the United States, a similar process was carried out as in Canada, by interviewing one emergency management professional and one planning professional from New York and Vermont, respectively. The purpose of these interviews was to engage planners and emergency responders on flood planning and response through the lenses of local/regional programming and policy. Another goal was to gain a better understanding about current flood prevention and response activities in the arena of planning and policy, and potential areas of improvement. It was difficult to get input and feedback regarding Theme 3. Key outcomes included the following conclusions: 1) there exists a need for education and outreach for local planning and emergency management professionals, the property development/real estate community, and property owners; 2) stakeholders are primarily focused on mitigation flooding along tributaries; 3) recommendations for flood prevention and recovery for Theme 3 must spread the risks and benefits of flood mitigation equitably across residents of the Lake Champlain Basin; and 4) there is potential for long term solutions in planning and zoning on the local level through comprehensive land use planning, zoning codes and building codes/inspections.

## Theme 3 Interviews with US Stakeholders

The United States SPE team conducted four interviews on March 16, 2016 with stakeholders including one emergency management professional each from Vermont and New York, and one planning professional each from Vermont and New York. Interviewees were chosen based on previous involvement with the study and professional experience. Representation included the state of Vermont; Chittenden County, Vermont; Clinton County, New York; and Essex County, New York.

The purpose of these meetings was to engage with the planners and emergency responders around issues related to flood planning and response through the lenses of local/regional programming and policy, to gain a better understanding about current flood prevention and response, including potential areas of improvement, and to gauge stakeholder interest in a Theme 3 workshop. SPE US team members and other IJC study members were present at each meeting, with a series of prepared questions that were asked in a semi-structured format on topics including communication of flood hazard and risk, flood planning, education, and response to proposals related to the Themes.

## Final stakeholder engagement survey

Final stakeholder engagement meetings were conducted in Quebec, Vermont and New York throughout the Fall 2021 and Winter 2022 to present results from the Study and draft recommendations. In the United States, meetings were conducted with the Lake Champlain Basin Program Technical Advisory Committee (a group of technical experts from colleges/universities, municipal, state and federal government agencies); LCBPs Citizens Advisory Committee (residents of the basin); and a mixed group of political officials, elected representatives at federal, state and local levels, and emergency responders and planners. In Quebec, two meetings were conducted: one with environmental and watershed organizations, and one with municipalities and regional county municipalities.

Following the meetings, a survey was distributed to attendees of these meetings in the United States and Canada. This survey focused specifically on understanding stakeholder preferences for the four Themes and gathering comments on the recommendations, their acceptability and perceived feasibility. The survey asked respondents to provide general comments on the presentation from the Study as well as specific comments on recommendations. The survey was nearly identical in Canada and the United States and included questions on social and political acceptability, and feasibility of the recommendations. In the United States, approximately 130 people attended the meeting and 31 responses were collected. In Canada, there were 37 attendees to the meetings and 18 responses were collected from representatives of 14 organizations (three environmental organizations, two watershed organizations, six municipalities and three regional county municipalities).



# APPENDIX B - Updated Recommendations

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## Climate Change

The multiple approaches to climate modeling employed by the Study all indicated major uncertainty in future water regime with a very low (but not null) probability for larger floods than the spring flood of 2011, and the potential for more frequent and extended periods of low water levels in the Lake and River. The Study has produced water supply scenarios using a variety of techniques, and that information should be made available to all interested parties. Therefore, the Study Board recommends that the IJC advise the governments to encourage decision-making bodies to consider climate change in their decision making across all aspects of flood risk management and response.

## Reduce Water Levels - Structural Solutions and Governance

The Study Board recommends the IJC advise governments that it is possible to achieve a modest relief of flood (on the order of 10 cm on the Lake and 15 cm at Saint-Jean-sur-Richelieu for an event like the spring 2011 flood) and drought water levels by returning the hydraulic regime at the Saint-Jean-sur-Richelieu shoal to a more naturalized hydraulic state. This can be achieved by removing some flow-impeding human artifacts in addition to some selected excavations of the shoal and installing a submerged weir in the area of the Saint-Jean-sur-Richelieu shoal (Measure 1).

If desired, additional flood relief can be gained through combining the removal of the artifacts, selected excavations of the shoal, and the submerged weir with a modest water diversion through the Chambly Canal (for a total peak water level reduction of 15 cm on the Lake and 20 cm at Saint-Jean-sur-Richelieu for an event like the spring 2011 flood, Measure 3). While this measure that includes the Chambly Canal water diversion is less economically performant, this addition brings greater water level relief for larger flood events and should be presented to the governments for their considerations.

From the Study's evaluation of the proofs of concept, the Study Board is of the opinion that these moderate structural solutions are technically feasible, socially and economically acceptable. A limited environmental review on both potential structural solutions was conducted that indicated encouraging results.

If the governments decide to implement a structural solution, a process should be put in place to analyze binational social, political, environmental, legal, and economic implications of the final structure design and operation.

The Study Board recommends that the IJC encourage the governments to implement a bi-national governance mechanism to oversee the implementation and operation of any structural solution the governments may opt to pursue. Functions of a bi-national governance mechanism for Measures 1 or 3 would include, among others:

- Binationally defining the final design and performance requirements of the submerged weir and removal of shoal material
- Designing and implementing a bi-national adaptive management (AM) program
- Enabling a binational decision-making in response to the binational AM program

In addition, the following functions apply to Measure 3:

- Binationally defining the final design and performance requirements of the Chambly Canal diversion
- Implementing a binational water management plan associated with the final design
- Overseeing the application and decisions associated with the operation of the diversion

## Impede Flows - Watershed Storage

The Study Board recommends that the IJC encourage the governments to continue protection of existing wetlands as they provide flood relief (reduction of the peak water level by 15 cm in Lake Champlain and 12 cm in the Richelieu River during a spring 2011-scale flood) at the scale of lakeshore and Richelieu riverfront communities.

The LCRR Study has determined that without the creation of a very large area (650 km<sup>2</sup> or greater) of new wetlands, there cannot be significant flood mitigation at the scale of lakeshore and Richelieu riverfront communities during major flood events. Therefore, the Study Board does not recommend pursuing a strategy for acquiring land and creating new wetlands as a singularly effective flood management policy for lakeshore and Richelieu riverfront communities.

However, the Study Board recognizes that wetlands reduce local tributary flooding, support biodiversity, and have important environmental co-benefits. Consequently, the Study Board encourages the governments to not only continue to protect these existing wetlands but where possible, to restore wetlands and create new ones. The LCRR Study recognizes the incremental and cumulative benefits of multiple strategies for overall flood reductions in the LCRR system. The LCRR Study encourages the governments to continue to pursue the implementation of practices that have a net positive impact on watershed storage to benefit both local tributary flooding issues and the overall effort to reduce flood impacts in the LCRR system.

