BUILDING COLLABORATION ACROSS

THE GREAT LAKES – ST. LAWRENCE RIVER SYSTEM

AN ADAPTIVE MANAGEMENT PLAN

FOR ADDRESSING EXTREME WATER LEVELS

Breakdown of Roles, Responsibilities and Proposed Tasks

PREPARED BY

THE INTERNATIONAL GREAT LAKES – ST. LAWRENCE RIVER ADAPTIVE MANAGEMENT TASK TEAM

FOR

THE INTERNATIONAL JOINT COMMISSION

FINAL REPORT
MAY 30, 2013

Note to Reader: *The International Great Lakes-St. Lawrence River Task Team was established by the International Joint Commission and is comprised of an equal number of members from the United States and Canada. Members of the Task Team serve at the pleasure of the Commission and are expected to be full participants in all activities of the Task Team. As with all IJC Boards and Task Forces, the Task Team members serve the Commission in their personal and professional capacity, not as a representative of their agencies or employers.*

Executive Summary

In March 2012, the International Upper Great Lakes Study (IUGLS) Board concluded a five year study reviewing the regulation of water levels on the upper Great Lakes. In follow-up to recommendations made, the International Joint Commission (IJC) issued a directive to the International Great Lakes-St. Lawrence River Adaptive Management Task Team (Task Team) on May 29, 2012 to develop an Adaptive Management Plan for the Great-Lakes St. Lawrence River system. Furthermore, on April 15, 2013 the IJC provided their report to governments regarding the International Upper Great Lakes Study and endorsed the implementation of a comprehensive Adaptive Management approach supported by science and monitoring. The IJC noted their intention to provide further recommendations based upon the final report of their Task Team.This Adaptive Management Plan (AM Plan) addresses the IJC Directive and provides the details necessary to further inform governments on a strategy forward for adaptive management.

Background

Climate change poses new challenges for adapting to fluctuating Great Lakes water levels. Although the future is not certain, increases in temperature and alterations in patterns of precipitation are likely to affect water levels in the Great Lakes-St. Lawrence River system. There is strong evidence that in the future we will likely experience more extreme water levels – both high and low – that are outside the historical range experienced over the past century. Indeed, record low water levels occurred in January 2013 on Lakes Michigan and Huron.

Water level extremes can be addressed in two ways, either by managing water levels through dams or other structures, and/or by managing how we respond to the impacts of those water level changes. Our current approach for managing water levels is the regulation by the IJC of outflows from Lake Superior and Lake Ontario through dams on the St. Mary's River at Sault Ste. Marie and at the Moses-Saunders Dam at Cornwall/Massena on the St. Lawrence River. Outflows are controlled according to regulation plans that specify the rules for how much water can be let out under a range of conditions. However, the ability to alter lake levels through the regulation plans is limited, especially for the upper Great Lakes, and is dominated by changes in water supply that are driven by climatic factors such as precipitation and temperature. Periods of very wet or very dry conditions can produce large changes in water levels over time. Water level extremes can have profound effects on commercial shipping, hydropower generation, recreational boating, coastal communities, tourism, municipal and industrial water uses, and wetlands, fisheries and wildlife. Because the climate is changing and our ability to alter lake levels through lake regulation is limited, a broader, more comprehensive approach to manage the impacts of changing lake levels is needed.

Collaborative, integrated adaptive management offers an approach that helps address the uncertainties of an evolving future associated with climate change and the potential for extreme water levels and associated impacts. Adaptive management is a structured, iterative process for continually improving

management results by learning from the outcomes of previous policies and practices. The most recent studies on the regulation plans – the International Upper Great Lakes Study (IUGLS) and the Lake Ontario-St. Lawrence River (LOSLR) study – both concluded that adaptive management is the best way to address the uncertainties associated with climate change and the potential for extreme water levels and their associated impacts. The IUGLS Board recognized in their study that adaptive management provides a strong scientific basis for developing solutions to extreme water level conditions since it integrates long-term monitoring and modelling to assess the effectiveness of current plans, policies and practices for managing water level impacts. The Task Team was given a mandate by the IJC to develop a detailed Adaptive Management Plan that will evaluate and prioritize adaptive management activities in the Great Lakes – St. Lawrence River basin to address future extreme water levels. This document outlines that effort.

The Adaptive Management Plan (AM Plan)

The AM Plan is a practical approach for implementing the IUGLS Board's recommendation to apply an adaptive management strategy to address future extreme water levels in the Great Lakes-St. Lawrence River system. The Plan provides a new approach to addressing water level issues, one that is based on collaboratively working with partners across the Great Lakes-St. Lawrence system to gather and share critical information over time, assess the information with state-of-the art tools, develop adaptation strategies, measure success in managing the impacts of extreme water levels and adapt accordingly. Its goal is to support decision-making aimed at reducing the impacts to communities, the economy and the environment associated with extreme water levels.

The proposed AM Plan has two interconnected elements:

1. Ongoing review and evaluation of the effectiveness of the regulation plan rules at meeting their intended objectives; and
2. Collaboration on developing and evaluating solutions to problems posed by extreme water level conditions that cannot be solved through lake regulation alone.

The first element of adaptive management – on-going monitoring and evaluation of the regulation plans – is well defined because the IJC has a clear leadership role. Also, the IJC can identify the key indicators needed to monitor and evaluate the performance and effectiveness of the regulation plans and adapt the rules governing those plans if necessary. The second element will be a greater challenge. Water level impacts are widespread and can vary by sector and geography; furthermore many agencies, jurisdictions and stakeholders are involved in responding to water level extremes. No one agency manages the issues associated with water level impacts and therefore a more intensive level of collaboration is needed than has been seen to date on the issue. The Task Team strongly recommends the adaptive management approach for developing and evaluating solutions to problems posed by extreme water level conditions that cannot be solved through lake regulation alone. However, it recognizes that there are many questions with respect to implementation. Accordingly, the Task Team recommends developing some Adaptive Management Pilots (AM Pilots) to test and refine methods of collaboration outlined in this report. These pilots would address pressing Great Lakes-St. Lawrence

River water level issues at the local or regional scale. Evaluation of these pilots would provide insights and improve our capabilities for the broader application of adaptive management.

Two new bodies are proposed to implement the AM Plan: an *Adaptive Management Committee* (the AM Committee) reporting to the three Great Lakes Boards of Control and a *Great Lakes-St. Lawrence River Levels Advisory Body* (LAB). The AM Committee, reporting to the Boards of Control, would oversee the on-going assessment and evaluation of the regulation rules for the outflows of both Lake Superior and Lake Ontario. It would perform in an operational manner, although it would be focused on mid-term to long-term water level regulation decisions and not within-year decisions. Activities would include monitoring of key performance indicators on Lake Ontario, the St. Lawrence River and the St. Mary's River; the on-going use, maintenance and updating of tools used in evaluating the regulation plans; and assessment of other operational requirements of the Boards (such as an on-going assessment of the effectiveness of ice booms). The AM Committee would be supported by technical expertise from the jurisdictions that are currently represented on the Boards of Control. It would not address system-wide initiatives or exclusively develop new research or modelling tools, or develop major updates to models.

A *Levels Advisory Body* (LAB) is proposed to guide the broader collaborative activities that go beyond lake level regulation and relate to responding to extreme water level issues. The IJC would convene the LAB but the LAB would rely on the willingness of agencies and stakeholders to collaborate under its auspices to inform decisions and implement the AM Plan. The LAB would engage agencies, organizations and institutions from across the Great Lakes – St. Lawrence River system in five system-wide networks for the following thematic areas:

I. **Hydroclimate Monitoring and Modelling** to improve knowledge on water balance and water supply, the forecasting of net basin supply, lake levels and climate modelling;
II. **Performance Indicators and Risk Assessment** to assess risks of extreme water levels to shoreline property, commercial navigation, municipal and industrial water uses, recreational boating, ecosystems, hydropower and other interests;
III. **Evaluation and Decision Tools** to maintain, update and improve the tools needed for the evaluation of regulation plans over time and develop new tools to support decision-making on potential responses to extreme water levels;
IV. **Information Management and Distribution** to facilitate the sharing of water level-related data and information among the Great Lakes-St. Lawrence River system community; and
V. **Outreach and Engagement** to educate and establish two-way communication on water level-related issues throughout the Great Lakes-St. Lawrence River system community.

The LAB would facilitate collaboration on adaptive management by defining and prioritizing tasks, leveraging resources, promoting mechanisms for accountability and tracking, and communicating the successes of the AM Plan. The LAB's work would include identifying data collection needed to support on-going risk assessment that may be more efficiently and cost effectively carried out collaboratively on a system-wide or large-scale basis (e.g., digital nearshore data collection) and advising the IJC on the development of updates to bi-national, system-wide impact models that support evaluation and

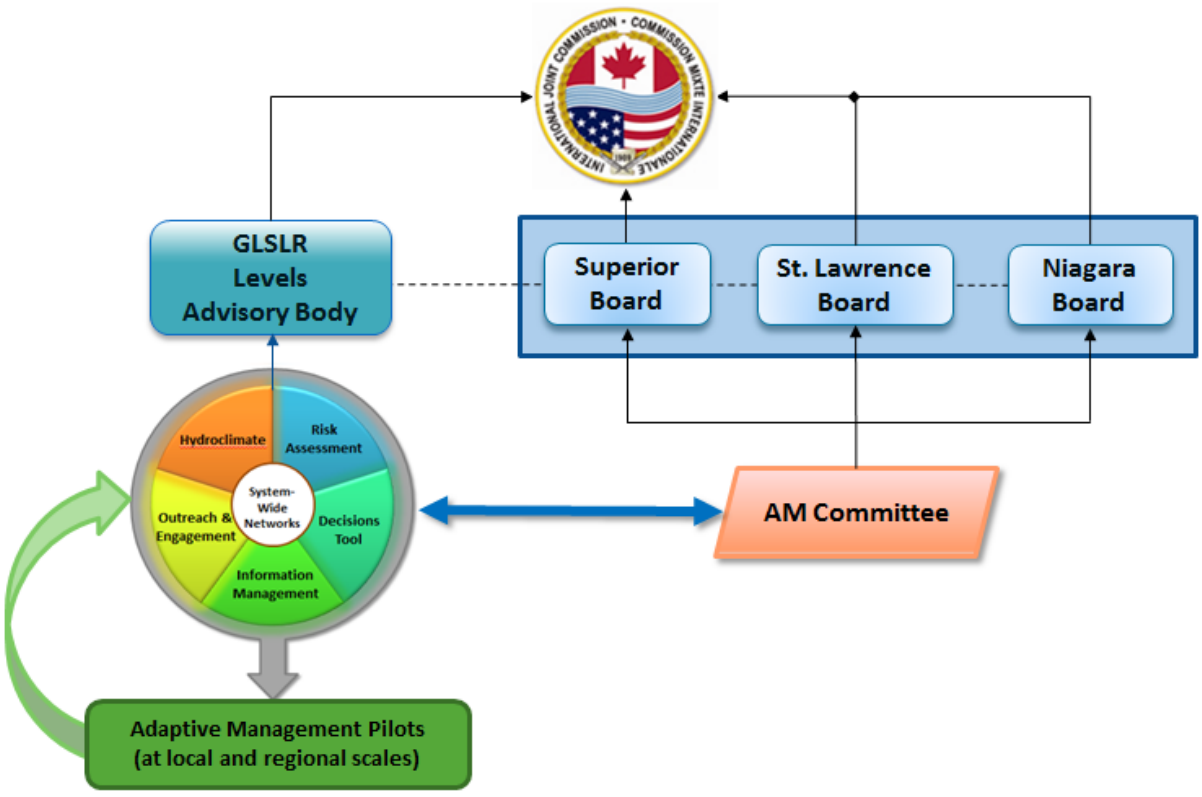
decision-making. The LAB would also promote linkages between water levels and water quality and make the necessary connections across the five system-wide networks.

To undertake specific tasks of the AM Plan, the LAB would utilize existing mechanisms (existing Great Lakes – St. Lawrence River partners and their programs) through the five system-wide networks, or form new task teams if existing mechanisms do not exist. The goal would be to carry out the AM Plan for system-wide initiatives as resources and opportunities arise, always striving to be up-to-date on system-wide trends and changes. The LAB would report its progress in a forum provided by the IJC; however, the IJC would not have any special authority over the participating agencies or stakeholders.

The LAB would use collaborative Adaptive Management Pilots to test components of the AM Plan on a more focused and manageable scale. The goal of the LAB for these Pilots would be to support, assist, and advance locally or regionally initiated projects by providing informational tools, knowledge, and collaborative methods to derive optimal solutions. While the specific role of the LAB would likely vary significantly from pilot to pilot, depending on the site-specific water level issues and the amount/type of available technical support, the LAB would ensure the principles and process of adaptive management are consistently applied.

The overall goal of the AM Plan is to support decision making aimed at reducing the impacts to communities, the economy and the environment in the Great Lakes-St. Lawrence River system from extreme water levels.

Proposed Adaptive Management Framework



Task Team Recommendations:

The Adaptive Management Task Team recommends that the IJC explore with governments the best options for undertaking the full Adaptive Management (AM) Plan. Specifically, the IJC should:

1. Issue a directive to the Boards of Control to implement adaptive management of lake regulation and through this directive, establish an AM Committee reporting to the Boards of Control. This AM Committee would maintain tools developed as part of the International Upper Great Lakes and Lake Ontario – St. Lawrence River studies and provide Boards of Control with technical and logistical support for this new, continuous monitoring and evaluation process.

2. Make a request to governments for a formal standing reference to address on-going water level-related issues through adaptive management. Specifically, this reference should give the IJC the authority to convene a collaborative forum referred to by the Task Team as the Great Lakes-St. Lawrence River Levels Advisory Body (LAB) for undertaking the AM Plan.

3. With or without a reference, the IJC should convene the Levels Advisory Body where individuals would participate at the invitation of the IJC, but would do so with the commitment and support of their agencies and jurisdictions. The LAB should be tasked with:

    a. Conducting system-wide planning based on the five networks outlined in the AM Plan:

        i. Hydroclimate monitoring and modelling
        ii. Performance indicators and risk assessment
        iii. Evaluation and decision tools
        iv. Information management and distribution
        v. Outreach and engagement

    b. Initiating adaptive management pilots as soon as possible to test and refine methods of collaboration in addressing pressing issues on a local or regional scale

4. Work with governments to seek funding for supporting the proposed on-going system-wide AM Plan.

Acknowledgements

The Adaptive Management Plan was developed by the bi-national Great Lakes-St. Lawrence River Adaptive Management Task Team (Task Team) with important staff support as listed in Appendix 2 and in consultation with the Lake Ontario-St. Lawrence River Working Group. In developing the Plan, the Task Team received helpful advice and suggestions from a bi-national Advisory Group of Great Lakes-St. Lawrence River agencies and organizations as listed in Appendix 3. As well, the Task Team also received comments through their public comment period (March 15-April 15). The Task Team Chairs greatly appreciate the time and contributions of everyone who participated.

Photo credits for cover page:

Baird and Associates; Environment Canada; International Joint Commission; and Ohio Sea Grant

Table of Contents

Building Collaboration Across the Great Lakes – St. Lawrence System: An Adaptive Management Plan For Addressing Extreme Water Levels

Introduction

The International Joint Commission (IJC) tasked the International Great Lakes – St. Lawrence River Adaptive Management Task Team (the Task Team) with developing a plan for Adaptive Management (AM) to guide informed decision-making to better address extreme water levels throughout the Great Lakes – St. Lawrence River (GLSLR) system. Extreme water levels are those considered to be at or outside the historical period of record (as recorded by consistent gauges, 1918-present). The Task Team is an outcome of recommendations from both the IJC Lake Ontario - St. Lawrence River Study (LOSLR study) and the IJC International Upper Lakes Study (IUGLS) for new approaches to regulating Lake Ontario and Lake Superior. As a result of these studies, adaptive management was identified as an important component of any new possible regulation plans as a mechanism to measure and verify the expected benefits of the regulation plans and to help address future extreme conditions beyond those which can be addressed through normal regulation of water levels. Adaptive management is a structured, iterative cycle for improving actions through long-term monitoring, modelling and assessment. Adaptive management allows decisions to be reviewed, adjusted and revised as new information and knowledge becomes available and/or as conditions change (IUGLS, 2012). Figure 1 depicts the adaptive management cycle and highlights the importance of collaboration and institutional arrangements both in terms of the state of the science and social interactions.

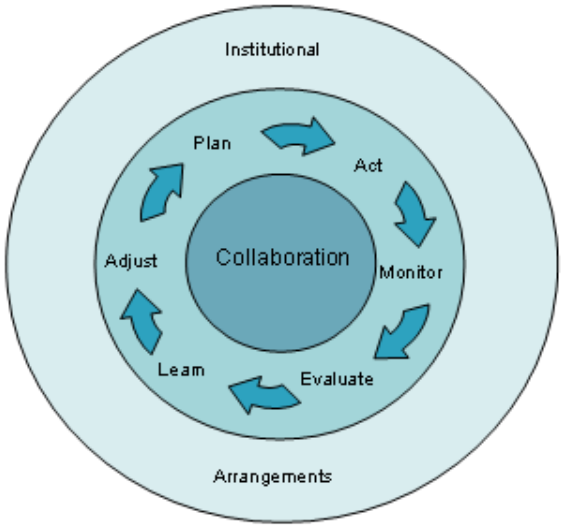


Figure 1 ***Adaptive management function diagram (IJC, 2008)***

On May 29, 2012, the IJC issued a directive (Appendix 1) to establish and direct the International Great Lakes - St. Lawrence River Adaptive Management Task Team (Task Team) to develop a detailed Adaptive Management Plan (AM Plan). The IJC directed the Task Team to evaluate and prioritize adaptive management activities in the Great Lakes – St. Lawrence River basin to address future extreme water levels. The IJC requested that the Plan be consistent with the recommendations of the IUGLS Board's Final Report (March 2012) to the International Joint Commission, entitled *Lake Superior Regulation: Addressing Uncertainty in the Upper Great Lakes Water Levels*. The IJC also asked the Task Team to consult and collaborate with the Lake Ontario – St. Lawrence River (LOSLR) Working Group to seek its views and inputs and to build upon its adaptive management efforts in arriving at a system-wide AM Plan.

The Commission appointed members and co-chairs to the bi-national Task Team, which is comprised of four Canadians and four Americans. The Task Team appointed a Canadian and a U.S. Secretary and is assisted by support staff. A list of Task Team members and support staff can be found in Appendix 2. In addition, the Task Team established a bi-national Advisory Group of Great Lakes – St. Lawrence River agencies as a forum for advising on and supporting the activities of the Task Team in fulfilling their mandate as specified in the directive. The Advisory Group was consulted on an initial draft of this document and provided advice on the development of the AM Plan through their professional capacity and knowledge of the hydrologic system. Members do not represent the position or views of their respective agencies or organizations, but work to bring a collaborative and consensus-based perspective to the development of the AM Plan. This version of the AM Plan is a reflection of comments and feedback received. A list of Advisory Group members is included in Appendix 3. This document has also undergone a public review process which included the posting of the draft document to a public website and a series of public webinars to describe the various components of the AM Plan. Public feedback has been incorporated into this final report.

This document consists of two sections. The first section provides the background and rationale for the AM Plan. The second section is the DRAFT AM Plan itself and includes priority activities, proposed structure, roles and responsibilities and estimated costs.

Background and Rationale

1.1 Context and Background

The Great Lakes are a complex and dynamic system. Water level fluctuations on the Great Lakes - St. Lawrence River system vary on timescales ranging from months to millennia and are influenced by natural and anthropogenic factors, and long-term climate trends. Extreme water levels and changing flows through connecting channels and the St. Lawrence River pose significant risks to the economic and social well-being of the Great Lakes - St. Lawrence River region. When those water levels approach the extremes of the historic range, due to either persistent wet or dry conditions, the impacts can be detrimental and costly. High water levels can cause significant damage due to flooding, erosion, overtopping of shore protection structures, loss of beaches and recreational lands and their economic and social benefits, loss of wetlands, high channel flows that can impede navigation, and a greater susceptibility to storm damage from wind and waves. Low water can lead to increased dredging, ships forced to lighten their loads, encroachment of development in the nearshore, exposure of mudflats, undercutting of shore protection, loss of marina services and access to boat launch facilities, risks to water supply infrastructure, nearshore water quality issues, reductions in hydropower generation and ecosystem effects (e.g., isolating fish from their spawning habitats, or stranding wetlands). While the ecosystem requires natural variation in water levels over seasonal, yearly and decadal cycles, and flourishes under dynamic conditions, extended periods of extremely low or high water periods can also pose issues for ecosystem function and nearshore fish and wildlife habitats (Midwood and Chow-Fraser, 2010).

Fluctuations of water levels and flows in the Great Lakes and their connecting channels are expected to continue over time, due both to natural and human influences on the system. Lake levels have exhibited a significant degree of natural variability in the historical record as is demonstrated in Figure 2.

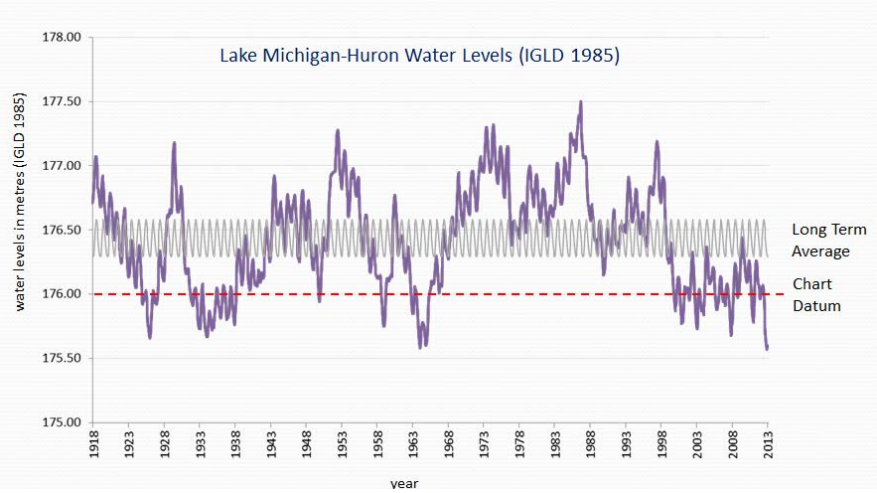


Figure 2 ***Water levels on Lake Michigan-Huron over the historical record (1918-2012)***

The land surface is also adjusting over time as it recovers from the retreat of the glaciers, known as glacial isostatic adjustment (GIA). The land surface is slowly rising, particularly on the north shore of Lakes Superior and Huron (Georgian Bay) and subsiding in other parts of the system, most notably on south western shores of Lakes Superior and Michigan relative to their outlets (IUGLS, 2009). Shorelines and channel beds are also dynamic due to erosion and depositional processes at work. Humans have made dramatic changes to the physical conditions in the system over the past century through the construction of dams and locks, dredging, diversions, and hardening of the shoreline. Human-caused climate changes add yet another dimension, potentially exacerbating the changes to this dynamic system. All of these factors combine to generate uncertainty in managing the risk associated with lake level changes.