## Improve Flood Response

The Study Board recommends that all of the weather and hydrological information generated by the National Oceanic and Atmospheric Administration (NOAA, in the US) and Environment and Climate Change Canada (ECCC) and the Ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC, in Canada) be made available to and used by the respective agencies responsible for the production and dissemination of flood forecast, guidance and warnings.

- Continuation and enhancement of the collaboration between the various Agencies, namely NOAA, ECCC and MELCC, must be encouraged to ensure all available forecast data and their interpretations are shared in real time with the ultimate goal that the official forecasts on each side of the border are of the highest possible quality and are accompanied by a concerted and consistent cross-border interpretation.
- Improved modeling and forecasting tools developed for the Lake Champlain-Richelieu River basin can greatly aid flood response planning and should be maintained. They showed the possibility of extending the forecasting horizon and providing new operational products relevant to basin's stakeholders such as water set-up, wave, flood extent and depth, and their consequences on the shore, for example: roads cut off, social vulnerabilities, and monetary impacts.

On that basis, the governments are encouraged to operationalize the improved modeling and forecasting tools and coherent risk assessment systems and support/maintain them after the Study. The LCRR tools, supporting data and documentation should be transferred to appropriate agencies in Canada and the US by no later than March 2023.

To support flood preparedness, simulations of flooding of various magnitudes and the related maps produced by the Study should be made available to all interested parties by no later than March 2023.

## Floodplain Management

The Study Board recommends that the IJC encourage the governments to make the best use, in relation to their own context, of the LCRR Study's analysis of best practices related to risk mapping, risk communication, floodplain management, and flood insurance, which include:

- Enhance flood risk mapping for targeted audiences. This includes updating and adding more details to existing flood risk maps.
- Develop flood risk communication campaigns designed for specific target audiences within the LCRR basin.
- Consider floodplain occupancy through the lens of resiliency. This includes land use strategies that avoid, accommodate and retreat from flooded areas, updating and strengthening the enforcement of land use regulations based on flood risk, and shielding development in high-risk flood zones.
- Explore and/or expand flood insurance. This includes further investigation of the state of flood insurance in the watershed and promoting an insurance arrangement that shares financial liability for flood damages.

Moreover, the Study Board recommends that the IJC advise the governments that the benefits of flood water level reductions should be maintained with adaptive land use planning and floodplain management, particularly constraining land use in areas protected by structural solutions.

## **Capacity Building**

The Study Board acknowledges that the various stakeholders involved in water issues in the Lake Champlain – Richelieu River Basin regularly have different and sometimes divergent understandings of the causes and impacts of flooding in the basin. As such, the Study Board recommends that the IJC encourage governments to create spaces where all the stakeholders involved in watershed issues can address various aspects of the flooding problem in Lake Champlain and the Richelieu River basin with a goal of achieving a better understanding and collaboration among all stakeholders.

The Study Board also recommends the IJC encourage the governments to continue to engage in capacity building for improved flood mitigation, including initiatives to support communities in preventing or preparing for flooding impacts and making planning tools available.

## **Data Products**

The Study Board recommends to the IJC that the LCRR tools, models, and supporting data required to implement the recommendations of the Study Board should be made available to appropriate agencies in Canada and the US by March 2023.



# APPENDIX C - Notes on Implementation of SPE Recommendations

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This section describes SPE's recommendations for advancing flood mitigation in the LCRR basin, as well as recommendations for future IJC flood references throughout its binational jurisdiction. The recommendations represent the activation of findings from the studies SPE conducted over the course of the study, as well as best practices and knowledge from scholarship.

Further details regarding each recommendation are provided below. Each recommendation is organized in five sections. These are:

1. **Key findings.** This section draws together multiple points of data and broader research findings to develop the empirical and theoretical foundations that compel each recommendation.
2. **Recommendation overview.** This section outlines the overarching recommendation and key objectives for implementation.
3. **Linkages to the four Themes of mitigation.** This section outlines how the broader recommendation supports mitigation under each Theme, as well as other thematic considerations. This section also discusses preliminary observations regarding enabling and hindering factors to implementation.
4. **Transboundary considerations.** This section describes how each recommendation may be interpreted and implemented in the cross-boundary context of the LCRR. Many of the recommendations require transboundary coordination. The mechanisms of achieving this coordination are described in this section.
5. **State/Provincial and local considerations.** This section outlines how the recommendations may be implemented at state/provincial and municipal scales.

The transboundary, state/provincial and municipal recommendations are organized using the “lever”, “entry point” and “pathway” framework. This framework facilitates implementation by pinpointing the “where, what and how” of activating each recommendation.

- Levers- refer to the specific action intended by each recommendation. Levers are distinguished by controllable elements or features with social, economic and governance structures. Levers are directly manipulatable. Levers represent the “what” is to be done in each recommendation.
- Entry points- refer to specific policies, laws, regulations, programs and agencies/offices or agents that have the ability to implement each recommendation. Entry points represent the “where” change or action is to occur.
- Pathways- refer to specific steps that could be taken to achieve implementation of the recommendations. Pathways refer to the “how” change may take place.

## Recommendation 1: Transboundary dialogue and whole-systems approach.

<b>Key findings</b>	<p>SPE studies revealed that flooding and its associated impacts are the outcome of a complex system of interactions and feedback loops that includes climate and weather, basin-level ecological functions, and economic, social and political activities. Thus, the causes and impacts of flooding in the LCRR are multidimensional. While spring flooding in the LCRR basin is caused by strong winter/spring precipitation and temperature fluctuations, and summer/fall flooding is caused by severe storms, the risks of floods are exacerbated by environmental, land use and other social/political decisions and actions. Through this lens, SPE's research demonstrated that there are diverse perspectives on the need for risk reduction and mitigation, as well as on the acceptability of specific mitigation strategies. Professional and nonprofessional flood stakeholders are aware of the complexities in transboundary environmental management, and illustrated a diverse and multidimensional set of objectives, concerns, priorities and perspectives.</p> <p>Based on these conclusions, SPE recommends...</p>
<b>Recommendation 1</b>	<p><b>that the governments of the basin be encouraged to play an ongoing role in supporting transboundary and trans-jurisdictional dialogue about flooding in the LCRR, as well as promote a whole-systems approach to flood mitigation, adaptation and resilience.</b></p> <p>To address flooding comprehensively, the IJC's recommendations to the governments of the LCRR should consider mitigation measures that assist public and private stakeholders throughout the basin before, during and after flood events. To address flooding multidimensionally, SPE recommends promoting mitigation measures that address the public and private economics of flooding, social vulnerabilities and inequities, the diverse ways that residents of the LCRR interact with waterways such as recreation and agriculture, ecological concerns and governance of flood management. Furthermore, the governments of the LCRR should be encouraged to consider mitigation strategies through the lens of policy coherence, to maximize synergies and minimize trade-offs. This will achieve policy integration among the multidimensional mitigation strategies. For example, the challenges of flooding are connected to water quality challenges, and mitigation actions should be synergistic with water quality improvements. Nature-based mitigation actions also bring ecological benefits, and opportunities for achieving these co-benefits should be maximized.</p> <p>The results of the IJC LCRR study should be viewed as the first phase of mitigation strategy assessment. In-depth environmental, historical and economic analysis should be performed, as well as public comment sessions. All federal, state provincial and local review processes should be carried out. All mitigation measures should be assessed through geographic, environmental, temporal, economic, social and political/governance lenses. Assessment through the geographic lens will reveal impacts of the measures on upstream and downstream communities and users. Assessment through the environmental lens will reveal impacts to ecosystems, as well as impacts under different precipitation regimes. Assessment through the temporal lens will develop understanding of how these measures will impact flooding and flood impacts before, during and after floods and over short, medium and longer-term time horizons. Assessment through the economic lens will reveal the comprehensive benefits and costs of different measures. Assessment through the social lens will reveal how the benefits of mitigation strategies are spread among communities and stakeholders, and whether these measures assist the most vulnerable residents of the LCRR. The social lens also considers the impacts of mitigation on recreation and cultural uses of water and floodplains. Finally, assessment through the political/governance lens will develop models for ongoing management of mitigation measures.</p> <p>Comprehensivity and multidimensionality can be achieved through intergovernmental and multidisciplinary dialogue about flood mitigation. SPE suggests the IJC play an ongoing role in</p>

supporting transboundary and transjurisdictional dialogue about flooding within the LCRR jurisdictions, as well as encouraging implementation of the LCRR study recommendations. This should include funding support, facilitation of planning processes and training, development of program/policy infrastructure, and awareness raising. The governments of Canada and the United States should be encouraged to maintain next-phase funding for the LCRR study, including funding of outreach coordinators. This will maintain awareness, interest and communication, and demonstrate commitment.

Examples are provided for each Theme, below...

**Theme 1:** Theme 1 measures represent engineered measures for altering water levels in the LCRR. Data from Canada and the United States suggested some support for these measures exists (among emergency responders, especially), but that stakeholders are wary of their effectiveness, costs and environmental impacts. Elected officials and government staff appear equally skeptical about these measures. SPE’s takeaways from research conducted throughout the study indicated that stakeholders hold diverse understandings of what is meant by major, moderate and minor structural measures. Stakeholders hold many different perspectives on acceptable benefit/cost thresholds, and those may be different from the perspectives of government decision makers. Local actors who were interviewed, upstream of Saint-Jean-sur-Richelieu, were worried about consequences of potential structural measures. This, along with the heterogeneous governance structures among the provinces, states and communities of the LCRR, indicated that coming to agreement on Theme 1 measures may be challenging. Further outreach and education about the needs, effectiveness and consequences of Theme 1 measures are needed. Theme 1 measures may provide some relief to vulnerable populations and municipal infrastructure, and these objectives are among stakeholders’ top priorities. Theme 1 measures must be understood as a system and managed and maintained accordingly. Furthermore, the spatial, temporal and social co-benefits and unintended consequences of these measures must be analyzed. For this reason, SPE recommends limiting consideration of Theme 1 measures and options to those with only the most positive benefit-cost ratios.

**Theme 2:** Theme 2 measures represent non-engineered means of influencing water levels through increasing water storage in floodplains and wetlands. Evidence demonstrates that existing wetlands and floodplains play an important role in reducing loss and damage from floods, but that constructing new features to promote upland water storage is unlikely to significantly improve flooding along the lakeshore or Richelieu River. There was strong support for continued conservation of wetlands and floodplains in Canada and the United States. SPE data reflected that communities in the LCRR were already pursuing some Theme 2 measures through different means and programming. Thus, Theme 2 measures are synergistic with current actions in the LCRR basin. There is an inherent inequity in Theme 2 measures. The space for these actions exists along the tributaries in Vermont and New York, while the benefits would accrue in Canada. The heterogeneous governance structures and diverse understandings of risk held by stakeholders throughout the basin may pose a challenge for a significant transboundary push for Theme 2 measures. Furthermore, when assessed at broad scales, the benefit/cost ratio of Theme 2 measures illustrates that the creation of new and additional wetlands and water storage is not a viable mechanism for reducing downstream impacts. SPE recommends that the IJC show support for ongoing conservation efforts in Vermont, New York and Quebec, but limit pursuing development of new water storage capacities to specific areas of extreme damage that are supported by additional analysis.

**Theme 3:** Theme 3 measures represent emergency response strategies including flood forecasting and emergency protection of residents and community assets. There was strong support for these measures, especially among emergency responders. SPE data suggested that top priorities for emergency responders included enhanced communications among responders and residents, and among responders from different agencies/jurisdictions including federal, state and local levels. There was strong support for formalizing and institutionalizing knowledge

transfer mechanisms among agencies/jurisdictions. The vulnerability analysis and flood forecasting tools produced by the study can assist in advancing mitigation and should be used throughout the basin. SPE recommends using tools developed during this study and training/assisting communities to use them effectively. For example, in Quebec, analyses made by the project offices formed by the Ministry of Municipal Affairs and Housing could benefit from the tools. It should be noted that responders tend to view on-the-ground tactics of protection, such as sandbags and Aquadams, as limited methods of last resort in highly localized contexts because of the impacts these measures might generate to neighboring areas (i.e., they could cause flooding elsewhere). The forecasting tools and vulnerability analysis produced by the study can assist emergency managers in the deployment of these on-the-ground tactics. Again, training, updating, and maintaining these tools is necessary. A system for these functions should be developed. The capacity building network recommended in SPE’s recommendation 2 represents one way to go about this work.

**Theme 4:** Theme 4 measures represent policy solutions to flooding. These could include insurance programs for private property owners, financial mechanisms for discouraging development of floodplains and encouraging property owners to relocate outside of flood prone areas, and regional/municipal zoning and land use programs/ordinances that reduce flood risk and promote resilience. There exists strong support for these programs among planners and emergency responders. There was also recognition that these strategies must be highly tailored to local conditions. There was some concern among planners that these programs can be manipulated in ways that promote inequities, and these weaknesses must be addressed. Among residents, there was concern that insurance programs could impact property values and the potential to sell properties. Finally, real estate professionals may oppose floodplain and flood history disclosure requirements, along with insurance programming, as these may complicate real estate transactions and influence the real estate market. Generally speaking, stakeholders desired voluntary and customizable measures, as well as education/awareness raising at the intersection of flooding and property management and land use, rather than top down regulation. Property owners are not always aware of steps they can take to protect residents and structures from flooding. Education could play a role in improving homeowner concern and investment in flood resilience.