Science indicates that the climate is changing, but there is uncertainty regarding how this will impact water levels (IUGLS, 2012c). There is also uncertainty in how these impacts will interact with other natural and human-induced factors that also influence water levels (IUGLS, 2009). There is strong evidence that extreme water levels (both high and low) outside the historical range are plausible, and in fact Lake Michigan-Huron set new record low water levels in January 2013 (based on 1918-2012 period of record)(DFO, 2013; Environment Canada, 2013; USACE, 2013b). There is considerable stakeholder concern and media attention over the current low water levels, their cause, and actions being taken to address them. Better tracking and understanding of these changes can help reduce uncertainty and inform solutions.

Concern over high and low water levels is not a new issue. For the past half century the IJC, at the specific request of the U.S. and Canadian governments through what is known as a “reference”, or under its continuing authority with the support of the U.S. and Canadian governments, has undertaken numerous studies to examine options to alleviate the impacts of high and low water levels through both structural and non-structural measures. These studies include:

- 1964-1973 Regulation of Great Lakes Water Levels Reference Study (under 1964 reference) (IJC, 1973)
- 1977-1981 Great Lakes Diversions and Consumptive Uses Reference Study (under 1977 reference) (IJC, 1981)
- 1977-1983 Limited Regulation of Lake Erie Study (under 1977 reference) (ILERSB, 1981)
- 1987-1993 Water Levels Reference Study (under 1986 reference) (Levels Reference Study Board, 1993)
- 1999-2000 Report on the Protection of the Waters of the Great Lakes (under 1999 reference) (IJC, 2000)
- 2001-2006 Lake Ontario – St Lawrence River Study (under 2000 IJC directive) (ILOSLRSB, 2006)
- 2007-2012 International Upper Great Lakes Study (under 2007 IJC directive) (IUGLS, 2012)

The two most recent studies built upon previous work and recommended a reconsideration of the IJC’s rules and approach for managing the outflows from Lake Ontario and Lake Superior with new regulation plans being considered. While these new regulation plans would provide important improvements

based on balancing interests in a dynamic system, it is nonetheless recognized, as it has been by all the previous studies, that any regulation plan is limited in the ability to affect impacts of extreme water levels. In particular, this was an important finding of the 1993 Levels Reference Study. Arguably the most comprehensive water levels study of its kind, it examined both structural and non-structural measures for alleviating the adverse consequences of fluctuating water levels on the entire Great Lakes – St. Lawrence River system. That study explored more fully the issues of fluctuating water levels than had ever been accomplished before and stated that,

"*… the essence of the nature-human complex is inescapably systemic; that an ecological dynamism deserves priority consideration before taking any action on water level fluctuations; that misperceptions and misunderstandings of the water fluctuations phenomenon and of our ability to affect It abound; and, that the extant bi-lateral and hierarchical governance poses impediments to concerted and coherent collaboration"* (Levels Reference Project Management Team, 1989)

The final report presented 42 practical actions that government could take and called for comprehensive and coordinated land-use and shoreline management programs, but the recommendations required collaboration, and there was no collaboration strategy once the study was completed. This was an important contributing factor to the fact that the majority of these recommendations were not realized.

Over the past 50 years, these IJC studies have usually been driven by extreme low or high water levels. While excellent bi-national data collection, analysis and collaboration was conducted during these studies, there has generally been limited follow-up or continuity between these studies, and the data and information gathered for one study was not necessarily maintained for the next study. This has resulted in unnecessary knowledge gaps and insufficient data for trends analysis and verification. The fact that there has been a series of such studies suggests a couple of things. First, that extreme water levels have been and are likely to continue to be an issue faced by the Great Lakes-St. Lawrence River community and focused on by federal, state and provincial, First Nation/Tribal, and local governments, as well as the IJC; this focus may even increase with climate change. Second, that the current approach of conducting a study every time there are extreme water levels may not be the most efficient and effective way of addressing the problem. Recommendations from these studies often tend to fade once the event that prompted the study is over, and sometimes there is no on-going driving force to help ensure that accepted recommendations are implemented. An effective on-going mechanism for addressing water level related issues is lacking.

A half century of studying water level extremes on the Great Lakes has taught us that data collection, analysis, and collaboration must be on-going and part of routine business. Fragmented data collection and analysis that lacks continuity over time fails to accurately inform decision makers at the local, state, provincial, and federal levels as well as the public on how best to assess and prepare for the challenges of living with the dynamic Great Lakes - St. Lawrence River system. This AM Plan evolved from the understanding that better decisions are based on continuous coordinated monitoring, consistent data gathering, and efficient data-to-decision protocols. Much work is ongoing throughout the Great Lakes –

St. Lawrence River system but a more holistic and integrated approach would bring benefits to the Great Lakes-St. Lawrence River community.

1.2 Rationale for this AM Plan

1.2.1 Purpose and Outcomes of Adaptive Management

Water level extremes can be addressed in two ways, by managing water levels through dams or other structures, and/or by managing how we respond to the impacts of those water level changes. The current approach for managing water levels is the regulation by the IJC of outflows from Lake Superior and Lake Ontario through dams on the St. Marys River at Sault Ste. Marie and at the Moses-Saunders Dam at Cornwall/Massena on the St. Lawrence River. Outflows are controlled according to regulation rules that specify how much water can be let out under a range of conditions. However, as noted earlier, the ability to alter lake levels through the regulation plans is limited, especially for the upper Great Lakes, and is dominated by changes in water supply driven by precipitation and temperature.

Based on this, the Task Team identified two key purposes for the IJC to be engaged in adaptive management:

1. ***For on-going review of the Regulation Plans*****:** Adaptive management will be used to monitor the effectiveness of implemented regulation plans in meeting intended objectives and to assess changing conditions and determine if the regulation plan may require adjustments based on what is learned over time and/or as conditions change.; and

2. ***For Improving Responses to Extreme Water Levels***: Adaptive management will be utilized to provide an improved collaborative, systematic and iterative approach to inform on-going decision-making at all levels of government, by stakeholders and by the general public in response to changing water level conditions. This would be to ensure a strong continuous scientific basis for developing and evaluating options to issues posed by water level conditions, recognizing the limitation in regulating water levels and flows via existing or new structures to address risks of extreme water levels (IUGLS, 2012).

The first purpose relates directly to IJC mandates under the Boundary Waters Treaty involving the authorization of a use, obstruction or diversion of boundary waters. The Boards currently undertake on-going monitoring and periodic review of regulation plans as requested by the IJC. Some have suggested that the Boards have always conducted adaptive management through periodic updating of the Lake Superior Plan and through deviations related to the regulation of Lake Ontario outflows; however, this has historically been implemented in an ad hoc fashion and not systematically applied based on a structured science-based process informed by formal monitoring and modelling programs (IUGLS, 2012). Implicitly, such a process requires an understanding of existing vulnerabilities and a mechanism to evaluate how outcomes would change based on modification to the regulation rules.

Adaptive management will provide a means for on-going monitoring and analyses to allow for continuous and systematic review and evaluation of the performance of the outflow regulation plans and fill a much-needed gap for on-going analysis. An adaptive management approach for reviewing the performance of the regulation plans over time appears well supported and endorsed by Great Lakes - St. Lawrence River agencies in both countries, as is evident by the considerable contributions already being made to this effort by U.S. and Canadian agencies in supporting initial tasks as part of the AM effort (see Box 1 for an example).

Box 1: Flood Risk Verification on Lake Ontario

Ongoing efforts to understand the vulnerability of coastal development to changing Lake Ontario water levels is a critical component of the proposed Adaptive Management Committee. Property owners continue to be concerned that any change to the existing regulation plan will greatly increase their risk of flooding. The AM Plan includes a requirement to verify flooding model results from the Flood and Erosion Prediction System (FEPS) used in the evaluation of new regulation plans to ensure it is adequately capturing the potential impacts. As an initial step, staff from Environment Canada and the U.S. Army Corps of Engineers, in consultation with staff from New York Department of Environmental Conservation and Ontario Ministry of Natural Resources, saw benefit in applying an updated 'Flood Tool' developed as part of the International Upper Great Lakes Study for specific locations of the Lake Ontario shoreline where there was uncertainty regarding the original FEPS model results. This excel based tool allows for the testing of specific storm events with various water level scenarios to better understand potential flood damages under different water level regimes and a range of storm conditions.

Staff from Environment Canada, the U.S. Army Corps of Engineers and New York Department of Environmental Conservation were trained to populate and utilize the Flood Tool in March and April 2012 by the designers of the Flood Tool, Baird and Associates. With that training, agency staff worked together to test the Flood Tool at specific locations of the Lake Ontario shoreline including small stretches of the Greece and Sodus shoreline in the U.S. and the Brighton shoreline in Canada. The bi-national project team coordinated on input data, reviewed results, and worked together to prepare a draft report documenting their preliminary activities and findings. Due to the range of agency involvement, the team was able to tap into a variety of relevant information sources. For example, staff from the U.S. Army Corps of Engineers and New York Department of Environmental Conservation were able to work with colleagues from New York Department of State to identify past flood insurance claims to help compare to the Flood Tool results. On the Canadian side, several agencies worked collaboratively to help verify certain flood elevations used in the models. Information from this effort was reviewed by the broader Lake Ontario technical sub-group and those comments continue to be integrated. Additional information session webinars were conducted with agency staff on the Canadian and U.S. shoreline including Conservation Authorities and additional staff from the US Army Corps of Engineers and New York State. This demonstrates an excellent collaboration where expertise in both countries and at various agency levels was collectively utilized to more efficiently and effectively undertaken a common task.

Figure above is of high water levels on Lake Ontario in 1973. Photo provided by Baird & Assoc.

The Flood Tool effort is ongoing as additional sites remain to be evaluated and further detailed information continues to be available to refine the Flood Tool application at existing sites. The intent is to continue this work within the framework of the proposed Adaptive Management Committee.

The second purpose is not a direct responsibility of the IJC; however, it has been established that, in the absence of an IJC Study on water level related issues (of which there have been many), there is no overarching mechanism to track and assemble system-wide information on trends and changing conditions to the system that could impact decisions related to managing water levels and flows, or in responding to challenges posed by changing water levels and flows. As a result, there is no on-going

collaborative strategy for developing, compiling, synthesizing, or sharing on a system-wide basis the data, tools, information and knowledge that is needed for:

- understanding why and how the system is changing;
- understanding existing and potential risks posed by changes;
- fully understanding the complexities of problems posed by extreme water levels, changing conditions, and the resiliency of the system to those changes; and
- developing and evaluating options that support sustainable environmental, economic, and social needs, both now and under future conditions.

For example, some regions of Lake Michigan-Huron and Lake Superior have been suffering as a result of an extended period of low water levels on the upper Great Lakes and are likely to continue to suffer as a result of a combination of persistently low net basin supplies, slowly rising Canadian shore elevations still responding to the retreat of the glaciers, and increased conveyance of flows out of Lake Michigan-Huron that have permanently lowered water levels on that lake (IUGLS, 2009). Wetlands may be lost because of the low levels for example in Georgian Bay, where the bedrock material prevents erosion and downcutting of the channels that connect the wetlands to Georgian Bay. Consequently, wetlands become hydrologically disconnected or "stranded" from Georgian Bay as water levels drop below the elevation of the rock sills (Chow-Fraser, 2006, DePinto et al. eds., 2011). Impacts that commercial navigation, recreational boaters and other interests have felt for years may get worse. Many shoreline residents have asked for new structures (dams, sills, weirs etc.) in the St. Clair River to raise Lake Michigan-Huron levels, and while the IJC has recently recommended further investigation of new restoration structures in the St. Clair River (IJC, 2013), the IUGLS concluded that implementation would be difficult due to environmental concerns and institutional requirements and could take years or decades for the increase in lake levels to be achieved (Brown, 2011; IUGLS, 2012). Meanwhile, in January 2013, Lake Michigan-Huron dropped to a new record low level (Environment Canada, 2013; USACE, 2013b). The question is, who manages low water impacts on Lake Michigan-Huron? The answer is that there are many agencies and stakeholders involved, each able to take different types of actions, and the decision processes for these actions are to a great degree independent from one another. There is currently no forum that brings together the all the players for establishing multi-objectives, determining what authorities to apply in solving complex issues, or determining what information products and tools are best applied, and no established methods for monitoring and evaluating the effectiveness of each element of the solution. This draft AM Plan offers an opportunity to better manage water level impacts more effectively and efficiently by working together collaboratively to support decision-making towards optimal solutions.

The IJC, given its history in coordinating bi-national science and research in responding to government requests (i.e., references) on how to best to address water levels related issues, seems the appropriate umbrella organization to help coordinate system-wide adaptive management activities focused on improved system-wide coordination of science needed to support on-going decision-making related to developing and evaluating sustainable solutions.

So, consistent with the recommendations from the IUGLS, the Task Team has considered the role of adaptive management beyond the Great Lakes - St. Lawrence River regulation plans in this AM Plan. **The Task Team believes a forum for collaboration among agencies and stakeholders that measures our collective success in managing the impacts of extreme water levels and adapts accordingly could help provide the most credible strategy for improving economic, environmental and social outcomes from extreme water levels.**

The objective of an AM Plan is to ensure the Great Lakes – St. Lawrence River community is equipped to make informed decisions on changing water levels and climate conditions and that governments at all levels and stakeholders work collaboratively in a system-wide context to develop and apply multi-objective, flexible and sustainable solutions that include:

- improved understanding of why and how the system is changing (through collaborative monitoring and modelling),
- improved understanding of existing and potential risks and complexities of problems (through collaborative monitoring, modelling and assessment),
- performance metrics for understanding success of options (chosen collaboratively)
- tools for developing and evaluating options(integration, synthesis, and decision support – developed collaboratively),
- transparent, accessible and interoperable information readily available to users system-wide,
- on-going assessment and evaluation of solutions maintained with feedback to decision-making processes, and
- stakeholders fully engaged with mechanisms to inform the decision-making process.

This AM Plan calls for collaboration similar to the way Great Lakes - St. Lawrence River agencies and organizations work collaboratively during IJC studies to gather data and undertake scientific analysis to address the issues.

The value of adaptive management is evident in the fact that some of this work has begun already by various agencies that have recognized the benefit of collaboration. (see Boxes 1,2,4, 5 and 6 for examples). Independent from the IJC, but very similar in concept, the Nature Conservancy (TNC) has initiated two projects with significant public and private investments that have many of the elements that would be found in an adaptive management as described in this report – a multi-agency, multi-objective analysis that crosses political boundaries, a systems approach and stakeholder involvement (see Box 2):

Box 2: Examples of Adaptive Management Efforts by the Nature Conservancy

Example 1:

The Nature Conservancy (TNC) plans to create a network of functional coastal habitats in the **Western Lake Erie Coastal Conservation Project** This is an effort that includes large-scale coastal restoration as well as multi-objective planning, including stakeholder engagement to better understand community needs and values and articulate a shared vision. The work involves a broad array of partners, including key federal agencies (EPA, NOAA, USGS, USFWS), academic institutions (University of Michigan-Dearborn, Ohio State University), state natural resource agencies (including AOC managers), non-profit organizations (Ducks Unlimited, local land trusts), hunt clubs, businesses, private landowners, and other parties. Combining the on-the-ground experiences in this region with information about future climate and water levels developed in IJC studies could help predict those projects' ability to deliver anticipated benefits under current and future lake level conditions and will so inform project priorities. This project's restoration strategies will promote adaptation, as the availability of habitat increases in a landscape where there have been major losses, and improves connectivity both at local and continental (i.e., through providing more stopover habitat for birds) scales.

Example 2:

A TNC project in **Green Bay** is designed to protect and restore wetland habitat and remove connectivity barriers (culverts, dams) to improve the health of the bay. Northern pike, a top predator in Green Bay, is being used as a focal species because they use the open waters of the bay but also need access to the tributary network and coastal and interior wetlands for spawning. Data collected on this species could be used by to verify Northern Pike Performance Indicator in the models used in the International Upper Great Lakes Study. TNC is working with the Wisconsin Department of Natural Resources, Ducks Unlimited, Oneida Nation, UW-Madison, UW-Green Bay, USFWS, the Shedd Aquarium and county governments. Adaptive management techniques will be used in the management of structures for support of wetland hydration and creation of habitat connectivity for fish migration).

1.2.2 What Adaptive Management is Not

The previous sections have described what adaptive management is and why it is important. To help avoid misunderstandings, the Task Team felt it was important to discuss what adaptive management is not and what it will not do.

Adaptive Management will not result in one "super agency" with a great deal of power.

- Adaptive Management provides for more efficient governance within existing agency roles, mandates and structures. The networks concept proposed as part of this AM plan offers a forum for information-sharing to make it easier for agencies to be aware of what other agencies are doing and work collaboratively to address the same problem.

Adaptive Management will not undermine effective programs and policies.

- Adaptive management is designed to measure effectiveness so that adaptive changes can be made based on real evidence to improve effectiveness. The evidence can be used to identify the performance of programs and provide a rationale against across-the-board spending cuts. Adaptive management can help support the case for the much needed programs while building the constituency for this knowledge.

Adaptive Management does not undermine existing authorities.

- This Adaptive Management Plan is designed to work through organizations and their existing authorities to prioritize tasks, leverage resources, and engage current programs and resources

if they exist to undertake specific tasks. There is no formal authority over agency participation or their decisions. Involvement is based on the concept that it is more effective and efficient to work collaboratively and that better, more sustainable outcomes will result.

Adaptive management is not the same as adaptation.

- Adaptive management is the iterative process for "learning while doing" and adjusting actions as necessary to address changing conditions. Adaptation is the broader context of responses taken and actions implemented to address risk. The two are inherently linked and this document discusses both concepts, but this AM Plan focuses on monitoring, modelling and assessment activities necessary to:
  - improve lake level regulation benefits over time; and
  - improve understanding of extreme water levels impacts and related outcomes and potential solutions that cannot be addressed effectively through lake level regulation in an effort to:
    - reduce damages,
    - save money through more efficient use of resources,
    - preserve ecosystem function, and
    - inform stakeholders and practitioners.

These outcomes are generally within the areas of natural resource restoration and protection, water resource and coastal zone management, infrastructure planning/design, and an improved public understanding of how hydroclimate changes affect daily lives.

Adaptive Management will not solve all problems.

- Adaptive management provides the information, tools and methods for supporting decision-making, but it does not make those decisions and it cannot make difficult problems disappear. Decisions will be made by those who have authority and competing objectives may make decisions difficult. Compromise and balance may be required. Nevertheless, adaptive management does provide a forum for a better exchange of information and knowledge, it provides a structured science based process to collectively understand the full breadth of issues, understand multi-objectives, consider alternative solutions and evaluate effectiveness of actions taken.

There will be different perspectives on the advantages of adaptive management:

- Boards of Control will see adaptive management as a means to ensure a structured, science based approach to the on-going review of the regulation plans and as an effective way to inform the public on the performance of the regulation plans.
- Stakeholders (e.g., in the regional pilots) will see a collaborative approach towards solving problems that have not been solved by fragmented management, and the approach will focus on the problem, not the particular process of an agency.
- Elected officials may see the Adaptive Management pilots (refer to section 2.5) as a fact-based approach to addressing water level related controversies.

- Some agency managers will see adaptive management as a way to improve the performance of their programs despite budget restrictions.
- Non-governmental organizations (NGOs) may see adaptive management as an evolution towards more progressive management approaches.

1.3 Genesis of the AM Plan

As described below, both the LOSLR Working Group and the IUGLS Board proposed adaptive management strategies as part of the new approaches to managing outflows from Lake Ontario and Lake Superior.

1.3.1 The LOSLR AM Strategy

The LOSLR Working Group was organized by the IJC in December 2009 and is made up of the governments of Canada, United States, Québec, Ontario and New York to provide advice in response to IJC proposals on how to (a) manage water levels and flows in the Lake Ontario - St. Lawrence system and (b) better define and adequately protect all interests – environmental, social and economic – both upstream and downstream of the Moses-Saunders Dam, in compliance with the Boundary Waters Treaty (IJC, 2009).

The LOSLR Working Group has supported the concept of adaptive management as an important part of any new approach to managing the outflows of Lake Ontario. Efforts to explore adaptive management related to LOSLR have focused primarily on the on-going assessment of the Lake Ontario – St. Lawrence River regulation plan. While there is a high degree of confidence by experts in the scientific and analytical elements of the underlying LOSLR study, which was extensively peer-reviewed, the research and analysis involved highly complex issues, including assumptions about future climate changes and water supplies that require monitoring to insure that the outcomes are in accordance with modelled projections. The environment is complex and dynamic and, unlike other interests, the reaction to a change in water management may only be measurable over years or decades. The LOSLR Working Group recognized that data gathering and monitoring over time is critical to evaluating the effects of any regulation plan and to adapting to reduce negative impacts. The review of regulation plans for Lake Ontario and the St. Lawrence River has been controversial and difficult to resolve. Opponents to a change in regulation plans continue to focus objections on uncertainties about the science and unknowns related to future climatic and economic conditions. The LOSLR Working Group recognized that adaptive management provides an effective way to address uncertainties through on-going strategic monitoring, analysis and review.

The LOSLR Working Group's adaptive management strategy focuses on four key elements which relate primarily to the on-going assessment of the Lake Ontario – St. Lawrence River regulation plan. These elements include:

1. Tracking of Key Performance Indicators
2. Improved Understanding of the Implications of Climate Changes on Water Levels and Flows: Coordinated Hydroclimate Monitoring and Modeling
3. Information Management and Evaluation Tools
4. Coordination and Application of the Adaptive Management Strategy

All of these elements have been taken into consideration in this AM Plan.

1.3.2 The Proposed IUGLS AM Strategy

The IUGLS Board found early in its study that there were considerable challenges in the design of regulation plans for Lake Superior that would be optimal for all possible future conditions including climate change. Through its investigations, the IUGLS Board arrived at three important conclusions. First, that major changes to the system over time can and will go undetected without proper monitoring and modelling of the system. Second, that water level extremes in the future, both on the low side and the high side are plausible and even probable (as demonstrated by the recent record low levels on Lake Michigan-Huron in January 2013), but the timing, duration and frequency of those extremes is uncertain. Third, that the regulation of Lake Superior outflows can do little to avoid future damages downstream of Lake Superior (IUGLS, 2012b).

These findings had important implications for how the adaptive management process evolved. The first two findings pointed to the need for ongoing monitoring and modelling that can support adaptive management, while the third justified the need to develop a collaborative adaptive management approach itself. The first finding emerged in the initial phase of the study when the IUGLS Board determined that it could not irrefutably establish why the level of Lake Michigan-Huron is lower, relative to Lake Erie, since the 1960s, mainly because the data collection process over that 30-year period was insufficient to draw conclusive results. This highlighted the need for on-going monitoring of physical changes to the system (IUGLS, 2009).

The second finding emphasized that we should not be too presumptuous about our ability to predict the effects of climate change, and it would be risky to prepare for only the futures projected by a limited number of global and/or regional climate models and greenhouse gas emission scenarios. The third finding probably had the greatest impact on the evolution of the adaptive management strategy. Recognizing that Lake Superior regulation alone can do little to minimize damages associated with high and low water levels on Lake Michigan-Huron, Lake St. Clair and Lake Erie, the IUGLS Board recognized that the potential for damage reduction lies with further water level and flow management through constructing new structures in the system and/or better management of the coastal zone, plus attendant monitoring and research, in order to develop a greater understanding of potential future risks and sustainable solutions (IUGLS, 2012a; IUGLS 2012).