**Lever:** During interactions with government agencies in the LCRR, IJC should promote a systems view of the LCRR basin, encourage cross-boundary collaboration, and foster multidisciplinary approaches. This includes promoting upstream/downstream considerations, social and economic concerns, and long and short term time horizons.

**Entry point:** IJC LCRR recommendations and documents, as well as meetings and other communications;

**Pathway:** Canadian and US governments maintain funding to LCRR study, including outreach coordinator roles. Continue communication with state and local decision makers and agency staff.

**Lever:** IJC should recommend that state and local governments adopt resolutions that proclaim the importance of continued participation in dialogue and study, and the importance of the LCRR system to local communities.

**Entry point:** IJC LCRR recommendations and documents, as well as meetings and other communications;

**Pathway:** LCRR PAG and Outreach Coordinators write draft resolution, circulate resolution,

Provincial and State Considerations

promote adoption among local and state governments.

**Lever:** IJC should work with governments of the basin to maintain ongoing dialogue among the United States and Canada regarding flooding in the LCRR, and support implementation of study recommendations.

**Entry Point:** IJC decision making and budgeting process, via continued funding to outreach coordinators and others involved in the LCRR study.

**Pathway:** IJC Commission decision making and budgeting.

**Lever:** IJC should encourage and facilitate the use of study products that do not require additional review and conduct a governance systems integration assessment to identify appropriate mechanisms for using these tools.

**Entry Point:** IJC commission and PAG via communications to governments of the LCRR.

**Pathway:** IJC PAG, continue outreach work with state and regional planning agencies.

**Lever:** IJC should reaffirm that further review of some recommendations must be conducted and that all federal, state/provincial, and local laws and review processes must be followed. This includes National Environmental Protection Act (NEPA) and state level environmental reviews, as well as awareness raising and public input processes. These review processes formalize comprehensive and systematic review of study recommendations by local stakeholders.

**Entry Point:** IJC documents and communications with federal, state and local governments.

**Pathway:** Lead federal, state, local agencies conduct reviews.

**Lever:** IJC should promote a comprehensive and multidimensional view of LCRR basin and flooding.

**Entry Point:** IJC, Study Board and PAG should work with state agencies and legislative/parliamentary representatives to advance a resolution acknowledging the importance of the LCRR system and flood mitigation.

**Pathway:** IJC and LCRR Study Board/PAG identifies state level champions to move resolution.

**Lever:** IJC, Study Board and PAG should work with state/provincial agencies to advocate continued funding and prioritization of flood resilience in LCRR.

**Entry point:** LCRR Study Board and PAG.

**Pathway:** Continue convening TWGs and stakeholders for dialogue.

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**Lever:** IJC Study Board and PAG should maintain educational/outreach efforts with state/provincial agency and elected officials.

**Entry point:** IJC Study Board and PAG.

**Pathway:** LCRR Study Board, outreach coordinators.

**Lever:** IJC Study Board and PAG identify a point person within each relevant state/provincial agency to continue engagement around flood mitigation.

**Entry Point:** IJC LCRR Study Board /PAG.

**Pathway:** Work with New York State Department of Environmental Conservation and Environment Quebec.

**Lever:** IJC Study Board and PAG should encourage state/provincial level environmental assessments prior to implementation of recommendations.

**Entry Point:** Identify lead agencies in Vermont, New York and Quebec

**Pathway:** Environmental assessment process including public comment.

**Lever:** IJC Study Board and PAG encourage local governments to pass local resolution of support, interest and involvement in management of LCRR for purposes of water quantity, quality and resource enhancement.

**Entry point:** Town councils.

**Pathway:** Draft resolution to local boards.

**Lever:** IJC Study Board and PAG encourage appointment a local representative to serve as point person for ongoing relationship building and management.

**Entry point:** IJC LCRR Study Board, PAG.

**Pathway:** Embed request in resolution.

**Lever:** IJC Study Board and PAG encourage local governments to consider impact of flood management and resilience in comprehensive planning, land use planning.

**Entry point:** Local urban/regional planning offices.

**Pathway:** Comprehensive planning process.

	<p><b>Lever:</b> IJC Study Board and PAG encourage local governments to conduct a local ordinance review for policy coherence with flood management and resilience.</p> <p><b>Entry point:</b> Local city councils, planning offices.</p> <p><b>Pathway:</b> Planning, zoning, engineering office.</p>
	<p><b>Lever:</b> IJC Study Board and PAG encourage local governments to participate in knowledge transfer activities.</p> <p><b>Entry point:</b> Local emergency planners and urban/regional planners, real estate professionals.</p> <p><b>Pathway:</b> Host ongoing workshops for planners, emergency responders, real estate professionals.</p>
	<p><b>Lever:</b> IJC Study Board and PAG encourage local governments to use study tools to enhance flood mitigation.</p> <p><b>Entry point:</b> Local emergency planners and urban/regional planners.</p> <p><b>Pathway:</b> Provide training workshops for planners, emergency responders.</p>

## Recommendation 2: Capacity building

<p>Key findings</p>	<p>SPE data illustrated a great deal of heterogeneity among the federal, state/provincial, and local level governments within the LCRR basin. Furthermore, relative to flooding the planning and response capacities of local governments are varied and, in some cases, divergent. The heterogeneity of governance structures in place may inhibit or limit flexibility and innovation, as well as uniform implementation of flood mitigation measures.</p> <p>For these reasons, SPE recommends...</p>
<p>Recommendation 2.</p>	<p><b>That the governments of the basin be encouraged to create an LCRR flood mitigation capacity building network to facilitate implementation of the study's recommendations.</b></p>

## Linkages to Themes 1-4

This recommendation aims to build capacity for implementation among government and nongovernment stakeholders at the federal, state, provincial regional and local scales. Capacity building may include the development of enhanced communication and collaboration pathways among the governments of the basin; professional development for government staff in positions that intersect with flooding and flood mitigation; increased funding for natural hazard planning and response; and improved data and technology management for flood forecasting, among other strategies.

In this case, capacity building would be accomplished through a transboundary network of professionals from relevant federal, provincial, state, regional and local levels. This would include representatives from public, private and nongovernment sectors.

Among the responsibilities that this network may hold are oversight and implementation of adaptive management and monitoring of implementation and flood mitigation measures. This includes adaptive management of structural and nonstructural solutions, including performance monitoring, supporting and improving climate modeling, communicating outcomes to governments of the basin through annual meetings, and supporting ongoing decision-making.