An adaptive management process might be used to trigger future study or implementation decisions for new structures such as the further investigations called for by the IJC in their recent report to governments. Nevertheless, exploratory institutional and technical analyses during the IUGLS indicate that new structures and required construction processes are costly, can be controversial, and may take years or even decades to complete (Brown, 2011). This suggests that measures which adapt to fluctuating water levels, such as better coastal and floodplain management may be the best hope for reducing these risks especially in the near term. Yet the IUGLS Board also concluded that efforts to coordinate approaches for managing risk and sharing successful approaches across jurisdictions have been limited, with little focus to date placed on long-term implications of climate extremes and planning for an uncertain future (Donahue, 2011). The goal of the IUGLS AM effort was to develop a better understanding of current and future hydrologic, climatic and physical changes of the upper Great Lakes through data collection and modelling to inform better decision-making.

While the IUGLS adaptive management strategy included reviewing the regulation plan affecting the upper Great Lakes, it had fewer requirements for tracking key performance indicators than the LOSLR AM strategy and a greater emphasis on the improved understanding of the implications of climate change on water levels and flows. The IUGLS Board included similar elements as the LOSLR effort, but also considered the need for outreach and engagement as part of the AM strategy, and linking water quantity and quality. The IUGLS Board also proposed a collaborative regional adaptive management study of the feasibility and effectiveness of coastal zone management initiatives to address specific local and regional vulnerabilities. In all, six core elements of adaptive management were identified as part of the IUGLS:

1. Bi-national Great Lakes hydroclimatic monitoring and modelling;
2. Ongoing risk assessment;
3. Information management and outreach;
4. Tools and processes for decision makers to evaluate their actions;
5. Collaborative regional Great Lakes - St. Lawrence River system risk assessment pilots for dealing with water level extremes; and,
6. Integration of water quality and quantity modelling and activities.

To implement the AM strategy, the IUGLS Board proposed a Levels Advisory Board convened under the IJC and the establishment of a number of sub-committees to undertake the various components of the AM strategy.

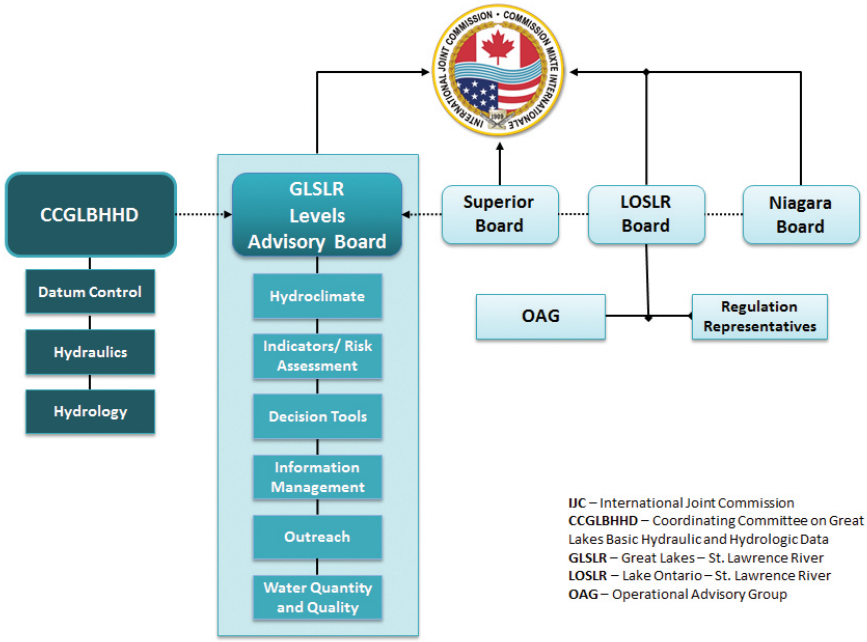


Figure 3 ***AM governance structure as proposed in the IUGLS***

The International Great Lakes-St. Lawrence River Adaptive Management Task Team (Task Team)

The Task Team was established by the IJC following the submission of the final IUGLS report. By a directive dated May 29, 2012, the IJC asked the Task Team to consider and build upon both the LOSLR and IUGLS AM efforts in developing a system-wide Great Lakes - St. Lawrence River AM Plan. The Task Team began by reviewing the IUGLS and LOSLR proposed adaptive management strategies and completed a cross mapping of activities. It also assembled a small team through in-kind contributions to undertake a preliminary gap analysis of the proposed activities related to both IUGLS and LOSLR AM strategies. The team identified activities that were currently underway, particularly related to the LOSLR AM effort, tasks that agencies are trying to get underway under existing programs and those that require new resources. The Task Team sought the input of numerous individuals across a number of Great Lakes-St. Lawrence River agencies and organization (see appendix 3) and the public through a series of eight webinars and on-line comment period between March 15 and April 15, 2013.

With the new focus of the updated GLWQA, particularly on the nearshore, climate change and habitat restoration, the linkages between climate, water levels and nearshore water quality cannot be overlooked. The IUGLS presented a separate element for linking water quality and quantity. The Task Team discussed this at length and agreed that this concept is extremely important and should be incorporated into each of the components of the AM Plan.

Integrating water quantity and quality linkages into an AM Plan

The Great Lakes Water Quality Agreement (GLWQA) is focused on restoring, protecting and enhancing the water quality and ecosystem health of the Great Lakes and, specifically, the chemical, physical and biological integrity of the waters of the Great Lakes. On September 7, 2012, the governments of Canada and the United States signed an updated Great Lakes Water Quality Agreement. The amendments address problems with invasive aquatic species, habitat degradation and the effects of climate change, and the updated agreement calls for developing plans to protect and restore nearshore areas (EC, 2012).

The integration between water quality and quantity is particularly relevant in the nearshore and in the context of climate change. This AM Plan promotes coordination with the GLWQA, primarily through the climate change and lakewide management annexes and the integration of hydrology and climate change impacts on nearshore water quality. It includes activities for the integration of nearshore models and shore processes with nearshore water quality monitoring and ecosystem impact analyses. Of particular relevance is the GLWQA effort to establish a nearshore framework. The hydroclimate monitoring and modelling required to support this AM Plan will also be required to support the GLWQA.

1.4 Important Bi-national Linkages

This AM Plan is intended to build a collaboration among agencies and stakeholders and it is to be built upon existing programs and leadership. There are a number of important bi-national linkages with existing Boards and Committees that will be mentioned throughout the AM Plan. A few of the most critical linkages are highlighted here and reiterated within the AM Plan. A full list of agencies and acronyms is provided in Appendix 4. All of these bi-national organizations and the many domestic Great Lakes and St. Lawrence River organizations have important roles to play in undertaking the AM Plan.

IJC Boards of Control

The International St. Lawrence River Board of Control (St. Lawrence Board), established in accordance with the 1952 Order of Approval for the works at Cornwall, ON and Massena, NY, has the primary duty of ensuring that outflows from Lake Ontario meet the requirements of the Commission's Order of Approval and are in accordance with an IJC-approved regulation plan (IJC, 2013c). This Board also has authorities from the IJC to deviate from that plan under extreme water level conditions. The International Lake Superior Board of Control (Superior Board) was established in 1914 by an IJC Order of Approval and is responsible for implementing the IJC's orders and directives regarding the regulation of flows from Lake Superior through the control structures in the St. Mary's River at Sault Ste. Marie (IJC, 2013a). Outflows are set by the Board on a monthly basis in accordance with an IJC-approved regulation plan. In addition to overseeing the operation of the control structures, the Superior and the St. Lawrence River Board of Controls both monitor repairs and maintenance of control facilities, implement any new regulation plans, communicate with the public, report semi-annually to the IJC and conduct special studies as requested by the IJC. Both these Boards are expected to play a direct role in the adaptive management process and proposed structure. A third Board, the International Niagara Board

of Control (Niagara Board), was established by the IJC in 1953 to review and approve the construction of the Chippawa-Grass Island Pool (CGIP) Control Structure and other remedial works at Niagara Falls and to exercise control over the maintenance and operation of the CGIP Control Structure to meet the scenic-beauty requirements of the 1950 Niagara River Diversions Treaty (IJC, 2013b). This Board's other responsibility is to oversee the installation and removal of the Lake Erie-Niagara River Ice Boom. However, given that water diverted from the river above Niagara Falls for hydropower generation is returned to the river below the Niagara Falls and the level of Lake Erie is not regulated by the Board, this Board is not governed by an Order of Approval for the management of outflows. So while this Board is still expected to be linked-in with the adaptive management process, its involvement will be less than the other two Boards of Control.

The Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data (CCGLHHD)

The Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data (CCGLHHD) is an ad hoc committee of scientists and engineers of the two federal governments, established in 1953 that advises the governments and supports the Boards of Control in the areas of coordinating bi-national water levels and the Great Lakes vertical datum, coordinating flows and models in connecting channels, and coordinating water level forecasts and basin water supplies for the Great Lakes (USACE, 2013a). It is expected that this Committee will remain an important entity and will be a key player in the adaptive management effort, particularly related to bi-national hydroclimate monitoring and modelling. The long-standing success of this Committee serves to validate the network concept.

The Great Lakes Executive Committee

The Great Lakes Executive Committee (GLEC) was established pursuant to Article 5 of the newly amended Canada-U.S. Great Lakes Water Quality Agreement (GLWQA) to help coordinate, implement, review and report on programs, practices and measures undertaken to achieve the purpose of the GLWQA (Binational.net, 2013). The GLEC replaces the former Bi-national Executive Committee (BEC) and serves as the forum to advise Canada and the United States (i.e., the Parties to the GLWQA) through the GLEC Co-Chairs, represented by Environment Canada and the U.S. Environmental Protection Agency. The GLEC offers opportunities for Federal, State, Tribal, Provincial and Municipal Governments, First Nations, Métis, watershed management agencies, and other local public agencies to participate. Given the new focus of the GLWQA on climate change and the nearshore, it is expected that important linkages between the GLEC and the various components of the AM Plan will need to be explored. Suggested linkages are provided throughout the discussion.

Great Lakes—St. Lawrence River Water Resources Regional Body

The Great Lakes Governors and Premiers created the Regional Body on December 13, 2005, by signing the Great Lakes—St. Lawrence River Basin Sustainable Water Resources Agreement (CGLG, 2013). The Agreement details how the Great Lakes States and the provinces of Ontario and Québec will manage and protect the availability of Basin waters, and it provides a framework for each State and Province to enact laws for its protection. Among other things, the Agreement commits the States and Provinces to

developing a five-year cumulative impact assessment of water withdrawals from the system, as well as to strengthening the collection of technical data and the sharing of information to improve decision-making by the governments. Given many overlapping needs in terms of coordinated hydroclimate and climate changes science, decision tools, information management, and outreach and engagement, the Regional Body should be linked in with the adaptive management effort to allow for better sharing of information and more efficient use of limited resources.

Great Lakes Commission

The Great Lakes Commission (GLC) is an interstate compact agency that promotes the orderly, integrated and comprehensive development, use and conservation of the water and related natural resources of the Great Lakes basin and St. Lawrence River (GLC, 2012). Its members include the eight Great Lakes states with associate member status for the Canadian provinces of Ontario and Québec. The Commission was established by joint legislative action of the Great Lakes states in 1955 (the Great Lakes Basin Compact) and granted congressional consent in 1968. A Declaration of Partnership established associate membership for the provinces in 1999. Commission products and services focus on communication and education, information integration and reporting, facilitation and consensus building, and policy coordination and advocacy.

Great Lakes Fishery Commission

The Great Lakes Fishery Commission (GLFC) was established by the Convention on Great Lakes Fisheries between Canada and the United States in 1955 (GLFC, 2010). It is made up of eight Commissioners (four each from the United States and Canada) and one U.S. Alternate Commissioner. Commissioners of the United States are appointed by the President for six-year terms. Commissioners of Canada are appointed by the Privy Council and serve at the Council's pleasure.

The Commission has two major responsibilities: to develop coordinated programs of fishery research on the Great Lakes, and, on the basis of the findings, to recommend measures which will permit the maximum sustained productivity of stocks of fish of common concern; and to formulate and implement a program to eradicate or minimize sea lamprey populations in the Great Lakes.

Great Lakes – St. Lawrence River Cities Initiative

The Great Lakes and St. Lawrence Cities Initiative (GLSLCI) is a bi-national coalition of mayors and other local officials that works actively with federal, state, and provincial governments to advance the protection and restoration of the Great Lakes and the St. Lawrence River by integrating their environmental, economic and social agendas. Founded in 2003, the Cities Initiative has grown to include one hundred and one member municipalities of all sizes from around the Great Lakes and St. Lawrence Basin, representing over 15 million people. Headquartered in Chicago, the Cities Initiative also has staff located in Ottawa, Montreal and Quebec City. The Cities Initiative is a 501(c)3 organization in the U.S. and a registered corporation in Canada. The Cities Initiative receives its core funding from membership

dues and is provided additional financial support from the following foundations: the Joyce Foundation, the Mott Foundation, the Wege Foundation, the BRICO Fund, and Chicago's Environmental Fund.

The National Ocean Policy (not bi-national)

The emerging U.S. National Ocean Policy specifically calls for close collaboration with Canadian partners in addressing the challenges in the Great Lakes region and embodies the goals of this AM Plan for more effective and efficient coastal and marine planning. Building on the recommendations of two bi-partisan commissions, President Obama established the National Policy for the Stewardship of the Ocean, Our Coasts, and the Great Lakes by Executive Order 13547 on July 19, 2010 (The White House, 2010).

Fundamentally, the National Ocean Policy coordinates the many ocean and Great Lakes related activities of Federal, State and Tribal governments to achieve more efficient, responsive government. Improved coordination, better stewardship of government funds and sustainable use of natural resources are the pillars of the National Ocean Policy. The National Ocean Policy will be implemented in each of the U.S. regions in a way that is responsive to regional needs and utilizing the concept of a Regional Planning Body to leverage existing collaborative groups and unique situations. The Great Lakes Regional Planning Body has been active since December 2011.

1.5 Existing IJC Authority

1.5.1 Authority under Boundary Waters Treaty

At the request of the two federal governments, the IJC reviews and may approve certain projects that affect water levels and flows across the Canada-U.S. boundary. Under the Boundary Waters Treaty (Treaty), the IJC must follow an order of precedence when approving water uses, and in certain cases must ensure that affected interests are protected from injury that may be caused by the operation of such projects. The specific conditions and criteria that must be followed are set out by the IJC in Orders of Approval for each project. The IJC has continuing jurisdiction over the subject matter of its Orders and it may adopt new regulation plans for managing water levels and flows provided any new plan is consistent with the existing Order. Changes to an IJC Order must follow the requirements of the Boundary Waters Treaty. To make effective lake regulation decisions, the IJC requires, at a minimum, information on hydroclimate and water level impacts plus decision tools to integrate the water level and impact components into results that can be incorporated into its decision processes. Adaptive management activities that directly support the on-going evaluation of regulation plans fall within existing IJC authority.

Article IX of the Treaty (the reference provision) provides that the governments may request the IJC examine and report on issues of concern. If the Governments of Canada and the United States were to issue a letter of reference to undertake the full scope of the AM Plan, including efforts to support and build capacity for regional decision-making to address extremes, this would provide the IJC with the specific authority needed to address the questions raised by the governments in greater detail.

The IJC has made recommendations to the governments in the past for potential references and the governments have issued standing references in response, such as the Great Lakes Water Quality Agreement. The Governments of Canada and the U.S. also issued a reference to the IJC dated April 15, 1977, requesting it establish an advisory board to assist in obtaining information on a number of matters related to the IJC's continuing responsibilities regarding Great Lakes water supplies, levels and flows. This Board existed between 1979 and 1982, and shows that the governments have requested advice in the past which may be even more relevant today given the issues of climate change.

A reference would support IJC authority to convene a forum for undertaking the AM Plan.

1.5.2 Authority in the Absence of a Specific Reference

The IJC has explored its role in assisting governments with future environmental challenges. In a 1997 report, entitled "The IJC and the 21st Century", the IJC responded to a request by the Governments of Canada and the United States for proposals on how to best assist them to meet the environmental challenges of the 21st Century. In its report the IJC wrote:

"*No other institution has the IJC's broad mandate or its successful track record in preventing and resolving transboundary disputes around environmental and water-resource issues, and no other institution provides the opportunities for officials from all levels of government, scientists, stakeholders and interested citizens to work together on these issues. The Commission's flexibility and historic emphasis on consultation, joint fact-finding, objectivity and independence, and its ability to engage local governments and serve as a public forum are important assets to the parties in meeting the challenges of the 21st century."* (IJC, 1997)

The IJC's principal recommendation in the 1997 report was to establish international watershed boards by merging existing IJC boards in certain basins and directing them to take an ecosystem approach to carrying out their responsibilities. The International Watersheds Initiative (IWI) promotes an integrated, ecosystem approach to issues arising in transboundary waters through enhanced local participation and strengthened local capacity (IJC, 2012). The initiative was conceived to facilitate the development of watershed-specific responses to emerging challenges such as intensified population growth and urbanization, global climate change, changing uses of water, pollution from air and land, and introductions of exotic species. The mandate of the IWI seems consistent with the goals of the proposed collaborative pilots, which are also focussed on building local capacity for prudent planning, resiliency and restoration in the face of an uncertain and ever-changing future.

Furthermore, the principles of adaptive management are consistent with and complement recommendations from previous IJC reference studies, and recommendations of the IJC including their most recent recommendations to governments dated April 15, 2013. As well, adaptive management is a basic principle of the 2012 Great Lakes Water Quality Agreement and is also consistent with Guiding Principles of the IJC as a means to work collaboratively and transparently.

The AM Plan

2.1 Framework for the Adaptive Management Plan (AM Plan)

This AM Plan is an action plan of activities required to carry out effective adaptive management. It provides a system-wide framework for planning support through state-of-the-art hydroclimate and climate change science for the Great Lakes - St. Lawrence River system; on-going understanding of risk and how the system is changing; tools for developing and evaluating solutions; and linking that information and knowledge with those who need to make decisions from a water levels management perspective, those managing water level impacts, and those most affected.

This AM Plan integrates both adaptive management strategies proposed by the LOSLR Working Group and the IUGLS Board and provides a new collaborative approach that recognizes the uncertainties of climate change and is aimed at supporting decision-making focused on minimizing the impacts of extreme water levels. It includes two key elements:

I. on-going review and evaluation of the performance of the outflow regulation plans., and
II. a continuous, collaborative scientific basis for developing and evaluating solutions to problems posed by water level conditions that cannot be solved through lake regulation.

In both cases the AM Plan includes five interrelated and interdependent components that together provide the information, tools and process for on-going and adaptive decision making. These components include:

1. Hydroclimate Monitoring and Modeling
2. Performance Indicators and Risk Assessment
3. Plan Evaluation and Decision Tools
4. Information Management and Distribution
5. Outreach and Engagement

These five components provide the basis for the AM Plan in supporting the principles of adaptive management, to monitor, evaluate, learn and adjust. This AM Plan provides the prototype for an on-going collaborative adaptive management effort. A full spectrum of required activities is identified and priorities are identified because they are essential building blocks to the AM Plan and/or they are opportunistic in terms of being relatively easy to implement. It is expected that this AM Plan will evolve and change over the coming months and years as the agencies engage and collaborate more fully in undertaking the components of the AM Plan, as more is learned, and/or as conditions change. This AM Plan is intended to build upon and synthesize the existing programs and leadership for applying adaptive management and only proposes new governance structures where no alternative currently exists.

This AM Plan calls for the establishment of two new groups: a Boards of Control Adaptive Management Committee (AM Committee) and a Great Lakes - St. Lawrence River Levels Advisory Body. The AM Committee is proposed to focus exclusively on the first element of the AM Plan regarding on-going review and assessment of the regulation rules for outflows from Lake Superior and Lake Ontario. This element is within the mandate of the IJC and its Boards of Control to periodically review and assess the regulation plans. The new AM Committee is proposed to undertake and oversee the specific requirements and activities to allow for a structured, systematic review of the regulation plans. This AM Committee would assist the Boards of Control by providing the technical expertise to undertake the formal evaluation of the regulation plans.

The Great Lakes – St. Lawrence River Levels Advisory Body (LAB) is proposed to concentrate on the second element of the AM Plan focussing on system-wide changes and a continuous, collaborative scientific basis for developing and evaluating solutions to problems posed by water level conditions that cannot be solved through lake regulation.

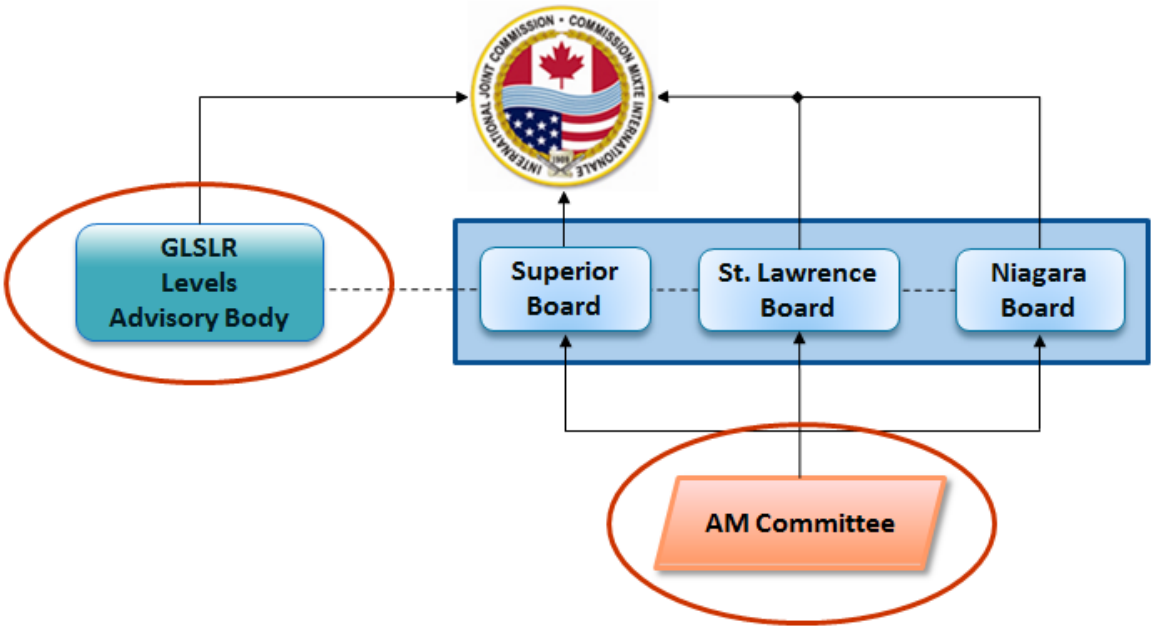


Figure 4 ***Two new formal groups proposed circled in red***

2.2 Boards of Control Adaptive Management (AM) Committee

The Boards of Control would be assigned with responsibility for adaptive management by the IJC and the IJC would establish an AM Committee reporting to the Boards of Control to address those components of the AM Plan that directly relate to the on-going assessment and evaluation of the current regulation plans and any on-going operational questions such as ice management or boom operations if requested by the Boards of Control. This AM Committee would oversee specific monitoring of key performance

indicators on Lake Ontario, the St. Lawrence River and the St. Mary's River as identified in this AM Plan. It also would address the on-going use, maintenance and updating of tools used in evaluating the regulation plans. This AM Committee would report to the Superior, Niagara and ISLRB Boards of Control. This AM Committee would be supported by technical experts from the jurisdictions that are represented on the three Boards of Control similar to the technical experts sub-group that currently supports the LOSLR Working Group. This AM Committee would be operational in nature, but focused on mid-term to long-term assessments (not within-year decisions) and while the AM Committee could be requested to examine the implications of operational decisions made on a monthly or weekly basis by the Boards of Control if requested, they would not be involved in those operational decisions on a regular basis. For Lake Ontario outflows the Board would continue to be advised by the Operational Advisory Group and the Regulation Representatives (as shown in Figure 5), particularly related to any short term deviations of the regulation plan as per the authority of the Board.

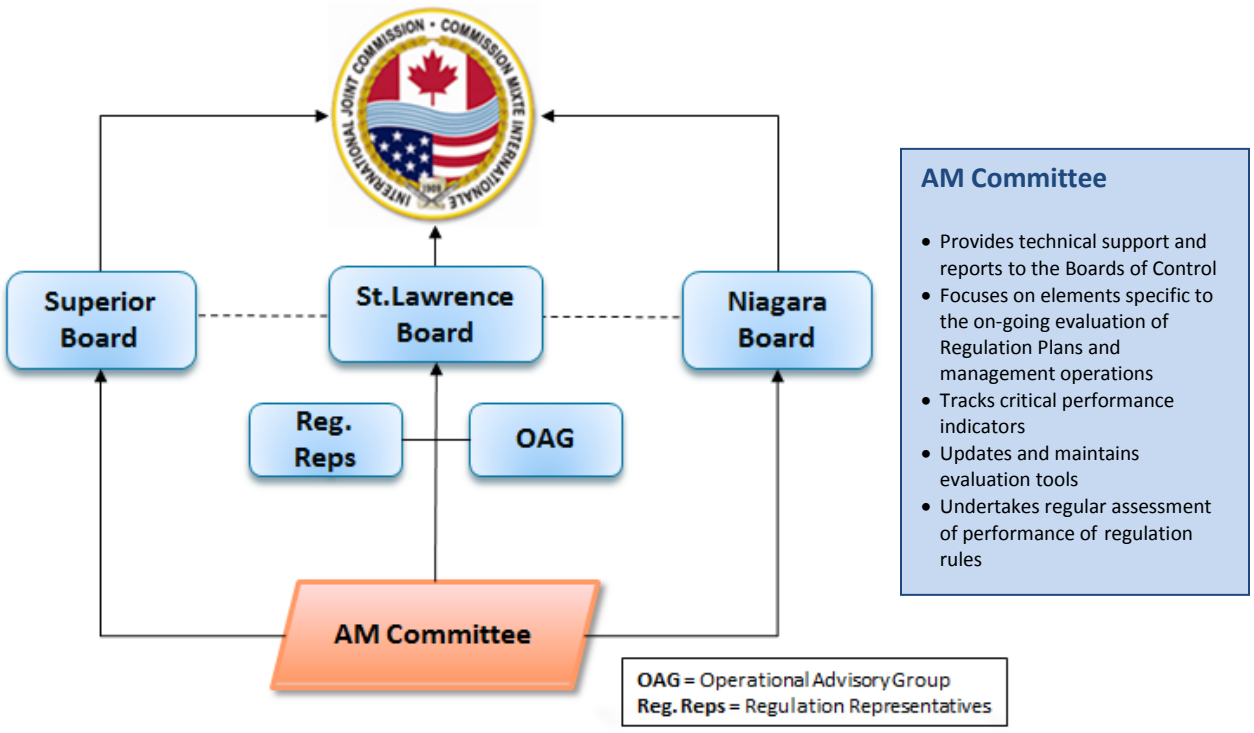


Figure 5 ***Proposed AM Committee***

It is not intended that the AM Committee would conduct extensive new exploratory research, system-wide analyses, model development, or major modification to modelling tools, which would be covered by the broader LAB and its supporting networks. This AM Committee, while formally reporting to the Boards of Control, would coordinate and work directly with the LAB to help inform some of the priorities in system-wide research and analyses needed to support the AM Committee's efforts in the on-going evaluation of the regulation plans.

The AM Committee would be assigned with on-going monitoring of important performance indicators to allow for the periodic review of the regulation plans. There are four key environmental performance indicators that have been identified for follow-up: wetland vegetation, bird communities, northern pike, and muskrat. These four performance indicators were identified during the LOSLR Study and subsequent follow-up as being highly significant in terms of representing broad ecosystem response, being sensitive to water level changes, and representing a relatively high degree of scientific certainty. In addition, there are a number of socio-economic performance indicators that have been identified for follow-up to verify simulated model results, particularly from the Flood and Erosion Prediction System (FEPS) developed and used in the LOSLR Study. Some follow-up to recreational boating, commercial navigation, municipal infrastructure and hydropower has also been identified for the Lake and River and are included in the AM Plan for proposed follow-up by the AM Committee and Board of Control. There is also proposed follow-up monitoring and modelling to ensure that any new LOSLR regulation plan does not result in unexpected environmental or socio-economic impacts on the lower St. Lawrence River, especially on species-at-risk.

Based on regulation plan formulation and evaluation efforts undertaken in IUGLS, there were only a few performance indicators identified that would be greatly improved or degraded by the Lake Superior regulation plan. Therefore, minimal follow-up of performance indicators is required in the near term, though ongoing assessment of emerging issues may identify additional performance indicators over the longer term. As an initial priority for the AM Committee, follow-up analysis is needed to assess the implications on a few performance indicators specific to the St. Mary's River area.

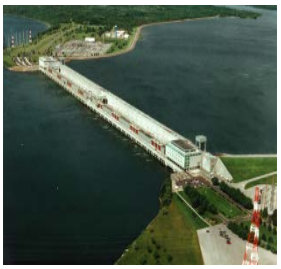
On-going maintenance and updating of evaluation tools such as the Shared Vision Models, Integrated Ecosystem Response Models (IERM, IERM2 and IERM2D), the Flood and Erosion Prediction System and Shore Protection models are required and would be the responsibility of the AM Committee to allow for on-going evaluation of the regulation plans. The AM Committee would be responsible for updating the models based on new monitoring data and inform the Boards of Control on the status of the regulation plans in achieving intended objectives or whether any adjustments to the plans may be warranted based on the evaluation results.

The AM Committee would report on their monitoring and evaluations of the regulation plans on a semi-annual basis to the Boards of Control. Should, at any time, the Boards determine that an adjustment to one of the regulation plans or operational procedures is warranted based on the findings of the AM Committee, they would report this to the IJC who may request more detailed evaluation, and/or consider a modification to the regulation plan or operations. (see Box 3 for an example of how this might work).

Box 3: Board of Control and AM Committee Interaction

Example Scenario: Lake Ontario water levels have been declining and are well below average and nearing the trigger levels for deviations as directed by the IJC. The Board of Control is receiving much public pressure to take all measures possible to hold additional water on the lake. Proponents of the ecosystem know that this natural variability is needed for healthy nearshore habitats and for the birds and animals that depend upon them. The Board of Control asks its Regulation Representatives (Reg Reps) to assist them in assessing a number of different deviation strategies under the current set of circumstances. The Reg Reps evaluate a number of possible water supply scenarios through model simulations using the models maintained and updated by the Adaptive Management Committee (AM Committee). The AM Committee's models include the Integrated Ecological Response Model that has been maintained based on long-term monitoring of wetlands and indicator species as well as the Shared Vision Model, which includes economic implications. The Reg Rep advice is provided to the Board based on the on-going science and technical support provided through the AM Committee on what can be achieved through deviations and what the potential environmental and economic implications might be both upstream and downstream so the Board can consider a balanced, science based approach. Using the forecast tools and information developed collaboratively by the Hydroclimate Network of the Great Lakes-St. Lawrence River Levels Advisory Body and AM Committee, the Reg Reps also provide advice to the Board of Control that a return to wetter conditions is forecast for the next 30 to 90 days but the longer term dry cycle is likely to continue at least into the following year. Considering the advice, the Board of Control decides on a deviation strategy which it submits to the IJC in advance for approval so it is ready to implement if the deviation triggers are reached. The AM Committee continues to track key performance indicators and provides the Board with its regular assessment of the effects of regulation and their deviation strategy on the various interest categories and the implications for the lake and the upper and lower St. Lawrence River. The results are made available through Board's Communications Committee and through the Outreach and Engagement Network of the Levels Advisory Body which provide the Board a report on the reaction to their decisions.

Figure to the right is of the Moses-Saunders Hydroelectric Generating Station on the St. Lawrence River



2.2.1 AM Committee Roles and Responsibilities

The proposed role of the AM Committee would be as follows.

a. Work on behalf of the Boards of Control to carry out adaptive management efforts related to the on-going evaluation of the regulation plans and in addressing any on-going operational questions that might arise.
b. Provide the technical expertise to oversee and otherwise carry out the activities to allow for the on-going evaluation of the regulation plans.
c. Formulate strategic work plans for executing activities in support of that AM Plan as approved by the Boards of Control.
d. Provide technical progress reports at Boards of Control meetings and raise issues that require Boards' approval.
e. Coordinate with designated IJC liaisons.
f. Designate co-leads responsible for all information developed as part of the AM Plan; this information would be developed in a format appropriate for peer review and ultimate

incorporation into the broader information management and distribution system as part of the LAB activities.

2.2.2 AM Committee Tasks

The following lists a set of key priority tasks that have been identified as critical to the on-going evaluation of the regulation plans. These priorities have been chosen from a much broader list of proposed tasks, but represent a sufficient task list to provide an adequate and cost-effective follow-up assessment of the regulation plans. The adaptive management tasks pertaining to the on-going evaluation of the new regulation plan are to be considered as a priority within this AM Plan falling within the "direct" responsibility of the IJC, as indicated below. All AM Committee tasks are numbered beginning with an "A".

A1 - Assessing Ecosystem Response

A1.1 Monitoring of key Lake Ontario and Upper St. Lawrence River *(High priority)*

- Wetland and Bird community monitoring (see Box 4) (direct)
- Northern Pike data (direct)
- Muskrat data (direct)

A1.2 Monitoring of key Lower St. Lawrence River *(Medium priority)*

- Monitoring of key lower river environmental indicators (e.g. species-at-risk, muskrat, northern pike) *(direct)*

A1.3* Aquatic Invasive Species (AIS) evaluation (e.g. Phragmites) *(High Priority)

- Develop a surveillance program to monitor the effect of the any regulation plan on AIS establishment and spread in the Lake Ontario – St. Lawrence River System.

A1.4 Monitoring of key St. Marys River environmental indicators *(High priority)*

- Follow-up on St. Marys River outflows for Sturgeon habitat to ensure that June flow changes are having the intended benefit for Lake Sturgeon habitat. *(direct)*
- Follow-up on St. Marys River ramping of gate opening for minimizing impacts to fish habitat. *(direct)*

A1.5 Modelling of Ecosystem Indicators for Lake Ontario and Upper River *(Medium priority)*

- Continued integration of monitoring data into evaluation models. *(direct)*

A1.6 Ecosystem Modelling for Lower St. Lawrence River *(Medium priority)*

- Continued integration of monitoring data into evaluation models. *(direct)*

Box 4: Collaboration on Lake Ontario Wetlands Monitoring

Coastal wetlands of the Great Lakes are biologically diverse systems that hold great value for the ecosystem goods and services they provide. Vegetation communities in Great Lakes coastal wetlands exhibit vegetation zonation; different vegetation communities occur at different elevations. Hydrology (mainly water level history) influences the elevation that these communities occupy and their composition (species occurrence and abundance). The final report of the 5 Year Lake Ontario-St. Lawrence River (LOSLR) Study described the effects of the current water level regulation regime (Plan 1958D with deviations) on coastal wetland vegetation and bird communities. Following the LOSLR Study and recognizing the possibility that a new regulation plan may be implemented in the future, the Canadian Wildlife Service – Ontario, (a branch of Environment Canada) developed a monitoring methodology to track vegetation community dynamics and marsh bird community response in support of the principles of adaptive management.

The Canadian Wildlife Service piloted the methodology in 2006 at four sites, with full data collection at six sites in 2009 and eight sites in 2010-2012. The site sampling methodology involves a combination of resurveying some sites and adding new sites annually. In total, 15 different sites have been surveyed. Current project funds limit the amount of sampling on the Canadian side to eight sites per field season although from a study design standpoint, 16 sites are deemed logistically manageable and representative for the Canadian Lake Ontario shoreline. Representative sites include a range in hydrogeomorphic type, size, and location across the basin.

In August 2011, The Nature Conservancy was awarded funding through the Great Lakes Restoration Initiative to conduct a 3 year, $300K project to initiate the environmental monitoring called for in the framework for adaptive management on the U.S. shoreline of Lake Ontario and the upper St. Lawrence River. Through coordination on preliminary adaptive management efforts under the LOSLR Working Group, The Nature Conservancy engaged with NY DEC, the US Army Corps of Engineers, the IJC and Environment Canada in developing their methodology and in coordinating on necessary data collection (e.g. aerial imagery etc.). Sixteen sites were selected for monitoring and at the end of August 2012, a field training day was held with staff from the Canadian Wildlife Service to ensure data integrity and consistency among the monitoring sites in Canada and the US. Considerable non-Federal support also came through staff time for two surveyors by NYSDEC Division of Lands and Forests.

Vegetation data are summarized to determine the extent of five focal vegetation communities: submerged aquatic vegetation (upper extent only), non-persistent emergent, cattail (Typha spp.), meadow marsh and shrub (lower extent only). The eventual goal of these projects is to continue efforts to understand the dynamics of coastal marsh vegetation in Lake Ontario, including the role of local water level and hydrogeomorphology. This will lead to accurate evaluation of the effects of water level fluctuation on marsh vegetation should regulation of Lake Ontario be altered.

Together these wetlands studies in the U.S. and Canada are the first agency monitoring programs in the Great Lakes that incorporate wetland vegetation zones at discrete elevations. They have provided insight into hydrogeomorphic differences in wetland vegetation and provide high quality data to be used for future forecasting of habitat changes associated with water level regulation or climate change and represent a critical monitoring requirement under the Adaptive Management Plan.

Figure to the right is of a coastal wetland vegetation community surveying by Environment Canada – Canadian Wildlife Service Ontario.

A2 - Verification of Model Assumptions and Follow-up for Socio-Economic Interests

A2.1 Verify minimum flood levels for sensitive Lake Ontario and upper St. Lawrence River counties *(High priority)*

- Verify whether the static minimum flood levels used within the model are appropriate or whether they hide potential sensitivities.

A2.2 Update Lower River flood damages curves and long-term monitoring *(Medium priority)*

- To ensure that any possible new regulation plan does not inadvertently result in additional damages related to flooding caused by its implementation, the stage-damage curves need to be updated with the most recent information and the performance indicator impact functions adjusted if needed.

A2.3 Assess whether existing hazard zone delineations are adequate under the new regulation plan (not required on Lower River) *(High priority)*

- Flood hazard zones are partially defined by lake level elevation. Any possible new regulation plan should be assessed to determine whether it may change the defined flood hazard zone.

A2.4 Verify design water levels assumed in shore protection modeling (Lake Ontario only) (see Box 5for example) *(High priority)*

- Review existing inventories and/or other data sources to determine characteristics of shore protection

Box 5: Collaboration on Shore Protection Data Acquisition

Shoreline protection maintenance on Lake Ontario is the coastal performance indicator that was most sensitive to the differences among candidate regulation plans in the evaluations during the LOSLR Study. Sensitivity analyses of the shore protection results suggest that shore protection failure from overtopping is sensitive to the design water level elevation used within the model and that verification of top of structure elevation for existing and replacement shore protection would provide additional confidence of assumptions used within the model.

Recognizing the importance of verification of impact estimates, the New York Department of Environmental Conservation commissioned a field survey spanning several coastal counties that provided a large sample of top of structure elevation measurements. The study was just recently completed and the results are being interpreted by a collaborative multiagency LOSLR technical sub- group regarding the implications for the model results.

Figure to the left is of a vertical wall shore protection on the south shore of Lake Ontario. Photo provided by AECOM

A2.5 Monitor recreational boating activity for Lake Ontario and the Upper St. Lawrence River *(Medium priority)*

- Monitor recreational boating activity, including during the fall season, to test for sensitivities *(direct)*

A2.6 Update Lower River Recreational Boating Performance Indicators and Models *(Medium priority)*

A2.7 Update Lower River Commercial Navigation Performance Indicators and models *(Medium Priority)*

A2.8 Update Lake Ontario Commercial Navigation Performance Indicators and models *(Medium Priority)*

A2.9 Follow-up on Risk to Municipal and Industrial Water Uses Infrastructure *(Medium Priority)*

A2.10 Investigate Stability of St. Mary's River Compensating Works *(High Priority)*

- Follow-up on St. Mary's River study of dam stability to identify any necessary modifications to the compensating works on the St. Mary's River (Great Lakes Water Levels Task Force, 1987). *(direct)*

A3 - On-going Assessment of Regulation Plan and Operational Management

A3.1a and A3.1b:

Process to determine if changes to the plans (Lake Superior – A3.1a, and Lake Ontario – A3.1b) should be recommended to address future conditions *(Medium priority)*.

Understanding important hydroclimate or impact triggers for when a change may be warranted. Requires coordination with LAB and its networks.

- Establish appropriate impact and/hydroclimate triggers for shifting lake regulation rules
- Evaluate the appropriate shifts to the regulation plans under extremes

A3.2 Investigate Operational Management Questions Raised by the Boards of Control. *(Medium priority)*.

Address any specific questions from the Boards of Control regarding their on-going operations, such as ice management issues, or deviation operations.

- Evaluate current operations and examine whether improvements are possible over the long-term.

A3.3a and A3.3b:

Maintenance of evaluation tools and models for continued operation.

All of the evaluation models developed for the IUGLS (A3.3a) and the LOSLR study (A3.3b) require maintenance and user manuals for their on-going use in plan evaluation. ***(High priority)***

- User manuals for the evaluation and modelling tools (e.g., SVM, IERM, IERM2 and IERM2D, FEPS, Shoreline Protection Model, Great Lakes Navigation Model (GL-SAND), Optimization model) *(direct)*
- Assigning of stewards for models and training of internal staff (indirect)
- Refinement and finalization of models *(direct)*
- Maintenance and updating of evaluation and optimization necessary to incorporate new data and maintain operational capacity *(direct)*

A3.4 On-going Plan Development and Evaluation. *(Medium priority)*

Long-term support will be needed, along with trained staff to perform the evaluations and modify the plans if needed. Longer-term priority (not in first year).

- Incorporation of performance indicator updates into the Shared Vision Model *(direct)*
- Updating the Shared Vision Model with new information on interest vulnerabilities and emerging issues *(direct)*

A3.5 Coordination of AM activities and reporting ***(High Priority)***.

Reporting would be expected on a semi-annual basis as input to the Boards of Control progress reports at the IJC Semi-Annual appearances.

- Summary on AM activities, performance indicators and evaluation results in tables and graphs and highlights of any issues the Boards should be made aware of.

Possible Membership: Technical experts from the jurisdictions that are represented on the three Boards of Control plus additional experts as necessary to undertake the proposed tasks. The AM Committee membership could initially include the existing membership of the technical experts sub-group that currently supports the LOSLR Working Group.

Current Status: There is considerable adaptive management activity already initiated through in-kind contributions and a number of the jurisdictions are making efforts to secure funds to support adaptive management activities related to the on-going evaluation of the regulation plans. Some related department initiatives are underway that could directly support these activities and there is some external funding that has been acquired to directly support adaptive management activities, such as Great Lakes Restoration Initiative (GLRI) funds acquired by TNC and the New York State Department of Environmental Conservation (DEC) to conduct wetlands monitoring along the U.S. shore of Lake Ontario coordinated with the Canadian program (see Box 3) and GLRI funds acquired by the USACE to support adaptive management activities.

There is currently no agency identified to conduct follow-up monitoring related to Sturgeon habitat or the gate changes on the St. Mary's River. Some work was initiated as part of IUGLS to assess dam stability, but further work will require additional funding or agency support.

IJC Role: These are the primary adaptive management tasks in support of on-going assessment of regulation plan performance and are of direct concern to the IJC.

2.3 Levels Advisory Body (LAB)

A new Great Lakes – St. Lawrence River Levels Advisory Body (LAB) is proposed to be convened by the IJC to address system-wide related components of the AM Plan that can support both purposes of adaptive management. This includes:

- undertake ongoing coordinated bi-national Great Lakes - St. Lawrence River hydroclimate monitoring and modelling and climate change research,

- identify data collection needed to support on-going risk assessment that may be more efficient and cost effective if done collaboratively on a system-wide or large scale basis (e.g. digital bathymetric data collection),
- recommend the development or updating of any bi-national system-wide impact models that support system-wide evaluation and decision-making (e.g. IERM, SVM),
- advise on coordinated bi-national information management and distribution, and on coordinated outreach and engagement, and
- engage opportunistically in collaborative Adaptive Management Pilots to test the AM process for minimizing impacts

While the LAB is convened by the IJC, its authority is derived only from the willingness of agencies and stakeholders to use it to inform their decisions. The goal for the LAB would be to engage stakeholders, government agencies, and non-governmental organizations in a network fashion, perhaps building temporary task teams if needed. Existing institutions would undertake the elements of any collaborative agreement under their own authorities. The LAB would help prioritize tasks, work to leverage resources, engage current mechanisms in undertaking specific tasks of the AM Plan (e.g., the Coordinating Committee, Great Lakes Observing System (GLOS)) or form new task teams from willing participants within their network if existing mechanisms do not exist. The goal of the LAB would be to carry out the AM Plan for system-wide initiatives as resources and opportunities arise, always striving to keep current on system-wide trends and changes. The LAB would report its progress in a forum provided by the IJC, but the IJC would not have any authority over the agencies or stakeholders that agreed to participate.

The LAB would use collaborative AM Pilots on an opportunistic basis to test all components of the AM Plan on a more practical level. The LAB would propose collaborative AM Pilots when traditional approaches had failed and participants supported a collaborative effort to work towards solutions. The LAB would engage, facilitate, and collectively manage the collaboration but would not override the authorities of other agencies. Participation in the AM collaborative Pilots would be voluntary with benefits of engagement realized by the collaboration. If the LAB were to disagree with the actions taken AM Pilot participants it could object and potentially withdraw its support, but would have no formal authority over the participants' decisions.

The role the LAB may play could vary from site to site, depending on the issue and the existing support, but the ultimate goal would be to assist in providing information, tools and knowledge including guidance on collaborative methods to support the development and evaluation of sustainable solutions. The LAB would bring the benefit of a broader system-wide context in terms of understanding risks, the interconnections of the system and drawing upon a broader expertise and knowledge base and lessons learned from other locations and jurisdictions.