The capacity building network also supports communities in preparing for flooding, including making planning tools available, and assisting communities with preparing for the potential for floods larger than 2011.

The capacity building network should make annual binational updates on implementation and monitoring to governments of the basin.

The capacity building network may facilitate ongoing funding of implementation, generally.

The function of the capacity building network relative to the four Themes would include information sharing, training, planning, adaptive management and monitoring, assessing public support, identifying funding options and assisting in obtaining funds for flood mitigation.

**Theme 1:** The capacity building network is critical for implementing Theme 1 measures. Further research is needed to assess public support for structural measures, as well as strategies and mechanisms for identifying and securing funding. Government officials in the United States indicated that any mitigation strategies that adjust water levels, and do not include a transboundary governance mechanism, are unlikely to receive support. The capacity building network is the mechanism by which these activities can occur.

**Theme 2:** There is a need to maintain partnerships around Theme 2 strategies because they are synergistic with flood mitigation, yet require collaboration and coordination for implementation. The capacity building network is a place where coordination can occur, skills can be enhanced and planning is accomplished.

**Theme 3:** Flood response planning and forecasting can be enhanced with information sharing, training, and assistance finding/obtaining funding. These activities are central objectives of the capacity building network.

**Theme 4:** The capacity building network will assist local and regional planning agencies to develop flood resilient planning strategies through education, knowledge transfer, research and other strategies. This will build local officials' abilities for integrating flood resilience into comprehensive plans, land use plans, and other land use programs and regulations. The capacity building network will also serve as a place for building communications strategies and skills.

<p><b>Transboundary Notes/Details</b></p>	<p><b>Lever:</b> SPE recommends the creation of a capacity building network to facilitate information sharing, training, risk communications and messaging, integrative and transjurisdictional planning, acquisition of funding, and education and outreach to private sector, property owners, and other individuals.</p> <p><b>Entry Point:</b> LCRR Study Board and PAG in partnership with existing organizations in the basin.</p> <p><b>Pathway:</b> This network should be coordinated by, and situated within, existing organizations involved in management of the LCRR basin. This network would include representatives from federal, state/provincial, and local level governance organizations and agencies, as well as the scientific communities. It would represent diverse interests including those of upstream and downstream communities; public and private sector stakeholders; environmental, recreational and economic interests, and others. The network should include a clear mandate from relevant federal and state agencies, and robust reporting and monitoring requirements.</p>
<p><b>Provincial and State Considerations</b></p>	<p><b>Lever:</b> The LCRR Study Board and PAG should encourage provincial/state governments and agencies to appoint representatives to participate in the capacity building network. It should be noted that these representatives and the network itself will not have approval and decision making authority for mitigation actions. Those responsibilities sit with specific agencies in the United States and Canada. Representatives to the network may come from these agencies, among others, but would not speak for the agencies themselves. The network would be advisory only.</p> <p><b>Entry Point:</b> LCRR Study Board and PAG in coordination with lake-related organizations.</p> <p><b>Pathway:</b> IJC LCRR Study Board and PAG should work with state/provincial governments and facilitate the process of creating this deliberative and advisory body.</p>
<p><b>County and Municipal Considerations</b></p>	<p><b>Lever:</b> The LCRR Study Board and PAG should encourage regional/local governments and agencies to appoint representatives to serve on the network</p> <p><b>Entry Point:</b> LCRR Study Board and PAG in partnership with lake-related organizations.</p> <p><b>Pathway:</b> IJC Commissioners work with state/provincial governments, draft Transboundary Flood Network (TFN) bylaws, and facilitate the process of creating this deliberative and advisory body.</p>

### Recommendation 3: Consider flood mitigation within the contexts of geographic, governance and temporal scales.

<b>Key findings</b>	<p>SPE's research demonstrated that the social and economic impacts of flooding are not uniform throughout the basin. In Vermont and New York, residents showed a higher level of concern for tributary flooding than lakeshore flooding, for example. This means that quick-rising floods, high rates of flow, road washouts and the possibility of loss of life to humans and livestock may be priorities for mitigation in New York and Vermont. Quebec, on the other hand, faces slower rising water levels that impact a wider range of residents and for longer periods of time. In the context of lakeshore flooding, the long-term economic losses in Quebec are more severe than in the United States. Differences in impacts are visible at the community and neighborhood levels, as well. There exists social-demographic variation across the basin that influences the risk profile and vulnerability of particular communities, neighborhoods and even at the scale of streets. Additionally, the levels of government planning, emergency preparation, and response capacities of local governments vary.</p> <p>For these reasons, SPE recommends that...</p>
<b>Recommendation 3.</b>	<p><b>Flood mitigation measures should be considered within the contexts of geographic, governance and temporal scales.</b></p> <p>Through the lens of geographic scales, mitigation measures should bring relief to upstream and downstream stakeholders, as well as tributary and lakeshore community members. Care should be taken to ensure that the benefits and costs of mitigation are spread equitably across the basin and at the community scale. Through the lens of governance, flood mitigation measures should be nested within existing vertical and horizontal governance structures and networks. When it comes to funding, implementation and communication of a specific mitigation measure, a direct line-of-site from federal, to state/provincial, to local level government should be visible. Horizontal networks, such as those between regional emergency management or planning offices, exist and can assist implementation. Temporal scales should also be considered in implementation of flood mitigation measures. Short, medium and long-term objectives should be set, as well as monitoring protocols and scheduled assessments of implementation and effectiveness. Consideration of the impacts of flooding and mitigation measures on future generations should be considered to ensure that decisions made in the present do not reduce opportunities for social, ecological and economic success of future residents to the LCRR basin.</p>
<b>Linkages to Themes 1-4</b>	<p><b>Theme 1:</b> Theme 1 measures represent engineered measures. Those receiving the most attention in the study are located in Quebec, near SJSR. Data suggested that professional emergency responders favor these interventions more strongly than stakeholders with other interests in flood mitigation. Preliminary data suggested that residents and emergency responders in Quebec may support these measures more strongly than their counterparts in the United States. Stakeholder concerns regarding structural measures included environmental impacts, costs, equitable distribution of benefits, and ongoing management/decision making. Further assessment should be conducted to determine the impacts of these measures in the immediate vicinity of the interventions, as well as at distant upstream and downstream locations. These studies should explore the geographic and economic equitability of benefits and costs associated with these interventions. Should structural measures be developed, they must be accompanied by a transboundary governance system because of the up/downstream impacts that come with structures that regulate water levels.</p>

**Transboundary  
Considerations**

**Theme 2:** Theme 2 measures represent the creation of new upland flood storage and other nature-based mitigation measures. Stakeholders showed support for these measures. Existing floodplains and wetlands play an important role in mitigating floods, and further conservation and restoration efforts should be maintained, as they are synergistic with flood mitigation. Existing government programs, efforts from nongovernment organizations, and public support should be leveraged to accelerate implementation of Theme 2 recommendations.

**Theme 3:** Theme 3 measures represent flood forecasting and emergency response measures. There is strong support for these measures among the professional emergency management community. Governance scales may be the most relevant to this Theme, as the LCRR study's forecasting tools take considerable training and maintenance. Furthermore, there is a need for building capacity for emergency planning throughout the basin. Consideration must be given to how these tools are housed within existing agencies, and how they are distributed vertically and horizontally. Temporal goals for distribution, updating and maintenance, and training should be set, as well as long-term funding mechanisms.

**Theme 4:** Theme 4 measures represent planning and policy for flood adaptation and resilience as well as communication around flood risk. There is support for municipal and regional planning to address flooding within the professional planning community. Local comprehensive planning, zoning, land use and building codes represent potential avenues for flood resilient development at the local level. Property owner education is also a way for enhancing local level resilience. Vulnerability studies at the building scale should be promoted and supported and adaptation strategies provided with them. Neighborhood scale adaptation strategies should also be considered. Support for real estate disclosure and insurance programming is more complicated. An individual's attitude towards these interventions depends on their past experience with flooding. There will likely be push back on real estate disclosure and insurance programming from agents as well as sellers, and these systems are ineffective when they operate on a voluntary basis. When considering the intersection of geographic scales and Theme 4 measures such as planning, zoning and building codes, it is important that the LCRR study provide broad level recommendations to encourage and allow for flood adaptation and resilience at local levels, but that local decision makers and stakeholders shape the programs and policies implemented within their communities. When it comes to insurance programming, there is a need to consider broader scales (including outside the LCRR basin), as these programs require involvement from significant numbers in order to provide meaningful prevention incentives and returns on investment to policyholders. Consideration must also be given to the ways that best practices in planning for flood resilience and insurance programming are transferred from higher levels of government to the local scale. Finally, short, medium and long term goals, monitoring and feedback schedules should be developed. Assessment of short, medium and long term impacts of flood mitigation decisions must be conducted. Care should be taken to ensure that the agency and opportunities of future generations of residents in the LCRR are not limited by decisions made today.

**Lever:** Establish a flood mitigation capacity building network to facilitate ongoing dialogue, assessment, education and training around flood mitigation, adaptation and resilience at transboundary, federal, state/provincial and local levels. This is especially critical for generating binational support for Theme 1 measures.

**Entry Point:** Identify already existing organizations to host and participate in this structure.

**Pathway:** IJC LCRR Study Board and PAG identify appropriate organizations for inclusion, develop mission, workplan, structure including oversight and ongoing, sustainable funding mechanism. Ensure representation includes federal, state/provincial and local interests.

**Lever:** All work of the capacity building network must be considered through the lenses of geographic, governance and temporal scales.

**Entry Point:** The network's makeup/representation; organizational structure, mission and workplan; funding mechanism must represent difference scales.

**Pathway:** Facilitated development with oversight from LCRR Study Board to ensure inclusion of geographic, governance and temporal scale in all work.

**Lever:** With support from LCRR Study Board and PAG, the capacity building network should develop a reporting, monitoring and assessment program that assesses progress and impacts towards flood resilience goals. Assessment should address ecological, economic, social and governance impacts at watershed, subwatershed, regional and community scales. Assessment should occur along short, medium and long term time horizons. The impacts of flooding and flood mitigation on future generations of residents to the LCRR should be considered.

**Entry Point:** Capacity building network should develop and implement monitoring protocol.

**Pathway:** Convene local and regional experts to develop monitoring protocol.

**Lever:** LCRR Study Board and PAG should encourage use of best practices in municipal governance and planning related to flooding. Best practices should be used as the basis for local level mitigation decisions. Local governments and stakeholders should be able to tailor the implementation of best practices to local contexts.

**Entry Point:** Flood mitigation capacity building network. Local planning, zoning and building codes; local level planning offices, town supervisors and councils.

**Pathway:** Convene periodic workshops for planning professionals. Conferences for local government and planning officials already exist and may be appropriate venues.

**Lever:** LCRR Study Board and PAG should encourage development of a communications plan that uses best practices in risk communications. Best practices in insurance programming should also be considered.

**Entry Point:** Capacity building network. Regional NGOs already do some landowner outreach around environmental issues, including stormwater, water quality, erosion, agricultural practices and other topics. Some of these may be appropriate outlets. Real estate professionals, including realtors, lending banks and insurers, may be appropriate for education related to home risks and flood insurance.

**Pathway:** Network with LCRR study partners to identify appropriate organizations and institutions. Convene workshops around these topics.

**Lever:** LCRR Study Board and PAG should encourage next phase research into financial mechanisms for enhancing flood resilience among property owners, including insurance programming.

	<p><b>Entry Point:</b> This would be sponsored by the flood mitigation capacity building network.</p> <p><b>Pathway:</b> Convene workshops around these topics with property owners, regional/municipal governance staff, provincial/state agency personnel and others.</p>
<p><b>Provincial and State Considerations</b></p>	<p><b>Lever:</b> Identify personnel for representing appropriate state/provincial level agencies and organizations on the capacity building network.</p> <p><b>Entry Point:</b> LCRR Study Board and PAG identify personnel to sit on this network</p> <p><b>Pathway:</b> Ensure the board represents state/provincial interests.</p> <p><b>Lever:</b> Participate in all activities of the capacity building network.</p> <p><b>Entry Point:</b> Capacity building network</p> <p><b>Pathway:</b> TFN develops mission, bylaws, meeting schedule, workplans, etc. for monitoring, outreach/education/training, and funding.</p>
<p><b>County and Municipal Considerations</b></p>	<p><b>Lever:</b> LCRR Study Board and PAG identify personnel for representing appropriate agencies and organizations on the capacity building network.</p> <p><b>Entry Point:</b> IJC Commissioners and LCRR Study Board and PAG identify personnel to serve on this network.</p> <p><b>Pathway:</b> Ensure the board represents county/municipal interests.</p> <p><b>Lever:</b> Participate in all activities of the capacity building network.</p> <p><b>Entry Point:</b> Capacity building network.</p> <p><b>Pathway:</b> Capacity building network develops mission, bylaws, meeting schedule, workplans, etc. for monitoring, outreach/education/training, and funding.</p>