The LAB would address the various activities of the AM Plan by engaging a series of "networks" – flexible and informal associations of technical experts. Unlike standing committees, the membership of these

networks could ebb and flow depending on the priorities and focus of the AM Plan as it evolves and as different expertise is required, agency programs change and new science questions emerge. The system-wide networks could tie in with existing Great Lakes – St. Lawrence River partners and their programs as necessary. For example, a Hydroclimate Network could directly tie-in with the Coordinating Committee for Great Lakes Basic Hydrologic and Hydraulic Data and the Climate Change Annex sub-committee under the Great Lakes Executive Committee and with the various agencies that support these (e.g., Environment Canada (EC), National Oceanic and Atmospheric Administration (NOAA), US Geological Survey (USGS), US Army Corps of Engineers (USACE), Fisheries and Oceans Canada (DFO), Natural Resources Canada (NRCan), etc.) The idea again is that this is about synthesizing existing programs and expertise. Organizations would participate because it makes sense to be engaged and is beneficial for them to collaborate.

The following diagram depicts the main concepts of proposed AM framework with the LAB convened by the IJC and a series of flexible networks made up of existing Great Lakes – St. Lawrence River partners utilized to support the AM activities.

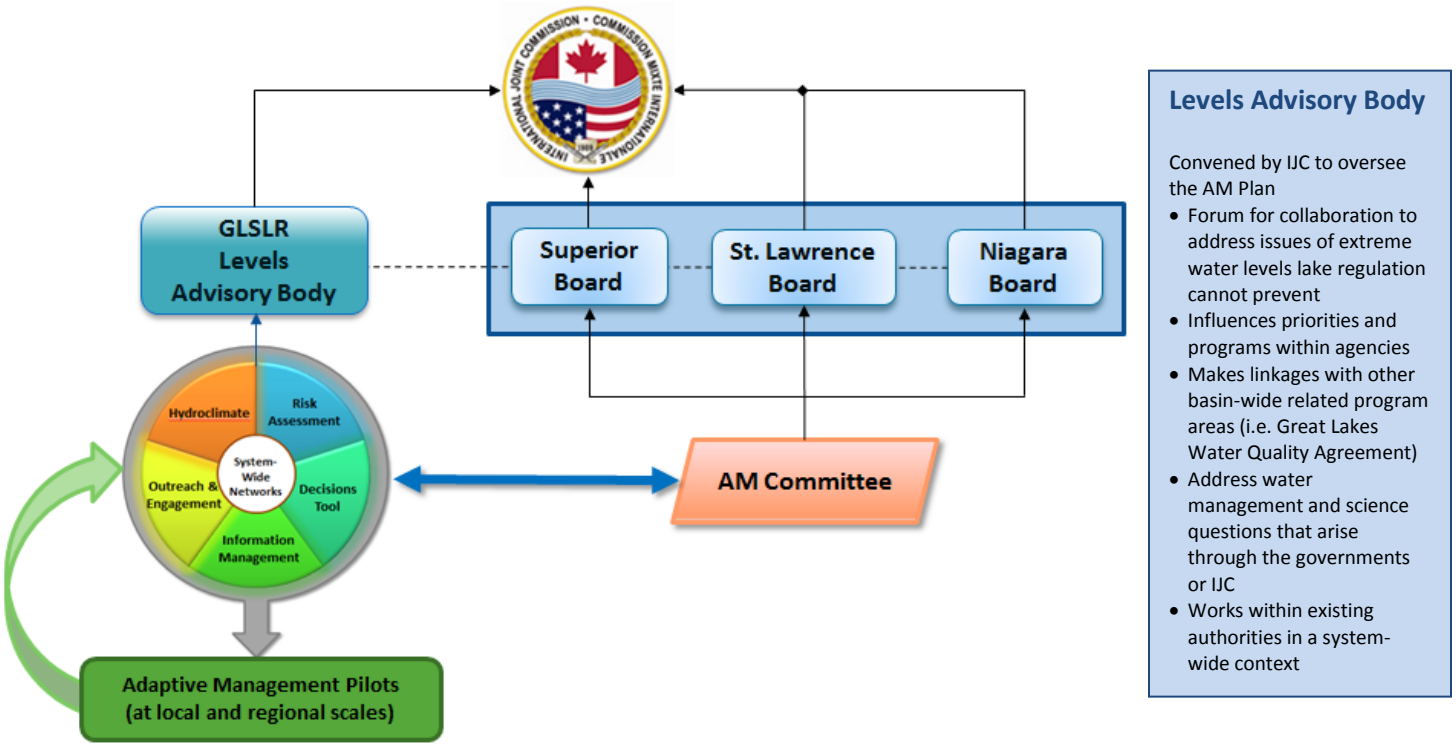


Figure 6 ***AM Framework proposed by the Task Team***

The LAB is proposed to be made up of senior officials from U.S. and Canada, including the States and Provinces, who already play a role related to the impacts of Great Lakes water levels. The LAB would be a forum for collaboration, synthesizing existing leadership and programs as an on-going commitment to

the already-established relationship with the IJC. The Task Team suggests the LAB be made up of senior officials so they can leverage the support and resources of their respective agencies and organizations, influence priorities and programs, seek funding opportunities, and better understand the broader system-wide linkages with related program areas. On the U.S. side, there appears to be a strong nexus between the proposed LAB membership and the National Ocean Policy Great Lakes Regional Planning Body (GL RPB). An intersection of membership would be synergistic to the common goals and objectives of both organizations while eliminating redundant efforts.

The LAB would also provide the IJC with a standing Body, perhaps under a standing reference from the two governments, to address water management and science-related questions that arise related to water levels and flows such as the recent IUGLS recommendations from the IJC to Governments.

2.3.1 Levels Advisory Body Roles and Responsibilities

The proposed role of the LAB would be as follows.

Working within existing authorities the LAB would oversee the strategic direction of the AM Plan:

a. provide the strategic direction and management oversight for the wide range of activities that fall under the competencies of the AM Networks in supporting the AM Plan, including review and updating of the AM plan overtime,
b. coordinate the support and resources from agencies and organizations involved,
c. encourage consistency in priorities and programs of supporting agencies and organizations,
d. identify funding opportunities,
e. ensure the vetting (through peer review and other means) of the science generated through the AM process,
f. approve strategic directions towards implementing the AM Plan,
g. potentially oversee and approve the distribution of any funds that may be contributed through the IJC towards meeting the priorities and the AM Plan
h. be a standing committee to address water management and science questions that arise through the Governments or IJC

Advise the IJC by:

i. providing semi-annual reports to the IJC on progress in applying the AM Plan, and
j. developing advice for the IJC on:
   - hydroclimate monitoring, modelling and research priorities to support the adaptive management program and advice on how the IJC could help in addressing those priorities,
   - key vulnerabilities throughout the Great Lakes - St. Lawrence River system to fluctuating water levels and how these may be changing over time as a result of natural and human-influenced changes to the system,
   - linkages between water quality and quantity,

- information/knowledge most needed by water managers and coastal managers to address risks of extreme water levels and how best to help get that information to them, and
- alternative strategies for addressing risk and the role of the IJC in facilitating change.

Suggested LAB membership

U.S.	Canada
U.S. Federal (e.g., USACE, NOAA, USGS, USFWS)	Canadian Federal (e.g., EC, DFO, TC)
Great Lakes state rep (2-8) (or NOP GL RPB)	Ontario
	Québec
Boards of Control	Boards of Control
Tribes*	First Nations*
Implementing Agencies (e.g., Great Lakes Commission, Great Lakes Observing System)*	Implementing Agencies (e.g., Conservation Ontario)*
University or non-governmental organization*	University or non-governmental organization*
Great Lakes Coastal Zone Manager* (e.g., State or County coastal managers)	Great Lake Coastal Zone Manager * (e.g., Conservation Authorities)
GLEC representative (e.g., EPA)*	St Lawrence Action Plan (SLAP) representative*
GLSLR Water Resources Regional Body representative (e.g., CGLG)*	GLSLR Water Resources Regional Body representative*
Municipal Representative (e.g., GLSLCI)*	Municipal Representative (e.g., GLSLCI)*
Stakeholder Groups (e.g., shipping, industry, environmental, riparian, rec. boating, etc.)*	Stakeholder Groups (e.g., shipping, industry, environmental, riparian, rec. boating, etc.)*
Outreach and/or public layperson*	Outreach and/or public layperson*
LAB Secretary (or secretariat including staff support)**	LAB Secretary (or secretariat including staff support)**

*Could be full members or associates as part of the Networks (yellow shading)
**Provide support to Board, but are not Board members (green shading)

The Task Team suggests that the Federal representatives include a link to the Great Lakes Executive Committee and that State and/or Provincial representatives include a link to the Great Lakes - St. Lawrence River Water Resources Regional Body. With the emergences of the US National Ocean Policy, the U.S. Advisory Board membership could be the same as the Great Lakes Regional Planning Body.

2.3.2 Levels Advisory Body Secretaries (or Secretariat)

Staff support will be required to assist with the logistics and program management activities of the LAB. This support could come through the agencies, but might be more appropriately supplied through the IJC similar to how the Great Lakes Regional Office supports the Water Quality and Science Boards of the IJC. The following activities would be supported by the Secretaries or Secretariat.

- Organize LAB meetings
- Maintain LAB correspondence, minutes and records of decisions
- Track project progress and report to the LAB
- Liaise with agencies on application of the AM Plan

- Liaise with IJC staff to keep them apprised of conditions and issues
- Coordinate System-wide Network activities
- Provide assistance to the System-wide Networks as required
- Support the LAB in the preparation of semi-annual reports and presentations to the IJC

2.4 The System-Wide Networks of the LAB

Five System-wide Networks have been proposed to implement the basic elements of the AM Plan:

1. **Hydroclimate Network**: responsible for strengthening hydroclimate monitoring and modelling, climate change science, and (in particular) providing coordination, vetting and management of Great Lakes – St. Lawrence River hydroclimate and climate change data and science; identifying and prioritizing required monitoring and modelling needs and, where possible, attempting to fill those gaps.

2. **Risk Assessment and Performance Indicator Network**: responsible for follow-up monitoring of specified indicators for on-going risk assessment, and establishment of any new performance indicators required to support collective on-going assessment of actions taken to address extreme water level conditions.

3. **Decision Tools Network:** responsible for updates and improvements of tools and methods for system-wide evaluation, and the development of new tools and methods for supporting decision making to address extreme water levels.

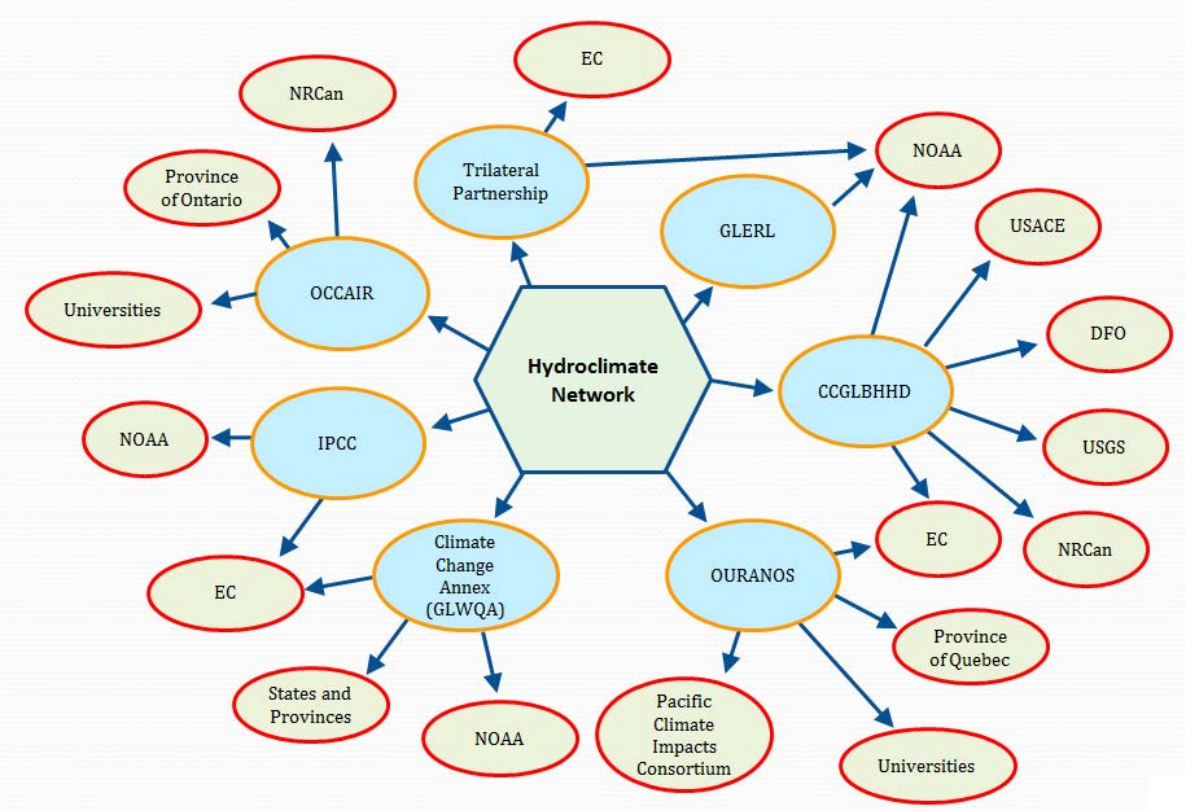
4. **Information Management and Distribution Network**: responsible for ensuring more comprehensive information management and distribution to required users and decision-makers.

5. **Outreach and Engagement Network**: responsible for public awareness and education, identifying target audiences and needs, and working with users and decision-makers to ensure two-way communication.

The System-wide Networks would be made up of U.S. and Canadian agencies, organizations, and consortiums that are already involved in the management of Great Lakes water level impacts and would have some stake in the undertaking of the various adaptive management activities. These Networks will evolve as work plans and priorities change over time. Each Network should have the technical expertise required to fulfill the obligations of the AM Plan and would be co-chaired by U.S. and Canadian technical experts.

The Network concept helps to ensure that all existing groups and agencies that need to be engaged will be involved. This approach is really just a synchronization of those already involved, but allows for a pooling of resources and expertise towards common goals and objectives. The figure below is an

example of the network concept for the Hydroclimate Monitoring and Modelling Network. This is meant as an example only and is not intended to show every possible linkage.



DFO – Fisheries and Oceans Canada
EC – Environment Canada
GLERL – Great Lakes Environmental Research Laboratory
NOAA – National Oceanic and Atmospheric Administration
NRCan – Natural Resources Canada
OCCAIR – Ontario Center for Climate Impacts and Adaptation Resources
OURANOS – Ouranos Consortium on Regional Climatology and Adaptation to Climate Change
IPCC – Intergovernmental Panel on Climate Change
USACE – U.S. Army Corps of Engineers
USGS – U.S. Geological Survey

Figure 7 Example of Hydroclimate Network (example only and not intended to be all-inclusive)

Each of the Networks would carry out specific tasks as identified in the AM Plan. An initial list of prioritized tasks has been compiled by the Task Team in coordination with various agency contacts knowledgeable about the various adaptive management elements. As per the IJC Directive, all tasks have been identified as being (1) *direct* (tasks required to directly evaluate the on-going performance of the regulation plans), (2) *indirect* (supporting tasks required to improve understanding of on-going changes to the system that could influence water management decisions), or (3) *regional* adaptive management activities conducted on a site basis (e.g., primarily to support local solutions to mitigate/adapt to the impact of high or low lake level extremes.) All activities related to the LAB have

been numbered beginning with a "B". High priority items are those that should be initiated in the first year of the AM Plan.

The following provides a short summary of the purpose of each Network in the AM Plan and briefly describes priority tasks. **Estimated costs are summarized for each Network in Table 1 in Section 2.6.2 Funding Adaptive Management.**

2.4.1 B1 - Hydroclimate Network

Hydroclimate is the relationship between climatic factors such as precipitation, temperature, wind speeds, barometric pressure, etc., and relates these to the effects on the components in the water balance of the Great Lakes (overlake precipitation, overlake evaporation, basin runoff and groundwater) and in turn relates this to the impact on water levels and flows in the Great Lakes-St. Lawrence River system. A number of specific needs and priorities have been identified for hydroclimatic monitoring and modelling to improve decision making by reducing uncertainties in the various components of the Great Lakes water balance. Improvements are needed to address a number of issues including, but not limited to, inadequate spatial coverage, inconsistent methodologies, temporal data gaps or insufficiently long records, failure to seamlessly present data from different networks, and incomplete use of new or emerging technology.

To address these issues, targeted hydroclimate monitoring and modelling is required to address each of the components of the water balance. In addition, there are specific requirements for improved numerical weather forecasting, improvement to existing Great Lakes hydrologic models, and improved Regional Climate Change modelling.

Priorities include:

B1.1 Improved measurement and understanding of the individual components of the water balance

- Improved measurement of over-lake evaporation through installation and maintenance of over-lake evaporation stations in the Great Lakes. Success with using observation stations on Lakes Superior and Huron to estimate evaporation rates and improve operational hydrometeorological models in both the US and Canada during IUGLS has led to an extension and expansion of observations to include six more sites across all five Great Lakes. These sites will require on-going maintenance and operation currently not covered in program budgets. *(indirect)* ***(High priority)*** (see Box 6 for example)

Box 6: Overlake Evaporation

More water evaporates off the Great Lakes than flows over Niagara Falls, but until recently, evaporation was estimated by an inadequately calibrated computer model due to a lack of measurements. The IUGLS Board funded evaporation measurement stations on Lake Superior and Lake Huron because the large uncertainty of modeled estimates undermined efforts to determine the cause of lower levels on Lakes Michigan and Huron. These measurements have been used to correct the model and greatly reduced the uncertainty in the evaporation estimates.. After the study four more evaporation monitoring sites were established and now evaporation is measured on each Great Lake.

No single agency funds these stations; the incentive to create them and the effort to sustain and use them comes from a consortium of U.S. and Canadian agencies and universities, funding is provided by Environment Canada and the U.S. National Science Foundation.

Figure to the right Evaporation station on Spectacle Reef Lighthouse, Lake Huron 50 km from Mackinaw City

- Improved use of precipitation data through the development of a real-time precipitation gauge database linking federal, provincial/state, and local gauge networks. This is needed because data from some precipitation gauges are currently unusable or of questionable utility in supporting regional precipitation analysis due to a lack of metadata information accurately describing their operational characteristics. This is a first step before it can be determined if the system of precipitation gauges is adequate to support on-going hydroclimate science. *(indirect)* ***(Medium priority)***

- Improved runoff estimates through better coordination of methodologies and an evaluation of the runoff gauge network. Multiple methods and estimates of Great Lakes runoff are now available through various models/agencies; as such, a comprehensive evaluation and coordination of Great Lakes runoff estimates is necessary. Furthermore, runoff estimates would benefit from an improved streamflow network; the first step to achieve this is a comprehensive runoff gauge network risk evaluation. *(indirect)* ***(Medium priority)***

- Improved estimates of connecting channel flow and possible changes in conveyance. The IUGLS demonstrated the need for on-going monitoring of connecting channel conveyance for changes that otherwise can go undetected. *(indirect)* ***(High priority)***

    - Establish a St. Clair/Detroit River conveyance monitoring plan.
    - Conduct period bathymetric surveys of the St. Clair/Detroit River in accordance with the established monitoring plan.
    - Undertake studies of ship-generated hydrodynamic impacts in St. Clair and Detroit Rivers and possible impacts to conveyance.
    - Estimate connecting channel flow through ongoing maintenance of new index velocity ratings at St. Mary's, St. Clair, and Detroit Rivers, and new stage-discharge rating at Niagara River.

- Improved understanding of change in storage of the lake through improved estimates of thermal expansion and contraction. Change in storage is currently not accounted for in estimates of residual net basin supply, causing a seasonal, systematic error in net basin supply estimates. *(indirect)* ***(Medium priority)***

- Improved integration of Great Lakes Water Balance Estimates through ongoing maintenance and improvements to models [i.e., Advanced Hydrologic Prediction System (AHPS), Global Environmental Model (GEM), and Modélisation Environmentale Communautaire Space, Surface Hydrology (MESH) model] and approaches to water balance closure and uncertainty estimation. Research and results from differing models present a chance for comparison and improvements to estimates of past and future net basin supplies. Tools for assessing uncertainty, and tracking changes and systematic differences in water balance components on an ongoing basis using information on the system as a whole, could help identify and quantify uncertainties in basin water supplies. *(indirect)* ***(High priority)***

- Provision of a tool for assessing uncertainty and tracking changes and systematic differences in water balance components on an ongoing basis using information on the system as a whole, such as by undertaking a state-space modelling approach to water balance closure and uncertainty estimation. *(indirect)* ***(Medium priority)***

B1.2 Improved Forecasting of Net Basin Supply (NBS) (overlake precipitation, plus basin runoff minus overlake evaporation)

- Improved integration and coordination of hydrologic models. Further research and development work could result in the MESH model coupled with GEM forecasts being used to forecast net basin supply for the Great Lakes. The AHPS has been in use for nearly 20 years, was recently evaluated, and is targeted for a series of critical improvements. The MESH and AHPS are to be coordinated to improve daily ensemble forecasts. *(direct)* ***(Medium priority)***

- Research for long-term (6-8 months) and short-term (2-4 weeks) forecasts to improve operation of regulation plan ***(LOSLR High priority)*** *(direct)*

- Research to improve physical and statistical understanding of relationships between ocean and atmospheric conditions and Great Lakes net basin supplies and attribution of Great Lakes water level trends and occurrences. The more that can be understood in terms of what is driving trends in basin water supplies, especially periods of very wet or very dry conditions, the greater the opportunity to improve the science of prediction. *(indirect)* ***(High priority)***

B1.3 Climate Modelling

- Continued regional coupled climate/hydrologic modelling (dynamic downscaling) using multiple modelling systems (Global Climate Models (GCMs) and Regional Climate Models

(RCMs)); and, analysis of the North American Regional Climate Change Assessment Program (NARRCAP) data for various GCM/RCM combinations as it becomes available. Improved climate models will allow for improved risk assessment and prudent planning. *(indirect)* ***(High priority)***

- Provision of a coupled Great Lakes and St. Lawrence River model along with an Ottawa River model to allow for further testing of plans under a greater range of plausible climate change scenarios. Current Regional Climate Models are separate for the Great Lakes and St. Lawrence River. This means there is limited application of regional climate change models for the lower river. ***(LOSLR High priority)*** *(direct)*

- Completion of IUGLS stochastic series to include Ottawa River inflows to provide an updated system-wide stochastic series. ***(Medium priority)*** *(direct)*

Potential Network Involvement: Key organizations working on hydroclimate science, including Environment Canada (EC), National Oceanic and Atmospheric Administration (NOAA) - Great Lakes Environmental Research Lab (GLERL), US Army Corps of Engineers (USACE), US Geological Survey (USGS), and related consortiums such as the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data (CCGLHHD), the Great Lakes Observing System (GLOS), Ouranos, a consortium on regional climatology and adaptation to climate change, the newly formed Climate Change Annex subcommittee of the GLWQA, the Northeastern Climate Science Centre and others not mentioned here.

Current Status: A number of the agencies have already initiated work on some of these tasks in response to recommendations from the IUGLS and LOSLR study efforts. For example, a consortium of U.S. and Canadian agencies has worked towards the installation of a number of overlake evaporation stations covering each of the Great Lakes. Work on improvements to the hydrologic models is continuing as referred to in Box 5. The IJC has also made a commitment with USGS to continue funding of the connecting channel flow gauges through the USGS International Gauges Program, within the funding limits provided through the U.S. federal budget process.

IJC Role: The IJC has an on-going need for understanding hydroclimate and climate change science in the Great Lakes - St. Lawrence River Basin to allow for on-going assessment of implemented regulation plans for both Lake Superior and Lake Ontario outflows and to understand system-wide climate changes in context of water management decisions now and in the future. The IJC can play a lead facilitation role working with governments to set priorities.

2.4.2 B2 - Risk Assessment and Performance Indicator Network

Conditions on the Great Lakes and the St. Lawrence River are constantly changing. There are economic and ecosystem vulnerabilities within the range of historic water levels (existing vulnerability) and it is expected that more extreme climate and water level conditions will lead to increased impacts. Therefore, as part of this AM Plan, facilitated and structured interagency collaboration will improve monitoring and risk assessment through an integration of existing and emerging physical, socio-

economic and environmental impact/vulnerability data and information. For example, if databases exist or are established that track shoreline development or permits for shore protection, this could be updated on a yearly basis into a coordinated database to allow for on-going assessment of shoreline property vulnerabilities. Changes in shipping economics related to changes in water depth can be monitored with support from navigation and port industries. Regarding ecosystems, there are existing environmental research programs that could be leveraged and possibly used in adaptive management to provide a more robust understanding of ecosystem vulnerabilities related to water levels and flows and integrated into the decision process for how best to address impacts of extreme water levels. Connections would be made through the network with other indicator efforts such as those developed in support of the State of the Lakes Ecosystem Conference and indicators established as part of the IJC's Science Advisory Board Indicators sub-committee, to name just a couple. Tracking changing physical conditions such as changing ice formations and storm patterns will also be important to understanding future risk. In addition, performance indicators will need to be established for collectively measuring the success of actions taken to mitigate the impacts of extreme water levels. Many of these activities in terms of on-going risk assessment and performance indicators may first be further defined, tested and applied on a pilot basis. The Adaptive Management Pilots are discussed further in Section 2.5.

B2.1 Ongoing monitoring of glacial isostatic adjustment in the system through the CCGLHHD

- Ensure data and information on glacial isostatic adjustment from the CCGLHHD is incorporated into hydrologic and shoreline models *(indirect)* ***(Medium priority)***

B2.2 Long-term monitoring/modelling of shoreline processes

- Obtain high resolution coastal bathymetry and shoreline topography on a priority basis *(indirect)* ***(High priority)***
- Develop site sediment and shoreline geomorphology characterization (start at priority sites) *(indirect)* ***(Medium priority)***
- Establish long term nearshore-shoreline profile monitoring sites and develop coordinated data set of existing information (start at priority sites) *(indirect)****(High priority)***
- Develop a system for mapping littoral movement of material at site locations (start at priority sites) *(indirect)****(Medium priority)***

B2.3 Track long-term climatic trends (link with hydroclimate network and start at priority sites)

- Track long-term trends in storm patterns and wind direction and assess implications to shoreline vulnerabilities *(indirect)* ***Med-High priority depending on site)***
- Track trends in ice cover and research to assess the role of ice in shoreline processes *(indirect)* ***(Medium priority)***

B2.4 Tracking of shoreline modifications and damages (start at priority sites)

- Update assessment of percent and type of shoreline protection *(regional)* ***(Med-High priority depending on site)***

- Track permit applications for low water related shoreline modifications *(regional)* ***(Med-High priority depending on site)***
- Track land use changes in the shoreline area *(regional)* ***(Med-High priority depending on site)***
- Coordinate and monitor reported shoreline damages *(indirect)* ***(Med-High priority depending on site)***

B2.5 Tracking and modelling of ecosystem changes (start at priority sites)

- Monitor/model changes in wetland ecosystem function and spatial extent of both emergent and submergent vegetation *(indirect)* ***(High priority)***
- Monitor/model the establishment and spread of wetland and aquatic invasive species as a function of climate change and changing water level regimes *(regional)* ***(Med-High depending on site)***
- Monitor/model the changes in connectivity between coastal wetlands, riparian wetlands, lakes, and tributaries to assess impact on coastal fish spawning and nursery habitats *(regional)* ***(High priority)***
- Undertake site specific research to confirm Integrated Ecological Response Models (IERM, IERM2 and IERM2D) results (start at priority sites) *(regional)* ***(Medium priority)***

B2.6 On-going Risk Assessment (undertake on a pilot basis)

- Apply high and low water assessment tools at test sites *(regional)* ***(Med-High priority depending on site)***
- Apply low water analysis to critical low water sites *(regional)* ***Med-High priority depending on site)***
- Apply IUGLS commercial navigation model *(regional)* ***(Medium priority)***
- Build marina damage assessment tool (similar to IUGLS) *(regional)* ***(Medium priority)***
- Apply ecosystem models at pilot sites *(regional)* ***(High priority)***

B2.7 Assessment of local solutions to water level risks and vulnerabilities (ONLY AS PARTICIPANTS – LOCAL AGENCIES WOULD LEAD)

- Based on local vulnerabilities, work with local agencies to articulate objectives for addressing issues at site locations *(regional)* ***(High priority)***
- Based on local vulnerabilities, identify possible local solutions to low and high water issues *(regional)* ***(Medium priority)***
- Develop tools to assess various water level scenarios on local conditions *(regional)* ***(High priority if tools don't exist)***
- Identify participation, policy, and funding requirements to address proposed changes *(regional)* ***(Medium priority)***

Possible Network Involvement: Agencies and organizations that can contribute to monitoring key performance indicators through on-going programs and/or special projects, including Environment Canada, Ontario Ministry of Natural Resources, Fisheries and Oceans Canada, US Army Corps of

Engineers, Great Lakes states, Great Lakes Commission, Conservation Ontario, Great Lakes Fisheries Commission, US Fish and Wildlife Service, Transport Canada, The Nature Conservancy (TNC), USGS Great Lakes Science Center etc.

Current Status: There is considerable adaptive management activity already initiated as part of the LOSLR effort related to the on-going evaluation of regulation plans and these will also be important performance indicators in assessing other responses. Additional performance indicators will need to be assessed for each lake and each critical issue. FEMA is currently updating flood lines and other agencies and organizations such as the Conservation Authorities in Canada conduct some vulnerability assessments, however, there currently is little coordination in this area. Emphasis will initially be directed to AM Pilot efforts to begin this coordination at a local or regional level.

IJC Role: Given the IJC's long history of being asked by Governments to assess what can be done to address changing water levels, they have a vested interest in understanding changing risk and vulnerabilities and tracking changes to the system.

2.4.3 B3 - Decision Tools Network

The decision tools network would associate experts on models, data, and other information that makes adaptive management easier or more effective. These tools would include guidance on skills needed to apply adaptive management, including but not limited to the cumulative experience from IUGLS and the LOSLR study.

The tools developed as part of the IUGLS and LOSLR study efforts to evaluate regulation plans would be used and maintained by the Boards of Control AM Committee, while any major revisions to the tools or development of new tools would be conducted through the Decision Tools Network.

Some of the LOSLR/IUGLS tools may be useful for issues beyond lake level regulation, since they measure the impact of water levels (whatever combination of factors creates those levels). These tools include the Shared Vision Models and the Integrated Ecological Response Models (IERM, IERM2 and IERM2D) developed for the two studies, the Flood and Erosion Prediction System developed for the LOSLR study, the commercial navigation models from both studies, the IUGLS shore protection model and a subsequent flood impact analysis tool developed for the IUGLS and applied to Lake Ontario to more closely assess local flooding and wave surge impacts.

But there other tools that will be useful, including:

- The planning and decision-making methods, the "plan" stage of adaptive management that creates the framework for the subsequent steps (act, monitor, evaluate, learn, adjust). These methods are well established in the water resources literature and address subjects such as effective public involvement, dispute resolution, decision theory, information management and communications.

- The integration of decision making and climate modeling. Until about twenty years ago, water management decisions were based on an assumption that climate would not change during the period to which the decision applied. Now most water management decisions have to consider both natural variability and man-made climate change, but the methods for doing that have had little time to mature. The IUGLS methods were better informed and more sophisticated than the LOSLR study methods. The IUGLS experience with these questions is well documented and will be very useful to other groups in and outside the Great Lakes.

- The data and research products acquired for the IUGLS and LOSLR study, but also, the methods used to design the research to fit decision makers' questions. Scientists and decision makers are expert in their own spheres, and that means an effort has to be made to help each understand the other. For example, a researcher typically estimates the skill of a forecasting model in terms of the parameter it predicts, whereas a decision maker judges forecasting skill by the consequences of decisions based on forecasting. In both LOSLR and IUGLS, there were intensively managed interactions between scientists and decision makers to assure the research products would be useful, and it will be important that those who practice adaptive management build on those successes.

These tools will have to be modified or new tools developed and documented to help evaluate alternatives other than lake level regulation. The need will manifest itself over time, starting with the AM pilots, as the use of adaptive management spreads and new alternatives come into play. The work involved in developing, documenting, maintaining and applying these tools will progress in three stages:

B3.1 Exercise and update the tools developed for the IUGLS and LOSLR study and encourage their use where applicable

- Link the IUGLS IERM2 and the LOSLR IERM to assess ecosystem risk *(indirect)* ***(High priority)***
- Undertake comparison of LOSLR and IUGLS shore protection models and consider updates in models to coordinate evaluation methodologies *(indirect)* ***(High priority)***
- Coordinate FEPS flooding evaluation model with newer Flood Tool procedures *(indirect)* ***(Medium priority)***
- Coordinate LOSLR and IUGLS recreational boating impact evaluation tools *(indirect)* ***(Medium priority)***
- Coordinate LOSLR and IUGLS commercial navigation impact evaluation tools *(indirect)* ***(Medium priority)***

- Ensure documentation and appropriate training of all users of the models (indirect) ***(High priority)***

B3.2 Modify these tools or develop new tools if needed for the AM Pilots

- Updating and improvement of existing IUGLS evaluation and optimization models based on new information (PIs and coping zones) and new software advances (beyond AM Committee work) as necessary for AM pilots *(indirect)* ***(High priority)***

- Updating and improvement of existing LOSLR evaluation and optimization models based on new information (PIs and coping zones) and new software advances (beyond AM Committee work) as necessary for AM pilots *(indirect)* ***(High priority)***
- Undertake model development to address emerging vulnerabilities or to replace any existing decision tools as necessary for AM pilots *(indirect)* ***(High priority)***
- Develop and document tools to provide on-going assessment of plausible risk (i.e. identification of problem water levels) as necessary for AM pilots *(indirect)* ***(High priority)***

B3.3 Modify these tools or develop new tools in subsequent regional or Great Lakes wide adaptive management.

- Updating and improvement of existing IUGLS evaluation and optimization models and documentation based on new information (PIs and coping zones) and new software advances (beyond AM Committee work) as necessary for regional or system wide AM *(indirect)* ***(High priority)***
- Updating and improvement of existing LOSLR evaluation and optimization models and documentation based on new information (PIs and coping zones) and new software advances (beyond AM Committee work) as necessary for regional or system wide AM *(indirect)* ***(High priority)***
- Undertake model development, documentation and training to address emerging vulnerabilities or to replace any existing decision tools as necessary for regional or system wide AM *(indirect)* ***(Medium priority)***

B3.4 Provide operational support in the application of decision tools at AM Pilot sites

- Coordinate the use of evaluation tools (including training) through a Shared Vision Planning process to support work at AM Pilot sites *(indirect)* ***(High priority)***

The information management system designed for the IUGLS benefitted from lessons learned from the LOSLR study, but now the LOSLR system needs to be improved to the same status. For example, it is not only easy to find IUGLS information and tools on the IUGLS.org website, the inter-relation between the decisions and the hiearchy of data, research, models and decision framework is evident. There is some work going on now to improve the availability of LOSLR study information, but more needs to be done.

If there are AM Pilots, part of the work will be to glean what can be used from the LOSLR/IUGLS toolboxes, what needs to be modified, and what, if anything new is needed.

Potential Network Involvement: IJC, EC, DFO, USACE, FEMA, USGS, USFWS, OMNR, Quebec, US States, GLC, GLOS, Conservation Ontario, academia etc.

Current Status: Currently the IUGLS IM system and shared vision model are being prepared for use in adaptive management of the regulation plans and that work will also support AM beyond lake level regulation to some degree. Beyond that there are no official mechanisms in place for the integration and on-going improvement of these tools. The IJC relies on agency support for some of these tools; however, many of the tools are proprietary and corporate knowledge is limited.

IJC Role: The IJC has a direct interest in the maintenance and updating of these tools to allow for on-going assessment of regulation plan performance.

2.4.4 B4 - Information Management and Distribution Network

The intention of this AM Plan is to support science based decision making by maintaining, integrating and building upon the information gathered as part of the LOSLR study and IUGLS. Information and data management systems, as well as tools to assess and evaluate results, are critical components of this AM Plan, so the data and information can be utilized effectively by those who need it to adjust to changing conditions. This AM Plan develops the oversight and coordination needed for an effective and efficient means of compiling, vetting, coordinating and distributing the data and information for use by those responsible for managing Great Lakes - St. Lawrence River water level related impacts. Data sharing agreements will be established as needed, as well as an approach to coordinate an information management infrastructure, information management protocols, standards and stewards.

The information generated through the previous IJC studies and this AM Plan is also highly relevant to other Great Lakes initiatives such as the Great Lakes Water Quality Agreement and the Great Lakes - St. Lawrence River Basin Sustainable Water Resource Agreement.[1] The ongoing hydroclimatic monitoring, modelling and data management systems of different agencies can be utilized to support coastal zone management and other Great Lakes resource management programs, including the Great Lakes Water Quality Agreement requirements. Information gained in terms of risk assessments can further inform decisions, but the information needs to be available and accessible from a trusted source. The Information Management and Distribution Network would bring together existing efforts to coordinate activities and work towards a distributed system that allows for access and data sharing across platforms. Most importantly, this Network would bring together the data and information most needed by decision-makers to address uncertainty.

The following tasks are highlighted as part of the information management and distribution effort:

B4.1 Establish information architecture to ensure that critical technology and standards are in place to support functioning and compatible Information Management (IM) systems across the Great Lakes – St Lawrence River System.

- Develop information management data schematic that identifies critical data and information linkages so information can be searched and found in a logical manner *(indirect)* ***(High priority)***
- Provide Data portal/Data visualization as a window to the data and information and allowing visualization and mapping of datasets *(indirect)* ***(High priority)***

[1] For information on the Great Lakes Water Quality Agreement, see the IJC's website: www.ijc.org/en/activities/consultations/glwqa/agreement.php
For information on the Sustainable Water Resource Agreement, see the website of the Council of Great Lakes Governors: www.cglg.org/projects/water/CompactImplementation.asp

- As a long-term goal, establish and maintain critical technology (hardware, software, bandwidth), standards and protocols to ensure all components function together for system operation *(indirect)* ***(Medium priority)***

B4.2 Information management protocols to allow for data search, retrieval, distribution and use.

- Establish and ensure metadata standards are met *(indirect)* ***(High priority)***
- Provide Quality Assurance/Quality Control (vetting of information) *(indirect)* ***(High priority)***
- Establish uploading and downloading protocols and permissions *(indirect)* ***(Medium priority)***

B4.3 Information management governance for ensuring on-going storage, maintenance and updating of data and information.

- Establish data stewards and roles and responsibilities *(indirect)* ***(High priority)***
- Establish data and model use and stewarding agreements/Memoranda Of Understanding (requires senior management levels) *(indirect)* ***(Medium priority)***
- Establish oversight body to ensure all of the above information management strategies are implemented *(indirect)* ***(High priority)***

Possible Network Involvement: Key data users; IM specialists; existing Great Lakes – St. Lawrence River data management networks (e.g., GLOS, GLC's Great Lakes Information Network (GLIN), NOAA, Global Environmental Observation System of Systems (GEOSS) Great Lakes Testbed, Water Resource Information Project (WRIP), etc.) and agencies and organizations who would play role as data stewards (IJC, NOAA, USACE, USGS, EC, DFO, NRCan, state and provincial resource management agencies, local and regional non-government agencies, conservation authorities, the private sector and academia).

Current Status: At present, information, data and models are not easily accessible to stakeholders and practitioners who must discover and implement this myriad of information themselves.

IJC Role: As a bi-national organization whose primary mandate requires coordinated hydroclimate information, the IJC appears to be the appropriate organization to lead this effort.

2.4.5 B5 - Outreach and Engagement Network

There are numerous agencies involved in outreach activities in the Great Lakes - St. Lawrence River Basin related to water levels and water level impacts. These agencies all play different and occasionally overlapping roles including federal, provincial and state agencies, local and regional non-government agencies, conservation authorities, Sea Grants, consulting firms and academia. The purpose of this Network is to build on and complement existing outreach activities in the Great Lakes - St. Lawrence system; to reach out with information and knowledge on risks of extremes and possible options; to engage agencies, organizations, academia and stakeholders in the adaptive management process and regional risk management; and to promote the sharing, exchange and leveraging of related programs and activities for supporting adaptive management. The intent is to engage existing outreach organizations and initiatives to make the most efficient use of existing resources and mechanisms for

reaching out and engaging stakeholders and regional decision makers. The following is an initial list of tasks, although this will be refined and expanded with input from the Network partners.

B5.1 Outreach and Engagement with users

- Identify needs of target audiences *(indirect)* ***(High priority)***
- Establish mechanisms for ensuring input and two-way communication *(indirect)* ***(High priority)***
- Develop an outreach strategy for ensuring input from users *(indirect)* ***(Medium priority)***
- Establish an education strategy for informing risk of water level fluctuations, ability of regulation to affect levels and flows, and factors affecting vulnerabilities such as glacial isostatic adjustment *(indirect)* ***(Medium priority)***
- Implement the education strategy across the basin *(indirect)* ***(Medium priority)***

Possible Agency Involvement: All agencies engaged through the other Networks, with a focus on coastal managers. This would also include GLC, Sea Grants, other NGOs, and Tribes/First Nations and many others who already do outreach and engagement.

Current Status: Many groups, including the Boards of Control and the IJC, conduct some form of public outreach. This effort would build on and complement existing efforts and be specific to the products generated through the LAB and in working with users and decision makers to ensure two-way communication. This is not intended to duplicate existing outreach, but to take advantage of existing efforts.

IJC Role: The IJC has a vested interest in on-going outreach and engagement. The LAB Secretaries or Secretariat could help provide support to this Network.

2.5 Adaptive Management Pilots

By definition, adaptive management (AM) is a straight-forward, systematic process for improving management actions or decisions. The process follows an iterative "plan, act, monitor, evaluate, learn, and adjust" sequence of tasks. It is a process that many people do unknowingly every day. For example: a sick person will visit the doctor, who develops a treatment plan based on the available symptoms and related information; the doctor acts by prescribing treatment therapy; together with the patient the treatment plan's therapy action is monitored to determine if the desired response results; if not, the doctor evaluates altering the treatment plan, learns more about the patient's therapy and adjusts the plan accordingly. The entire process then begins again and may be repeated to assure that the treatment plan is achieving the desired objective or restoring the patient's health.

Ultimately, the goal of AM within the context of this Plan is to improve economic, environmental and social sustainability of outcomes across the Great Lakes – St. Lawrence River system, through the joint application of relevant government authorities and effective resources. Typically, when dealing with natural resource management, hydroclimate variables, objectives that potentially conflict and an

engaged set of diverse stakeholders, this apparently simple process can become complex and most challenging to implement. The more complex and daunting the process appears to potential participants, the less likely they will engage. Yet the very success of the process is dependent on having participation by a diverse collection of decision makers, maintaining constant focus on the ultimate AM goal and objectives, including subject-matter experts and those people most affected by the management action.

2.5.1 Adaptive Management Pilot Concept

One approach to overcoming such challenges is to start small or scale down the overall process, by focusing on regional or localized areas of the Great Lakes – St. Lawrence River system, or focusing on particular sub-elements of the overall management action or problem. This scaled-down approach enables participants to more effectively "test drive" adaptive management's iterative tasks with minimal risk, to collectively identify information or knowledge gaps, to collaboratively test alternatives and to modify the management action or decision accordingly. As these scaled-down efforts succeed, more objectives may be added and successfully accomplished. Hence, by creating a series of small wins inherent to the overall pilot process, participants gain greater confidence and experience with the process and, accept additional process improvements, while outside observers are attracted to become participants.

Therefore, the Task Team recommends the use of Adaptive Management Pilots (AM Pilots), a series of regional or localized projects specifically designed to test the process, tools and methods of adaptive management implementation as outlined in this report. The AM Pilots would address pressing stakeholder-defined issues related to water level management and hydroclimate change, where past approaches have been less effective, and where a series of small successes can serve as examples for people outside the test regions to learn from and apply on larger scales where multiple objectives are desired.

The pilots are a practical approach to implementing AM. The details will vary among each AM Pilot, but in general, the basic concept or intent will be to apply AM principles within a consistent framework that is based on the concepts of shared vision planning to: reach consensus among the participants on issues or problems, objectives and performance metrics; evaluate how combinations of tools and methods from various participants lead to solutions that can improve performance; recommend implementing those solutions to the applicable authorities; then monitor the performance indicators and adjust the decisions, as needed, based on the monitoring evidence.

Partners in the collaborative AM Pilot should look for ways for one action can support and facilitate other actions or objectives. For example, it may be that improved nearshore data would allow coastal zone management regulation to be more effective, and also enhance engineering designs and construction specifications for shore protection structures that could provide home owners with information to make the protection more resilient to routine and extreme events. In this manner, the AM Pilots would eventually be multi-objective.

Accountability for AM Pilot performance is critical. Accountability results in credibility. It helps assure process implementation complies and is consistent with a common framework, thereby enabling effective evaluation and learning across multiple AM Pilots. Accountability requires a commitment by participants to engage faithfully and work collaboratively towards desired outcomes, a recognized authority to monitor and facilitate the process as needed, and periodic performance reporting and a completion or summary report that enables non-participants to understand how the process occurred and problems were overcome.

Each AM Pilot would follow a consistent framework or series of tasks and incorporate the following elements of success:

- employ all phases of the AM process;
- seek consensus-based collaboration;
- focus on defined issue(s), problem and desired outcomes that may reflect multiple objectives;
- encourage robust participation, especially including representation from stakeholders most affected by the management action, applicable management organizations, and technical or subject matter experts available through the AM Networks; and
- promote process and performance accountability.

2.5.2 Proposed AM Pilot Accountability (this section focusses on role of LAB)

The role of the LAB would be to convene the AM Pilot participants and provide a collaborative forum and tools to support the application of adaptive management. Wherever possible, priority would be to contribute to an appropriate forum if it already exists. In the absence of existing opportunities, the LAB will need to proactively convene the necessary partners for a given location. The local collaborators engaged for a given pilot site could include management agencies (including municipalities), NGOs and stakeholders, including along with additional local representatives from some of the entities making up the LAB. Each agency would act within its own authorities but be informed by the collaboration. The people in the region whose lives are potentially affected by water levels or extreme events would have access to the best information available so that they could more accurately determine their risk and fashion their own responses to reduce that risk.

The Task Team recognizes that the authority of the IJC and the LAB to participate is clear in some aspects but is less clear in others. Many agencies currently have the authority to enter into collaborative discussions on issues of common interest and jurisdiction. For example, the Corps of Engineers already has clear guidance in its continuing authorities program that encourages it to consider comments from any entity or stakeholder that would participate in a pilot. However, it is also understood that no agency, including the IJC, can override or replace the legal requirements for action in the individual programs that would be applied in the assemblage of AM Pilot recommendations; to continue the example, the Corps decision to recommend a continuing authority project can be informed by collaboration, but must be justified using Corps criteria. The LAB will not impose an AM Pilot; these collaborations will occur when the necessary participants approve and are committed to engage

faithfully and work collaboratively towards desired outcomes. Since participation is voluntary, each entity has the right to stop collaborating within the AM Pilots if doing so violated its requirements. The LAB would seek to facilitate continued progress and commitments to the AM Pilots although they are not expected to have direct authority to require participants to remain at the table.

Certain procedural details for the AM Pilots still need to be defined, including the most effective means for facilitating the efforts. Practically, many of these details can only be defined by working through the process of initiating an AM Pilot. However, the Task Team believes the chances of success for the pilots and AM in general would be greatly improved if governments provided the IJC a specific reference for facilitating this work because this sort of collaboration is unfamiliar and the methods of effective collaboration not widely known. A reference may also identify the necessary funding to undertake the AM Pilots. Absent a reference, it will be more difficult for agencies to justify the resources needed for collaboration within an AM Pilot, and that applies even to the IJC.

2.5.3 Proposed AM Pilot Framework

To be successful, the AM Pilots will require the engagement and participation from applicable government and resource management agencies (e.g., shoreline managers, regulatory agencies, etc.) and a focus on local issues as defined by the local stakeholders. The Task Team recognizes that such an approach will create variability in the form and function of each AM Pilot, but the principles and process of adaptive management will always apply. The Task Team suggests the LAB play a central role in initiating individual AM Pilots or connecting to appropriate existing forums in the priority areas and also ensuring that the principles of AM are being followed. Practically speaking, the Task Team expects the LAB contributions to individual AM Pilots would be through the establishment of small ad hoc pilot planning teams made of individuals from agencies participating on the LAB and with relevance to the critical issues being considered within the specific AM Pilot. These pilot planning teams would work with local resource management agencies and stakeholders on behalf of the LAB to facilitate a preliminary planning effort to identify appropriate outcomes and come to agreement on goals and objectives. The pilot planning teams would also be the direct link between the AM Pilot efforts and the resources of the broader LAB networks, including the Hydroclimate Network, the Risk Assessment and Performance Indicator Network, the Decision Tools Network, and the Information Management Network. Finally, they would support the ongoing evaluation of alternatives being considered by the local management agencies through resources available within the Networks. As an overarching framework, the following tasks have been identified for inclusion in each AM Pilot. All collaborative activities are numbered beginning with a “C”. All of the priorities for the tasks under the AM Pilots are identified through the networks in the earlier sections. Priorities are dependent of the sites and types of local or regional issues to be addressed (see Box 7 for examples of an AM Pilot).

Box 7: Imagining the Details of an Adaptive Management Pilot

Here are the three most frequently asked questions about pilots and the task team's best answers.

Who would lead the pilot? What would that entail?
Each pilot would require **planning** and **project management** leadership; these could be provided by the same or different entities. Planning leadership would be required to make sure the pilots actually followed the adaptive management principles. Project management leadership would encompass hosting, scheduling and budgeting. Someone would have to invite participation, find meeting places, facilitate contracting, work with the larger public and media, and facilitate disputes. One entity might take on one or both responsibilities, and there would be some overlap. Leadership might be affected by the source of funding, the desire for an objective center, or an existing regional reputation for leadership. While the Levels Advisory Body might not be directly involved in any pilot, it would have the ultimate responsibility of assuring that the pilots were true to the adaptive management principles.

Where would the money come from?
The essential premise of the pilots is the synergistic application of existing authorities and expertise, so much of the work that would be done would be funded under existing authorities. For example, FEMA might be involved in a pilot because of its remapping work, the Corps because it launched a Section 205 study. But there would always be a need to fund the collaboration – facilitated meetings among stakeholders, county government, the Corps and FEMA for example, that would not normally take place in the separated execution of each authority. The task team is recommending that the IJC seeks a government reference - a direction from Canada and the United States to the IJC to do adaptive management. The reference would make it easier for other agencies to apply their individual authorities and funding to a pilot and would also open the door to funding through the IJC to support the additional tasks of collaboration. The reference and associated funding are not in place now, however; until then collaborative funding would have to be found on a case by case basis. The fact that there are some nascent adaptive management efforts show this is possible (see Examples of adaptive management that have already begun, Box 1, 2, 4, 5 &6). The task team has also seen evidence that in some cases the need for additional funding can be minimal because individual efforts are often more effective and efficient with collaboration than without.

What would make a pilot more efficient and effective if it has no additional authorities?
There are three well established categorical explanations. First, the sharing and use of the best information can improve individual decisions that would normally be informed by inferior information. FEMA used information developed by IUGLS in its recent estimate of flood frequency on Lake Michigan. Second, collaborative assessments can improve their quality, reduce their costs and increase their acceptance. The work of the Coordinating Committee has demonstrated this for two decades but most readers can provide their own examples of efforts that were partially duplicative of other work. Finally, the pilots offer the possibility of using the output from one program to facilitate the application of another. For example, the climate studies and design height requirements for shore protection developed during the IJC studies could produce design advice to homeowners they could receive during the environmental review required under Section 404 of the Clean Water Act if permit reviewers agreed to provide that advice as part of the permitting process. Something similar is standard practice in the Town of Greece, New York, where each permit review stipulates a top of structure elevation.

The AM Pilots would follow a series of steps that are based on the concepts of Shared Vision Planning (Palmer et al., 2007).

C1.1 Build a team – engage decision makers, scientists, stakeholders and the public, leveraging and participating in existing initiatives as a first priority (coordinated through an appropriate pilot planning team as identified by the LAB)

- Identify shared objectives *(Regional)*

C1.2 Identify and understand the problems (risk and vulnerability assessments undertaken through the Risk Assessment and Performance Indicator Network and coordinated by the pilot planning

team of the LAB), taking into account, to the extent possible, multiple stakeholders in a given geographic area rather than focusing on a single interest

- Assemble existing data on damages/impacts/vulnerabilities *(Regional)*
- Collect new data as necessary to fill in gaps in understanding *(Regional)*
- Articulate a best understanding of potential risks *(Regional)*

C1.3 Describe the baseline condition (undertaken through a combination of the Hydroclimate and Risk Assessment and Performance Indicator Networks and coordinated by the pilot planning team of the LAB)

- Characterize the current management regime (what will happen absent new ideas from the pilot?) *(Regional)*
- Establish the current hydroclimate regime (past and future net basin supplies and water levels) *(Regional)*
- Assess the current shoreline characteristics and processes *(Regional)*

C1.4 Build an information management system for exchanging and sharing information between partners (see IM Network tasks - undertaken through the Information Management network and coordinated by the pilot planning team of the LAB) *(Regional)*

C1.5 Assess the current management regime – is it good enough to address the risks? (coordinated through an appropriate pilot planning team as identified by the LAB)

- Develop objectives and metrics for evaluation (performance indicators) *(Regional)*
- Formulate alternatives available from each agency and then construct combinations of actions from all these programs, including individual stakeholder responses (see Box 8 for examples). *(Regional)*

C1.6 Evaluate alternatives (using Performance Indicators and evaluation tools – see Decision Tools Network tasks) (undertaken using tools from the Decision Tools Network and coordinated by the pilot planning team of the LAB)*(Regional)*

C1.7 Select and implement preferred alternatives (carried out by participating agencies and stakeholders under their separate authorities and coordinated through an appropriate pilot planning team as identified by the LAB, as appropriate and necessary) *(Regional)*

C1.8 Monitoring performance and adapt based on what is learned about changing conditions and the actual effectiveness of actions taken (carried out by participating agencies and stakeholders under their separate authorities and coordinated through an appropriate pilot planning team as identified by the LAB, as appropriate and necessary) *(Regional)*

Box 8: Finding Solutions

The objective of an AM Pan is to ensure the Great Lakes – St. Lawrence River community is equipped to make informed decisions on changing water levels and climate conditions and that governments at all levels and stakeholders work collaboratively in a system-wide context to develop and apply multi-objective, flexible and sustainable solutions. There will not be a "one size fits all" solution, but rather the AM Pilots will focus on an adaptive management process that targets solutions specific to the issues and objectives of the local region. Some of the options for consideration may include both engineered and non-engineered approaches or a combination of adaptive actions to find the most optimal response to pressing issues. Some examples include:

Engineered Adaptive Responses

- Seawalls, revetments, groins, bulkheads, etc.
- Beach nourishment
- Flood proofing/ relocating vulnerable structures
- Floating docks/dock extensions/modular board walks
- Dredging
- Marina facility relocations
- Water intake modifications to access adequate depths
- Coastal wetland construction to mitigate losses
- Soft engineering/green infrastructure (e.g. re-vegetation of shoreline)

Non-Engineered Adaptive Responses

- Integrated shoreline management planning
- Zoning restrictions/ setbacks
- Acquisition of vulnerable properties, non-functional marinas
- Improved flood plain mapping/ technical services
- Alteration of recreational boating season
- Cargo load adjustments to reduce draft
- Abandoning non-functional water intakes
- Fish stocking programs to replenish diminished populations

The 1993 IJC Levels Reference Study (LRSB, 1993) examined measures to alleviate the adverse consequences of fluctuating water levels and also made a number of specific shoreline management recommendations, mostly focused on addressing high water level conditions.

Few examples exist of specific low water shoreline management activities other than dredging efforts, but one exception is an integrated approach to coastal management (e.g., permitting) being considered in Southern Georgian Bay, known as the Southern Georgian Bay Shoreline Management Strategy (SGBSMS). This effort is comprised of shoreline permitting regulatory staff from Fisheries and Oceans Canada, the local Conservation Authorities and the Ontario Ministry of Natural Resources. In responding to increased shoreline and nearshore modification activity (e.g., dredging), the SGBSMS is focusing on means to manage such activity while protecting and maintaining critical ecosystem functions. In general, the Strategy is promoting integrated coastal management planning as opposed to site-specific, "piecemeal" application of adaptive risk management measures (Donahue, 2011).

The Task Team suggests that the LAB should take the lead in fostering effective information management and the application of adaptive management methods, since these activities will be critical to the success of the local AM Pilots.

No pilot would be done without strong local and regional support, so the Task Team believes that the first pilots will be launched in areas that are currently struggling to address lake level impacts through other means. The intent would be to partner with local agencies, organizations and stakeholders and build on existing resources. It might be advantageous to have at least one pilot per lake, but in the short term the actual number may be less than that. The LAB could work to identify the necessary resources within their participating agencies and bring those resources to the effort or work with the IJC to identify the appropriate funding source, although the Task Team has not attempted to identify formal commitments at this time. It is expected that all participants in the AM Pilots, including local partners, will need to bring some resources to the effort to create a successful AM Pilot.

The agencies likely to be involved in the AM Pilots include Conservation Authorities, Coastal Change Analysis Program, DFO, EC, FEMA, Great Lakes States, NOAA, OMNR, USACE, USFWS, USGS, LAMPS, other state and provincial resource management agencies, local and regional government (e.g., GLSL Cities Initiative, counties and regional municipalities) and non-governmental organizations, the private sector and academia. With the emergence in the United States of the National Ocean Policy and the Great Lakes Regional Planning Body, there is potential for that entity to take a leadership role on the U.S. side in working with the LAB on the individual collaborative efforts.

Current Status: There is currently no comprehensive bi-national effort to undertake this work, although in the U.S. the National Ocean Policy recognizes the need for this type of planning collaboration and seeks to establish The Great Lakes Regional Planning Body to facilitate collaborative planning across U.S. Great Lakes stakeholder groups. In addition, some individual Conservation Authorities or other local Canadian or U.S. agencies have related information that could help support this effort.

IJC Role: The two federal governments have made numerous requests to the IJC over the last 50 years to study the impacts of high and low water levels and consider options for alleviating negative impacts. With the knowledge that there are significant limitations to reducing risk of extreme levels through regulation of water levels alone, the IJC would benefit from further understanding of the full scope of interest vulnerabilities; it could work with other levels of government in a collaborative way to help provide information and support towards developing solutions to help reduce the risk of impacts of extreme water levels while, in return, obtaining information on risks and vulnerabilities that would support any water level management efforts.

2.6 Funding and Accountability

2.6.1 Accountability, Tracking and Communicating Success of the AM Plan

Accountability would be managed differently in each of the two major AM components (lake level regulation and lake level adaptation).

On the lake regulation side, the AM plan has defined specific tasks to support the Boards of Control in the ongoing review and evaluation of the effectiveness of the Regulation Plans at meeting their intended objectives. A formal Adaptive Management Committee will focus on monitoring key performance indicators, updating evaluation tools and evaluating the Regulation Plans over time. Accountability will be through semi-annual reporting by the Boards of Control to the International Joint Commission and through the participating agencies' chains of command.

On the adaptation side, accountability would be similar to that of the Coordinating Committee on Great Lakes Hydraulics and Hydrologic Data; goals and objectives are set collaboratively with agencies committing resources and agreeing to schedules and products. Progress is monitored and checked through periodic meetings and communications. Semi-annual reporting by the LAB to the International Commission would also be required.

In undertaking the various activities of the AM Plan, long-term commitment from multiple agencies and jurisdictions will be required. To ensure that there is benefit for this commitment, it is paramount to track and communicate success. This will require some form of accountability to ensure those agencies and organizations who have committed to various components of the AM Plan deliver on those commitments. This may take the form of memorandums of understanding or other types of agreements or arrangements between and amongst the IJC, the LAB, and supporting partner agencies and organizations to document obligations and allow tracking of commitments.

Likewise, a clear framework must be established for determining the effectiveness of adaptive management towards meeting outcomes through clear metrics that demonstrate progress towards meeting overall goals. These metrics will be further scoped out by the LAB with input from contributing agencies, organizations, and the IJC, but should be consistent with specific milestones. For example, measure of success might include all agencies and organizations of fully engaged and collaborating on the AM Plan. It could be measured by successes in solving longstanding issues through the AM Pilots that have not been resolved through existing mechanisms. It could be that stakeholder are fully engaged and have ways of accessing information and ways to inform the decision-making process and complaints by stakeholders are reduced. The overall success of the AM Plan will be that the process is being effective in influencing decisions aimed at reducing impacts of extreme water levels in a cost effective, efficient and sustainable way.

2.6.2 Funding Adaptive Management

This AM Plan is grounded in the concept of collaboration and that agencies choosing to participate will recognize the benefits of working collectively as a more efficient means of fulfilling existing missions and improving outcomes. The Plan therefore, proposes a funding option whereby the agencies are expected to come to the table with existing resources and leverage them to help address priorities of the AM Plan. The IJC would also be expected to seek funds primarily in support of the secretariat for the LAB as well as to support some special projects that are deemed particular priorities by the IJC and/or governments, or that cut across agencies, such as the information management component of the AM Plan. It is expected that there will be a heavier funding requirement during the initial stages of implementing the AM Plan as the governance, monitoring protocols, evaluation tools, information management systems and outreach activities are being established. The IJC may wish to work with governments to determine the best mechanisms for seeking adequate funds over the first three to five years to initiate the AM Plan.

Table 1 below provides a summary of the initial cost estimates for undertaking the AM Plan. The cost estimates combine operational costs and staff time, represented as a dollar equivalent. The second and third columns of Table 1 provide a general assessment of current in-kind and external funding being applied to these activities respectively. These estimates are approximate and continue to be refined based on updated information. The vast majority of the current contributions support tasks specific to the Lake Ontario – St. Lawrence River effort. It must be noted that contributions are determined on a year-to-year basis using available agency resources and none of the supporting agencies have formal

commitments to maintain these contributions in future years. As well, most of the external funding is time limited. The fourth column provides three sub-columns with the estimated costs of high and medium priority tasks and the total estimated costs (sum of high and medium priority) to undertake the items listed in the AM Plan under both the AM Committee and LAB (listed by each Network). The estimates include all tasks and are based on input from various agencies and organizations and are continually being refined. It is expected that these estimates will need to be adjusted for individual tasks as part of a work planning process to support task implementation following the submission of this report to the IJC. The cost estimates represent the anticipated start-up costs (annual costs for approximately 1-3 years) and it is expected that ongoing costs would be greatly reduced. It is also possible to stagger certain projects in the start-up phase, thus reducing resource requirements in individual years. The fifth column provides an estimate for how much of the total cost would likely be covered through in-kind agency resources, based on past contributions and agency mandates. The sixth column identifies the additional resources that would be required to undertake all the identified tasks. These funds are not readily available and will have to be sought through some mechanism be it through agency reprioritizations, external funding such as the Great Lakes Restoration Initiative (GLRI), internal funding mechanisms such as Treasury Board submissions in Canada, or some other means.

The start-up tasks specific to the AM Committee are estimated to total approximately ~$1.8 million U.S. with approximately $560K in-kind and $100K external contributed to date and an additional ~$1.9 million Canadian with around $480K in-kind and $140K external contributed to date. The total estimated costs represent both high priority and medium priority tasks. Estimates of only high priority tasks for the AM Committee are ~$1.5 million U.S. and ~$1.2 million Canadian. It is also possible to stagger certain projects in the start-up phase, thus reducing resource requirements in individual years.

The start-up tasks for the entire AM Plan (including the AM Committee) for the U.S. components are estimated to total approximately ~$4.8 million U.S. along with up to $1.1 million U.S. for each U.S. pilot site. Canadian estimates are ~$5.3 million Canadian along with up to $1.1 million Canadian for each Canadian pilot site. For just the high priority tasks, both the U.S. and Canadian contribution estimates would be reduced to ~$3.4 million along with up to $890K for each pilot site.

Table 1: Preliminary Cost Estimates for the System-Wide AM Plan

Network		Estimate of Current In-Kind ($K)	Estimate of Current External ($K)	Estimate of Full Requirement ($K per year for 1-3 start-up years) (Note: some staging of tasks may be possible to reduce costs in individual years)			% Possible Through In-kind Resources *	Anticipated Additional Resources to Meet Full Requirements **
				High Priority	Medium Priority	Total		
AM Committee	U.S.	$560	$100	$1,495	$280	$1,775	30%	70% (~$1,250)
	Can	$482	$140	$1,205	$720	$1,925	25%	75% (~$1,450)
Hydroclimate Network	U.S.	$355	$90	$855	$475	$1,330***	25%	75% (~$1,000)
	Can	$400	$140	$965	$675	$1,640	25%	75% (~$1,225)
Risk Assessment and Performance Indicators Network	U.S.	$10	$175	$620 per site	$100 + $215 per site	$100 + $835 per site	0%	100% (~$925)
	Can	$30	$0	$620 per site	$100 + $225 per site	$100 + $845 per site	5%	95% (~$900)
Decision Tools Network	U.S.	$0	$0	$665 + $50 per site	$220	$885 + $50 per site	0%	100% (~$925)
	Can	$0	$0	$665 + $50 per site	$220	$885 + $50 per site	0%	100% (~$925)
Information Management Network	U.S.	$0	$200	$125	$200	$325	0%	100% (~$325)
	Can	$15	$0	$250	$200	$450	5%	95% (~$425)
Outreach Network	U.S.	$0	$0	$25	$75	$100	0%	100% (~$100)
	Can	$0	$0	$25	$75	$100	0%	100% (~$100)
Coordination / Secretariat	U.S.	$0	$0	$245 + $220 per site	$0	$245 + $220 per site	0%	100% (~$475)
	Can	$0	$0	$245 + $220 per site	$0	$245 + $220 per site	0%	100% (~$475)
	U.S.	$925	$565	$3,410 + $890 per site	$1,350 + $215 per site	$4,760 + $1,105 per site	15%	85% (~$4,975)
	Can	$927	$280	$3,355 + $890 per site	$1,990 + $225 per site	$5,345 + $1,115 per site	15%	85% (~$5,500)

*Assumes current contributions could be maintained – these are not confirmed commitments (% values calculated across each row by taking estimate of current in-kind contribution divided by total cost and rounding to nearest 5%)

**These resources could potentially be obtained through re-allocation of internal agency resources or securing of external funding (values rounded to nearest $25 thousand)

***Hydroclimate estimates do not include costs of St. Clair and Detroit River bathymetric surveys, which are expected to be undertaken periodically. Total cost estimates for both surveys are ~$1,250K

Recommendations

3.1 Recommendations of the Task Team for Implementation

The IJC should explore with governments the best options for undertaking the full Adaptive Management (AM) Plan. Specifically, the IJC should:

1. Issue a directive to the Boards of Control to implement adaptive management of lake regulation and through this directive, establish an AM Committee reporting to the Boards of Control. This AM Committee would maintain tools developed as part of the International Upper Great Lakes and Lake Ontario – St. Lawrence River studies and provide Boards of Control with technical and logistical support for this new, continuous monitoring and evaluation process.

2. Make a request to governments for a formal standing reference to address on-going water level-related issues through adaptive management. Specifically, this reference should give the IJC the authority to convene a collaborative forum referred to by the Task Team as the Great Lakes-St. Lawrence River Levels Advisory Body (LAB) for undertaking the AM Plan.

3. With or without a reference, the IJC should convene the Levels Advisory Body where individuals would participate at the invitation of the IJC, but would do so with the commitment and support of their agencies and jurisdictions. The LAB should be tasked with:

    a. Conducting system-wide planning based on the five networks outlined in the AM Plan:

        i. Hydroclimate monitoring and modelling
        ii. Performance indicators and risk assessment
        iii. Evaluation and decision tools
        iv. Information management and distribution
        v. Outreach and engagement

    b. Initiating adaptive management pilots as soon as possible to test and refine methods of collaboration in addressing pressing issues on a local or regional scale

4. Work with governments to seek funding for supporting the proposed on-going system-wide AM Plan.

Summary

In accordance with the May 29, 2012 IJC Directive, the Task Team has developed a detailed AM Plan that prioritizes adaptive management activities in the Great Lakes – St. Lawrence River basin to address future extreme water levels. Consistent with the recommendations of the International Upper Great Lakes Study Board's Final Report of March 2012 to the IJC, entitled *Lake Superior Regulation: Addressing Uncertainty in the Upper Great Lakes Water Levels*, the Task Team recommends as part of this AM Plan the establishment of two new groups: an AM Committee reporting to the Boards of Control to undertake the on-going evaluation of the regulation plans and assessment of other operational requirements; and a new Great Lakes-St. Lawrence River Levels Advisory Body (LAB) to oversee the application of the AM plan for addressing extreme water levels impacts that cannot be solved through lake regulation alone. The Task Team has consulted and collaborated with the LOSLR Working Group and has integrated all of the LOSLR adaptive management tasks into the system-wide AM Plan. The Task Team has been informed by the guidance of an advisory group consisting of individuals from agencies across the Great Lakes-St. Lawrence River system. This AM Plan identifies the specific tasks to be undertaken by both the AM Committee for the on-going evaluation of the regulation plans and identifies and prioritizes tasks to be undertaken by the LAB according to five thematic areas. The LAB would engage agencies, organizations and institutions from across the Great Lakes – St. Lawrence River system in a network fashion in the following five areas:

I. **Hydroclimate Monitoring and Modelling** to improve knowledge on water balance and water supply, the forecasting of net basin supply, lake levels and climate modelling;
II. **Performance Indicators and Risk Assessment** to assess risks of extreme water levels to shoreline property, commercial navigation, municipal and industrial water uses, recreational boating, ecosystems hydropower and other interests;
III. **Plan Evaluation and Decision Tools** to maintain, update and improve the tools needed for the evaluation of Regulation Plans over time and develop new tools to support decision-making on extreme water levels;
IV. **Information Management and Distribution** to facilitate the sharing of water level related data and information among the Great Lakes-St. Lawrence River system community; and
V. **Outreach and Engagement** to educate and establish two-way communication on water level related issues throughout the Great Lakes-St. Lawrence River system community.

Where there is a nexus between water quality and water quantity, these linkages will be made through the networks. In particular the networks will include, where appropriate linkages with Annex sub-committees of the Great Lakes Executive Committee under the GLWQA as well as to the Great Lakes-St. Lawrence Water Resources Regional Body.

Recognizing that there are many questions with respect to implementation of the AM Pan, the Task Team recommends as a first priority developing some AM Pilots to test and refine methods of

collaboration outlined in this report. These pilots would address pressing Great Lakes-St. Lawrence River water level issues at the local or regional scale.

The Task Team also recommends as a first priority, the application of the specific tasks required to provide on-going evaluation of the new regulation plan as part of the AM Committee. The Task Team has provided preliminary estimates of the costs of the adaptive management activities. While much of the total costs are expected to be covered through in-kind resources from supporting agencies and organizations that already provide programs and leadership in related areas, additional resource requirements have been identified. It has been difficult at this early stage for any of the agencies to estimate in-kind contributions in the abstract and during a period of fiscal restraint. The Task Team recommends the IJC provide leadership by seeking long-term funding to support a secretariat for the new Levels Advisory Body, and the various AM Networks. In addition, the IJC should consider seeking some start-up funding to help initiate one or more of the AM Pilots and to help support cross-cutting efforts such as information management and outreach and engagement.

The Task Team has found via its advisory group that there is strong interest among the Great Lakes - St. Lawrence River agencies and organizations to engage in this process, and many have already indicated a willingness to bring available resources to the table where consistent with existing mandates and programs. There is a recognition that a more effective, efficient and meaningful use of resources is possible working in a collaborative way under the gentle guidance and leadership of the IJC, an organization that by the IJC's own admission provides opportunities for officials from all levels of government, scientists, stakeholders and interested citizens to work together collaboratively on these issues.

The Task Team recommends that the IJC request governments provide a formal standing reference for addressing on-going water level related issues through adaptive management. Specifically, this reference should give the IJC the authority to convene a collaborative forum (the LAB) for undertaking the AM Plan. Agencies would participate at the request of the IJC, but would do so with the commitment of their agencies and jurisdictions.

References

Binational.net (2013). *Notification of Great Lakes Executive Committee Meetings*. http://www.binational.net/glec_notification-en.html

Brown, D. (2011). *International Analysis of Implementing a new Water Level Regulation Plan or Building New Structures: White Paper #2 What are the Key International Institutional Requirements for Building New Regulatory or Compensatory Structures?* Prepared for the International Upper Great Lakes Study Adaptive Management Technical Work Group. March 31, 2011.

Clites, A.H., and Quinn, F.H. (2003). The History of Lake Superior Regulation: Implications for the Future. J. Great Lakes Res. 29(1): 157-171. http://www/glerl.noaa.gov/pubs/fulltext/2003/20030026.pdf

Chow-Fraser, P. (2006). *Development of the Water Quality Index (WQI) to assess effects of basinwide land-use alteration on coastal marshes of the Laurentian Great Lakes. In: Coastal wetlands of the Laurentian Great Lakes: health, habitat and 739 indicators.* In: Simon TP, Stewart PM (eds) Coastal Wetlands of 740 the Laurentian Great Lakes: Health, Habitat, and Indicators. 741 Authorhouse, Bloomington, pp 137–166

Council of Great Lakes Governors (2013). *Overview*. http://www.cglg.org/

DePinto, J., Redder, T. and Mackey, S. (editors) (2011). *The Ecological Evaluation of Lake Superior Regulation Plans for the International Upper Great lakes Levels Study: Integrated Ecological Response Model Contextual Overview*. Prepared for the International Upper Great Lakes Study.

Donahue, M. (2011). *An Institutional/Governance Analysis for Implementing a Non-regulation Adaptive Response to Water Level Related Impacts*. Prepared for the International Upper Great Lakes Study Adaptive Management Technical Work Group.

Environment Canada (2012). *Canada-U.S. Great Lakes Water Quality Agreement*. http://www.ec.gc.ca/grandslacs-greatlakes/default.asp?lang=En&n=45B79BF9-1

Environment Canada (2013). *LEVELnews: Great Lakes – St. Lawrence River Water Levels – Michigan-Huron Sets Two New Recorded Lows in January 2013*. Volume 21, Number 2, February 15, 2013. (http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=7AD8D7A7-1)

Fisheries and Oceans Canada - Canadian Hydrographic Service (2013). *Water Levels Great Lakes and Montreal Harbour*. Monthly Water Level Bulletin, January, 2013. (http://www.waterlevels.gc.ca/C&A/bulletin_e.html)

Great Lakes Commission (2012). *About Us*. http://www.glc.org/about/

Great Lakes Fishery Commission (2010). *About Us – GLFC in Brief*. http://www.glfc.org/aboutus/brief.php#mission

Great Lakes and St. Lawrence Cities Initiative (2013). *About Us*. http://www.glslcities.org/aboutus.cfm

International Great Lakes Levels Board (1973). *Regulation of Great Lakes Water Levels*. Report to the International Joint Commission, December 1973

International Joint Commission, (1981). International Great Lakes Diversions and Consumptive Uses Study Board. Great Lakes Diversions and Consumptive Uses.

International Joint Commission (1997). *The IJC and the 21st Century: Response of the IJC to a Request by the Governments of Canada and the United States for Proposals on How To Best Assist Them to Meet the Environmental Challenges of the 21st Century*.

International Joint Commission (2000). *Protection of the Waters of the Great Lakes*. Final Report to the Governments of Canada and the United States.

International Joint Commission (2009*). Regulation of Lake Ontario and the St. Lawrence River: Canada-United States Working Group.* Draft Terms of Reference, December 4, 2009.

International Joint Commission (2012). *International Watersheds Initiative.* http://www.ijc.org/conseil_board/watershed/en/watershed_home_accueil.htm

International Joint Commission (2013). *International Joint Commission's Advice to Governments on the Recommendations of the International Upper Great Lakes Study.* A Report to the Governments of Canada and the United States. April 15, 2013.

International Joint Commission (2013a). *International Lake Superior Board of Control*. http://ijc.org/boards/ilsbc/

International Joint Commission (2013b). *International Niagara Board of Control*. http://ijc.org/boards/inbc/

International Joint Commission (2013c). *International St. Lawrence River Board of Control*. http://ijc.org/boards/islrbc/about/

International Lake Erie Regulation Study Board (1981). *Lake Erie Water Level Study.* Report to the International Joint Commission . Main Report and Appendices A through H.

International Lake Ontario – St. Lawrence River Study Board (2006). *Options for Managing Lake Ontario and St. Lawrence River Water Levels and Flows.* Final Report to the International Joint Commission, March, 2006.

International Upper Great Lakes Study (2009). Impacts on Upper Great Lakes Water Levels: St. Clair River. Final Report to the International Joint Commission, December 2009.

International Upper Great Lakes Study (2012). *Lake Superior Regulation: Addressing Uncertainty in Upper Great Lakes Water Levels.* Final Report to the International Joint Commission, March, 2012.

International Upper Great Lakes Study (2012a). *Adaptive Management: Strategy and Legacy*. Final Report of the Adaptive Management Technical Work Group.

International Upper Great Lakes Study (2012b).*Final Report of the Plan Formulation and Evaluation Technical Work Group*, Report to the International Upper Great Lakes Study Board, March 2012.
International Upper Great Lakes Study (2012c). *Hydroclimatic Conditions: Past, Present and Future*. Final Report to the International Upper Great Lakes Study Board, Submitted by the Hydroclimatic Working Group, March, 2012.

Lee, D.H., and Pietroniro, A. (2008). *Hydrology and Climate Modelling Strategy*. Prepared for the International Upper Great Lakes Study.

Levels Reference Project Management Team. (1989). *Living with the Lakes: Challenges and Opportunities*. A Progress Report to the International Joint Commission.

Levels Reference Study Board (1993). *Levels Reference Study: Great Lakes - St. Lawrence River Basin.* Submitted to the International Joint Commission, March 1993.

Midwood, J., and Chow-Fraser, P. (2010). *Water-level Induced Changes in Fish Communities in Coastal Wetlands of Eastern Georgian Bay*. Submitted to the Upper Great Lakes Management Unit, Ontario Ministry of Natural Resources.

Palmer, R., Cardwell, H., Lorie, M. and Werick, W. (2007). *Disciplined Planning, Structured Participation and Collaborative Modeling – Applying Shared Vision Planning to Water Resources Decision Making.* U.S. Army Engineer Institute for Water Resources. http://www.sharedvisionplanning.us/

The White House (2010). Executive Order 13547 – Stewardship of the Ocean, Our Coasts, and the Great Lakes. http://www.whitehouse.gov/the-press-office/executive-order-stewardship-ocean-our-coasts-and-great-lakes

United States Army Corps of Engineers (2013a). *Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data*. http://www.lre.usace.army.mil/greatlakes/hh/links/ccglbhhd/

United States Army Corps of Engineers – Detroit District (2013b). *Monthly Bulletin of Great Lakes Water Levels*.
http://www.lre.usace.army.mil/greatlakes/hh/greatlakeswaterlevels/waterlevelforecasts/monthlybulletinofgreatlakeswaterlevels/

Appendices

APPENDIX 1
IJC DIRECTIVE

DIRECTIVE
TO THE
INTERNATIONAL GREAT LAKES – ST. LAWRENCE RIVER TASK TEAM
May 29, 2012

The purpose of this directive is to establish and direct the International Great Lakes – St. Lawrence River Adaptive Management Task Team (Task Team) to develop a detailed Adaptive Management Plan (Plan) that will evaluate and prioritize adaptive management activities in the Great Lakes – St. Lawrence River basin to address future extreme water levels consistent with the recommendations of the International Upper Great Lakes Study Board's Final Report of March 2012 to the International Joint Commission entitled *Lake Superior Regulation: Addressing Uncertainty in the Upper Great Lakes Water Levels*. The Task Team will consult and collaborate with the Lake Ontario – St. Lawrence River Working Group to seek its views and input and to build upon its adaptive management efforts to arrive at a basin-wide Plan. In doing so, the Plan should identify and provide details of adaptive management activities required for the upper Great Lakes system, the Lake Ontario – St. Lawrence River system, and activities that are common to both.

The Task Team shall further define, refine and prioritize the activities comprising the Plan into a final report by December 31, 2012, to be considered by Commissioners. The Task Team should consider the International Upper Great Lakes Study's Adaptive Management Strategy entitled *An Adaptive Management Strategy: Breakdown of Roles, Responsibilities and Proposed Tasks by Sub-Committee (*draft dated December 15, 2011) in its deliberations to develop the Plan. This draft Adaptive Management Strategy recognizes that the government of Canada and the United States plan to use adaptive management approaches during implementation of the renewed Great Lakes Water Quality Agreement. The Plan, as developed by the Task Team, will evaluate the linkages between water quality and quantity, as discussed in the draft Adaptive Management Strategy. This evaluation is to be conducted at an exploratory level of detail with recommendations provided to assist the Commission in a more detailed examination of an overall water quantity and water quality adaptive management strategy for the Great Lakes – St Lawrence System. It is anticipated that this more detailed examination would take place in 2013 and would build upon the Plan, as created through this Directive.

The Plan should also address institutional arrangements and processes for administering the proposed Plan for the entire basin-wide system. The Task Team should consider the recommendation of the International Upper Great Lakes Study Board concerning the

establishment of a Great Lakes – St. Lawrence River Levels Advisory Board and further refine its: Terms of Reference, including roles, functions and responsibilities; membership; and the reporting structure within overall governance of the system. In doing so, the Task Team shall seek the views of the Commission's three Great Lakes Control Boards and the Lake Ontario – St. Lawrence Working Group.

When evaluating, costing and prioritizing adaptive management activities in the upper Great Lakes and the Lake Ontario-St. Lawrence River systems, the Task Team will categorize activities in the Plan as being within (1) the direct (e.g., monitor to ensure anticipated benefits of the adopted regulation plan are being realized), (2) indirect (e.g., when inflows are high and the regulation plan cannot protect society), and (3) regional adaptive management activities related to water level regulation (e.g., local corrective actions to mitigate the impact of low lake levels on wetlands). When including an activity within the Plan, the Task Team will specify whether it is within or beyond the Commission's existing authorities. The refined Plan shall:

- Articulate and prioritize all studies and activities to be performed and level of detail anticipated for each;
- Identify and clearly define goals and objectives of the Plan;
- Recommend the agencies or organizations capable of conducting aspects of each study or activity, specifying leveraging opportunities and in-kind contributions of interested organizations and their timing, recognizing the need for involvement by a bi-national team;
- Identify sources of, or means of obtaining, needed data and information;
- Establish the priority, duration and timing of each study or activity; and
- Estimate the human and financial resources, including expertise, required to conduct each individual study or activity and a summary for the entire Plan.
- Be documented in a report that contains, as a minimum, an executive summary, list of acronyms, table of contents, chapters, references, and appendices, such that all pertinent material is contained therein and follows standard scientific and engineering practices.

The Task Team shall:

1. Provide its work plan with an associated schedule of activities and budget to the Commission by June 29, 2012, outlining how it plans to proceed in developing the detailed Adaptive Management Plan and how it plans to engage the federal governments, the provinces, and states, as well as the wider body of stakeholders and the public in its efforts, the three Commission's Great Lakes Control Boards and the Lake Ontario – St. Lawrence River Working Group;
2. Provide a draft report containing the detailed Adaptive Management Plan to the Commission by October 1, 2012;
3. Engage the public seeking input on the draft, detailed Adaptive Management Plan; and
4. Provide the final report to the Commission by December 31, 2012.

The Commission will appoint Members of the Task Team and Co-Chairs to lead its efforts. The Co-Chairs will be responsible for organizing and executing the work of the Task Team, and for coordinating with, and reporting to, the Commission. The Task Team will be bi-national, comprising an equal number of members from each country.

Each Co-Chair, after consulting with members of the Task Team, may appoint a secretary. Under the general supervision of the Co-Chair(s), the secretary(ies) shall carry out such duties as are assigned by the Co-Chairs or the Task Team as a whole.

Members of the Task Team and any committees or work groups created by it or secretaries appointed by it will be responsible for their own expenses unless otherwise arranged with the Commission.

The Task Team shall make use of public input received in the development and refinement of the Plan. The Task Team shall distribute information widely to raise awareness of the effort to develop the detailed Adaptive Management Plan and its purpose. To the extent possible, the development of the Plan shall be an open and transparent process. The Task Team shall provide opportunities for the public to comment on the draft POS concurrently with the Commission's review. The Task Team shall coordinate its public involvement plans with the Commission.

The Task Team will strive to reach decisions by consensus and will immediately notify the Commission of any irreconcilable differences. Any lack of clarity or precision in instructions or directions received from the Commission shall be promptly referred to the Commission for clarification.

Documents, letters, memoranda, and communications of every kind in the official records of the Commission are privileged and become available for public information only after their release by the Commission. The Commission considers all documents in the official records of Task Team or any of its committees or work groups to be similarly privileged. Accordingly, all such documents shall be so identified and maintained as separate files.

APPENDIX 2
LIST OF TASK TEAM MEMBERS AND SUPPORT STAFF

Canadian		U.S.	
Name	**Organization/Affiliation**	**Name**	**Organization/Affiliation**
Wendy Leger, Cdn Co-Chair	Environment Canada – Meteorological Service of Canada	**Deborah H. Lee, US Co-Chair**	U.S. Army Corps of Engineers – Great Lakes and Ohio River Division
Patricia Clavet	Québec Center for Hydraulics and Hydrology Expertise - Ministry of Sustainable Development, Environment, Wildlife and Parks	**Jennifer Read**	Great Lakes Observing System and Michigan Sea Grant
Dick Hibma	Chair, Conservation Ontario	**Bill Werick**	Chair, Great Lakes Observing System
Jonathan Staples	Ontario Ministry of Natural Resources – Policy Division	**Donald Zelazny**	New York Department of Environmental Conservation
Sara Eddy Cdn Secretary	Department of Fisheries and Oceans	**Drew Gronewold U.S. Secretary**	National Oceanic and Atmospheric Administration – Great Lakes Environmental Research Laboratory
Support Staff			
Mike Shantz	Environment Canada – Meteorological Service of Canada	**Damianos Skaros**	New York Department of Environmental Conservation
Daniel Ferreira	Environment Canada – Meteorological Service of Canada	**Kyle McCune**	U.S. Army Corps of Engineers
Joanna Kidd	Kidd Consulting Inc.	**George Cotroneo**	U.S. Army Corps of Engineers
Bernard Beckoff	International Joint Commission	**Marvourneen Dolor**	Great Lakes Observing System
		Megan Bair	U.S. Army Corps of Engineers
		Frank Bevacqua	International Joint Commission

APPENDIX 3
ADVISORY GROUP TO TASK TEAM

Canadian		U.S.	
Name	**Organization/Affiliation**	**Name**	**Organization/Affiliation**
Jacques D'Astous	Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs	**Ernie Drott**	U.S. Army Corps of Engineers
Marc Mingelbier	Ministère des Ressources naturelles et de la faune du Québec	**John Allis**	U.S. Army Corps of Engineers & Superior Board of Control
Brigitte Laberge	Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs	**George Cotroneo**	U.S. Army Corps of Engineers – Buffalo District
Jérome Faivre	Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs	**Norm Grannemann**	U.S. Geological Survey & Council of Great Lakes Research Managers
Pascal Marceau	Ministère de la sécurité civile	**Charlie Wooley**	U.S. Fish and Wildlife Service
Phillipe Chenard	Great Lakes and St. Lawrence Cities Initiative	**Eric Vogelbacher**	National Ocean Council & Great Lakes Regional Planning Body
Sandra Cooper	Mayor of Collingwood & Great Lakes and St. Lawrence Cities Initiative	**Ken Hinterlong**	Federal Emergency Management Agency
Bonnie Fox	Conservation Ontario	**Craig Stow**	National Oceanic and Atmospheric Administration – Great Lakes Environmental Research Laboratory
Fred Dobbs	Nottawasaga Valley Conservation Authority	**Thomas W. Easterly**	Indiana Department of Environmental Management & Water Quality Board
Teresa Labuda	Conservation Halton	**Jon Allan**	Michigan Department of Natural Resources and Environment & Water Quality Board
Patrick Donnelly	Lake Huron Centre for Coastal Conservation	**Roger Eberhardt**	Michigan Department of Environmental Quality – Office of the Great Lakes
Alain Pietroniro	Environment Canada - Meteorological Service of Canada	**Suzanne Hanson**	Minnesota Pollution Control Agency NE Region
Linda Mortsch	Environment Canada - Climate Research Division	**Scudder Mackey**	Ohio Department of Natural Resources
Steve Cobham	Environment Canada - International Affairs Branch	**Lori Boughton**	Pennsylvania Department of Environmental Protection & Water Quality Board
Philippe Morel	Environment Canada - Regional Director General Atlantic and Quebec	**Tim Eder**	Great Lakes Commission
Serge Villeneuve	Environment Canada - Atlantic and Quebec Region (alternate)	**Victoria Pebbles**	Great Lakes Commission (alternate)

Dale Nicholson	Fisheries and Oceans Canada - Ecosystems Management, Central and Arctic Region	**Timothy Henry**	Environmental Protection Agency – Water Division, Region 5
Gavin Christie	Fisheries and Oceans Canada - Great Lakes Laboratory for Fisheries and Aquatics Sciences	**Dave Naftzger**	Council of Great Lakes Governors
Stéphane Dumont	Fisheries and Oceans Canada - Small Craft Harbours	**Ted Hullar**	International St. Lawrence River Board of Control
Daniel Lefebvre	Fisheries and Oceans Canada - Canadian Coast Guard	**Mark Colosimo**	International Joint Commission - Washington
Jennifer Keyes	Ontario Ministry of Natural Resources		
James Nowlan	Ontario Ministry of Natural Resources (alternate)		
Al Douglas	Ontario Centre for Climate Impacts and Adaptation Resources		
David Fay	International Joint Commission - Ottawa		
John Wilson	International Joint Commission - Windsor		

APPENDIX 4
LIST OF ACRONYMS

AHPS - Advanced Hydrologic Prediction System
AM – Adaptive Management
BEC – Bi-national Executive Committee
CCGLBHHD – Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data
CGIP – Chippawa-Grass Island Pool
DEC - New York State Department of Environmental Conservation
DFO – Fisheries and Oceans Canada
EC – Environment Canada
EPA – U.S. Environmental Protection Agency
FEMA – Federal Emergency Management Agency
FEPS - Flood and Erosion Prediction System
GCM – Global Climate models
GEM – Global Environmental Model
GEOSS - Global Environmental Observation System of Systems
GIA – Glacial Isostatic Adjustment
GLC – Great Lakes Commission
GLEC - Great Lakes Executive Committee
GLERL – Great Lakes Environmental Research Laboratory
GLFC – Great Lakes Fishery Commission
GLIN – Great Lakes Information Network
GLOS - Great Lakes Observing System
GLRI – Great Lakes Restoration Initiative
GL RPB – Great Lakes Regional Planning Body
GLSLCI – Great Lakes and St. Lawrence Cities Initiative
GLSLR – Great Lakes – St. Lawrence River
GL – SAND – Great Lakes Navigational Model
GLWQA - Great Lakes Water Quality Agreement
IERM - Integrated Ecological Response Models
IJC – International Joint Commission
IM – Information Management
IUGLS – International Upper Great Lakes Study
IPCC – Intergovernmental Panel on Climate Change
IWI – International Watersheds Initiative
LAB – Levels Advisory Board
LAMPs – Lakewide Action and Management Plans
LOSLR – Lake Ontario St. Lawrence River
MESH – MEC Space Surface Hydrology Model (MEC - Modélisation Environmentale Communautaire)
NARRCAP – The North American Regional Climate Change Assessment Program
NBS – Net Basin Supply
NGOs – Non-Governmental Organizations
NOAA – National Oceanic and Atmospheric Administration
NOP GLRPB – National Ocean Policy Great Lakes Regional Planning Body
NRCan – Natural Resources Canada

OCCAIR – Ontario Center for Climate Impacts and Adaptation Resources
OMNR – Ontario Ministry of Natural Resources
Ouranos – A consortium on regional climatology and adaptation to climate change
PI – Performance Indicators
RCM – Regional Climate Models
SLAP – St. Lawrence Action Plan
SVM – Shared Vision Model
TC – Transport Canada
TNC – The Nature Conservancy
USACE – U.S. Army Corps of Engineers
USFWS – U.S. Fish and Wildlife Service
USGS – U.S. Geological Survey
WRIP – Water Resource Information Program