## Recommendation 4: Adaptive management

<p><b>Key findings</b></p>	<p>The LCRR basin is dynamic. Ecological, social, economic and governance systems change. The data collected by SPE and others involved in the LCRR study represent a snapshot of the LCRR. Knowing that conditions change, it is vital for successful implementation of LCRR study recommendations that future data are able to be compared to the data collected in 2017-2022, and that data can be used to set benchmarks and track progress. Furthermore, as implementation occurs, new variables for change are inserted into the LCRR system. These changes will have intended and unintended consequences that need to be tracked, and in some cases addressed through amplification or remediation.</p> <p>Recognizing this, SPE recommends that...</p>
<p><b>Recommendation 4</b></p>	<p><b>The LCRR study recommendations should be implemented through an adaptive management process.</b></p> <p>Adaptive management is a process of implementation that takes a controlled and experimental approach to ecological management. Implementation occurs in small scale pilot projects where variables can be controlled. Monitoring occurs before, during and after implementation and the results of monitoring are used to adjust implementation in incrementally larger scale projects. In some situations, pilot projects may occur <i>ex situ</i>, through computer models, simulations or other forecasting activities, when controlled <i>in situ</i> field experimentation is not possible. Adaptive management takes an incremental and phased approach to implementation and includes stakeholder involvement.</p> <p><b>Theme 1:</b> Theme 1 represents engineered solutions to flooding. In an adaptive management context, the ecological impacts of these solutions should be robustly monitored prior to implementation. Social, economic and governance implications must also be monitored and discussed. A robust set of pre- and post-performance indicators must be developed. Under the current scenarios, removal of human artifacts should occur in incremental steps with monitoring in between. Construction of the submerged weir should occur as a third phase. Construction of the Chambly Canal diversion may be a fourth phase. All Theme 1 measures should be implemented incrementally and be reversible if negative unintended consequences occur.</p> <p><b>Theme 2:</b> Theme 2 represents the creation of new structures for water storage. This approach has been modeled to show insufficient capacity for significant improvement in flood conditions along the lakeshore and Richelieu River, at a reasonable cost. However, wetland conservation and floodplain storage programs are underway in the LCRR, albeit funded by other organizations and for other purposes. Monitoring should continue to verify the conclusion that new upland storage does not provide significant benefits to flood management, and/or adapt if future data shows promise in this Theme.</p> <p>In Quebec, Regional Wetland and Water Management Plans will bring updated information, favor dialogue between stakeholders and help identify actions.</p> <p><b>Theme 3:</b> Theme 3 represents flood forecasting, flood response and emergency management improvements. Adaptive management should include monitoring, benchmarking and performance assessment of these activities as they occur. Indicators should include ecological, social, political and economic factors. Organization effectiveness, communication and information/resource flows should also be considered. Hazards can be an opportunity for learning collectively. A “lessons learned” exercise should be carried in the post-flood phase,</p>
<p><b>Linkages to Themes 1-4</b></p>	

	<p>consisting of a retrospective analysis of the management of a flooding episode.</p> <p><b>Theme 4:</b> Theme 4 includes policy and planning actions at the regional, municipal and private sector scale. These programs should be implemented with flexibility and through pilot projects. Pilot projects need to be in compliance with existing and new regulations, and involve innovative adaptation approaches. Some regulations may have to be adapted to allow these pilot projects. Adaptive management should include monitoring, benchmarking and performance assessment of these activities as they occur. Indicators should include ecological, social, political and economic factors. Organization effectiveness, communication and information/resource flows should also be considered. All programs/policies should be implemented incrementally and be reversible.</p>
<p><b>Transboundary Considerations</b></p>	<p><b>Lever:</b> SPE recommends that the Study Board and PAG conduct a thorough review of best practices in adaptive management, and these practices be followed in development of the LCRR adaptive management process.</p> <p><b>Entry Point:</b> The adaptive management system should be overseen by the capacity building network described elsewhere in this report. There would be two advisory boards within the adaptive management program 1) monitoring group, composed of natural, physical and social scientists, to oversee monitoring. 2) management group, composed of resource managers, who will take the data and results from monitoring, and generate recommendations for future management. These groups would convene twice annually to develop, implement and refine the adaptive management process.</p> <p><b>Pathway:</b> Implementation of LCRR recommendations should occur through small scale experimental and pilot projects that are concurrent with a robust monitoring program. Monitoring should include ecological, social, economic and governance performance indicators. Data should be made publicly accessible. As data are collected and analyzed, resultant learning should be presented to decision makers and managers, who make subsequent decisions about implementation. This completes a feedback loop to decision making. Overall, implementation occurs in incremental and reversible steps, so that if monitoring illustrates unintended consequences or a failure to reach goals, damage can be reversed and minimized. Oversight of the monitoring and decision-making processes should be separate. Firewalls of influence should be constructed so that the experimental design and monitoring processes are consistent with best scientific and monitoring practices. It is important to note that monitoring should not only address implementation of mitigation measures, but also assess the effectiveness of organizational structures, communication, funding and social elements of flood management.</p>
<p><b>Provincial and State Considerations</b></p>	<p><b>Lever:</b> LCRR Study Board and PAG should assist Quebec, New York and Vermont to appoint equal numbers of representatives to the monitoring and management groups, within the adaptive management process.</p> <p><b>Entry Point:</b> Capacity building network will facilitate adaptive management, and convene an adaptive management advisory committee.</p> <p><b>Pathway:</b> Appoint biological/ecological, physical and social scientists to the monitoring committee. Individuals should have scientific backgrounds and would likely be employed in educational, research and governance institutions. Appoint individuals to the management group. Individuals may come from governance, education, research or private sector institutions. Funding to the network should be provided by the governments of the United States and Canada.</p>

**County and Municipal Considerations**

**Lever:** LCRR Study Board and PAG should develop monitoring metrics that represent the unique characteristics and contexts of Vermont, New York and Quebec.

**Entry Point:** Monitoring group, within adaptive management system and Transboundary Flood Network.

**Pathway:** Review current monitoring programs in place within each state and province, recommend improvements and determine a suite of indicators.

**Lever:** LCRR Study Board and PAG should assist the communities in Quebec, New York and Vermont to appoint equal numbers of representatives to the monitoring and management groups, within the adaptive management process.

**Entry Point:** Capacity building network will facilitate adaptive management, and convene an adaptive management advisory committee.

**Pathway:** Appoint natural, physical and social scientists to the monitoring committee. Individuals should have scientific backgrounds and would likely be employed in educational, research and governance institutions. Appoint individuals to the management group. Individuals may come from governance, education, research or private sector institutions.

**Lever:** LCRR Study Board and PAG should develop monitoring metrics that represent the unique characteristics and contexts of municipalities in Vermont, New York and Quebec.

**Entry Point:** Monitoring group, within adaptive management system and capacity building network.

**Pathway:** Review current monitoring programs in place within each state and province, recommend improvements and determine a suite of indicators.

## Recommendation 5: Equity.

<b>Key findings</b>	<p>SPE data illustrate a lack of uniformity in the vulnerability and risk profiles of regions and communities in the LCRR basin. Vulnerability is increased when residents with atypical health and medical needs, reduced resources, infant and senior age classifications, and inadequate housing live within flood inundation zones. Furthermore, the planning and response capacities of municipalities and counties are not uniform. Therefore, there is a need for considering the ways that the benefits and costs of flood management are spread among residents and communities in the basin, and to ensure that these are spread equitably.</p> <p>For these reasons, SPE recommends that...</p>
<b>Recommendation 5.</b>	<p>Implementation take an explicit, equity-oriented lens to monitoring flooding and flood mitigation to facilitate the equitable distribution of benefits and costs throughout the LCRR. Geographic, social, procedural and intergenerational equity should be considered.</p>
<b>Linkages to Themes 1-4</b>	<p><b>Theme 1:</b> Theme 1 represents engineered solutions to flood mitigation. Because these strategies directly influence water levels, flow rates and the geography of flooding, geographic equity is an important consideration. Upstream and downstream dynamics must be considered. Furthermore, minor and moderate Theme 1 strategies address flood impacts in particular places, while excluding others. Prioritization of the locations that receive mitigation should be examined through the lens of equity. Finally, Theme 1 measures represent an allocation of public funds that will protect private interests in some locations, while private property owners in other locations will be forced to bear the expense of flood mitigation themselves. Concerns such as these should be considered relative to Theme 1 mitigation measures.</p> <p><b>Theme 2:</b> Theme 2 measures represent watershed storage. These mitigation measures have been determined to insufficiently address flooding along Lake Champlain and the Richelieu River, and thus have not received further consideration.</p> <p><b>Theme 3:</b> Theme 3 solutions represent flood forecasting and emergency response. Forecasting and flood response planning should consider the LCRR study's vulnerability analysis, as this analysis highlights response needs based on the vulnerability characteristics of residents and property owners at hyper-local levels.</p> <p><b>Theme 4:</b> Theme 4 measures represent insurance programs and municipal scale planning initiatives to enhance resilience, and manage risk by managing floodplain occupancy and uses. SPE data illustrated that at the municipal level, flood resilience and adaptation policies can sometimes be manipulated, inconsistently implemented or otherwise unfairly used (or not used), so that the benefits and burdens of these policies are not spread equitably. Local level policies can also create inequities among residents and property owners in divergent income classes, as well as among homeowners and renters. Strong methods to assess vulnerability and resilience should help build locally adapted projects in an equitable manner. As these policies are reviewed and implemented, procedural equity must be achieved by ensuring community input in policy development. Planning standards should incorporate the principle of accountability and sanctions to raise the awareness and responsibility of municipal actors. Financial and technical support should be provided with these responsibilities. Finally, intergenerational equity considers whether decisions made today place unfair burdens on future generations. Policies should be viewed through this lens.</p>

<p><b>Transboundary Considerations</b></p>	<p><b>Lever:</b> The capacity building network should explore best practices in the institutionalization of equity considerations in environmental decision making and develop a framework for employing these features.</p> <p><b>Entry Point:</b> Flood mitigation capacity building network.</p> <p><b>Pathway:</b> There is a need for equity among upstream and downstream communities; tributary and lakefront communities; large and small population centers; property owners and renters; higher and lower income earners; social-demographic groups including first nations communities; and public and private interests.</p>
<p><b>Provincial and State Considerations</b></p>	<p>See below. Equity concerns at the provincial and state levels mirror those at the county and municipal levels.</p>
<p><b>County and Municipal Considerations</b></p>	<p><b>Lever:</b> As the LCRR capacity building network works with local governments throughout the basin, it should include training around equity issues among its knowledge transfer and other educational endeavors.</p> <p><b>Entry Point:</b> LCRR flood mitigation capacity building network.</p> <p><b>Pathway:</b> Theme 1 measures may create unintended consequences that are only visible at the local level, through adjustments to water levels and flow rates. These must be identified, communicated and mitigated. Theme 3 response planning must consider the vulnerability analysis, and focus efforts on vulnerable populations as well as economic loss. When considering Theme 4, at the local level there are concerns that local boards do not always implement local policies consistently and fairly. In particular, well-connected residents and property owners are able to negotiate variances to policies that other residents are forced to comply with. Theme 4 must be implemented proactively, fairly and consistently. This is an opportunity to convert obstacles into best practices through knowledge and funding.</p>

## Recommendation 6. Theme 1 diversions

<p><b>Key findings</b></p>	<p>The additional benefits (more specifically, damage prevention) that stem from diversion measures do not justify the additional costs.</p>
<p><b>Recommendation 6.</b></p>	<p>Based on the results of the cost-benefit analysis, SPE does not recommend implementing Theme 1 measures that use any type of diversion (minor or major) at the Chambly Canal.</p>
<p><b>Transboundary Considerations</b></p>	<p>Not applicable.</p>

## Recommendation 7. Event frequency

Key findings	Tailored insurance programs are more efficient and adapted than structural measures in the low frequency/extreme events space.
Recommendation 7.	SPE recommends the usage of Theme 1 measures that can mitigate frequent events, instead of focusing mitigation efforts solely on low frequency but extreme events.
Transboundary Considerations	Not applicable.

**SPE’s final recommendation is intended for operationalization throughout the IJC’s binational Jurisdiction.**

## Recommendation 8. Institutionalize social, political and economic research

Key findings	<p>The LCRR study represents the first time that an IJC reference has included study of social and political acceptability and feasibility in its exploration and review of flood mitigation. SPE’s research included a variety of questions and methods that were used to inform and narrow the scope of the study broadly, and shape the final recommendations.</p> <p>For these reasons, SPE recommends...</p>
Recommendation 8.	That ongoing and future IJC work in the LCRR basin include study and review of social, political and economic Themes. Furthermore, SPE suggest the IJC integrate SPE Analysis Groups in all future references throughout the agency’s jurisdiction.
Transboundary Considerations	<p><b>Lever:</b> IJC and LCRR Study Board continue to include and fund SPE in future phases of LCRR study work.</p> <p><b>Entry Point:</b> IJC Commissioners.</p> <p>Pathway: Development of references and budgets include SPE Analysis Group.</p> <p><b>Lever:</b> IJC integrate SPE Analysis Groups into future references.</p> <p><b>Entry Point:</b> IJC references.</p> <p><b>Pathway:</b> IJC Commissioners pass resolution to include SPE in future references.</p>

