Annex 4
Mitigation and Adaptive Management Action Plans

Introduction

This annex includes prototypes of mitigation and adaptive management plans. The International Joint Commission (IJC) would rely on agencies from both Canada and the United States if it were to pursue mitigation or adaptive management, and practical plans could be developed only as the result of those negotiations; they cannot be rigorously defined in the abstract by the Study Board.

The Study Board articulated its philosophy on mitigation in its fourth guiding principle, including the idea that mitigation would be required for those who suffered disproportionate losses from the change in regulation plans. The great majority of Study Board members felt that none of the candidate plans creates disproportionate loss or requires mitigation, but those who felt mitigation was necessary identified coastal stakeholders. The mitigation plan outlined in this annex calls for regulatory process relief (not a reduction in environmental protection) from state, provincial and federal authorities for the people who live along the shoreline, and an extension of the Corps of Engineers "Advance Measures" flood protection program, which are initiatives that the Board feels could be pursued without a finding of disproportionate loss.

The prototype action plan for adaptive management presented in this annex is a template developed by the Plan Formulation and Evaluation Group (PFEG). It was not reviewed and discussed by the full Study Board and therefore should not be construed as having full Board endorsement.

Mitigation Action Plan

Summary

- Since the IJC has no authority to implement mitigation, it can only suggest certain adjustments in existing management and mitigation measures related to flood risk reduction, for implementation by other federal, provincial, state and local authorities, where appropriate.

- The Commission's principal role in promoting mitigation will be its authority to *convene and convince the respective responsible entities* to undertake the suggested mitigation actions as a desirable complement to the selected Plan.

- Most of the potential mitigation requirements address slightly increased flooding and shoreline erosion, primarily on the U.S. side. Shoreline erosion, however, is inexorable, and long-term maintenance of existing shoreline protection structures is unsustainable under any of the Plans.

- The potential mitigation measures must be compatible with and build on prevailing coastal zone management practices.

- The following two principal mitigation measures are proposed for further consideration as part of the IJC Mitigation Action Plan:

    1. Consolidation and revision of the current shoreline protection permit procedures of New York State (Department of Environmental Conservation and Coastal Management Dept) and the Corps of Engineers as part of a new General Permit for existing shore protection structures. This will accommodate new design criteria necessitated by changes in Lake Ontario's average and 100-year range levels, inherent in the selected Plan.
    2. Extension of the Corps' Advance Measures flood protection program, to be specifically adapted to the unique conditions of the Great Lakes, for extreme flood conditions greater than the 100-year range.

Background

Mitigation actions are rarely taken as single measures—most are packages of complementary measures, relying on an extensive web of supporting regulations and mechanisms that already exist to address such problems. Rarely is a mitigation action implemented that is new or unique to the issue at hand. Hence, most mitigation actions are extensions, improvements or refinements of existing practices—that are not quite well coordinated or well adapted to the existing situations. The rationale and the logic behind mitigation are based on three generally accepted conditions:

- There must be significant loss or disproportionate harm, when evaluated against a baseline or existing condition.
- Damage (or losses) must be caused by an action by an identifiable entity.
- Mitigation action must be commensurate with loss, and compatible with and complementary to prevailing practices.

The great majority of potential actions and measures aimed at flood damage reduction and erosion protection are available, accessible, and part of the existing suite of conventional regulatory and coastal and land use management practices in most jurisdictions, applicable to both new development and existing private infrastructure. These measures are designed to provide homeowners with a range of remedies for flood damage and erosion reduction and protection, in acknowledgment that these risk reduction measures are components of an overall strategy, none of which individually, or collectively, can entirely prevent flooding or erosion under all circumstances.

The following is a summary of the losses for each of the candidate Plans, compared with the existing baseline condition, Plan 1958-DD:

- **Plan A^+** has small flooding damages in the upper and lower St. Lawrence River and a reduction in the numbers of the Least Bittern, a threatened species.

- **Plan B^+** has small erosion and shore protection maintenance losses on Lake Ontario, and flooding and maintenance losses on the upper St. Lawrence River as well as the lower St. Lawrence River. There is also a small loss in recreational boating on Lake Ontario and the upper St. Lawrence River. Plan B^+ has some reduction in the numbers of a few species, none of which are threatened or endangered.

- **Plan D^+** has minor shore protection and erosion damages on Lake Ontario, and recreational boating damages above the dam. The only environmental loss is a reduction in the wetlands fish abundance index on the lower river, rather than in a particular species, and the reduction is unidirectional for all plans, including the Natural Flow plan.

Fundamentally, plans A^+ and B^+ raise average water levels on Lake Ontario somewhat, while Plan D^+ decreases them slightly (+8 cm, Plan A^+; +5 cm, Plan B^+; -1 cm, Plan D^+), with some seasonal differences among the plans (see Final Report – Figure 29). The candidate plans also change the frequency of occurrence of extreme high and low lake levels, but by relatively small amounts. Plan A^+ reduces the frequency of the most extreme high and low levels on Lake Ontario somewhat, but with some increase in range in the levels on the lower St. Lawrence. Plan B^+ increases the frequency of the most extreme high levels slightly but reduces the frequency of very low levels on Lake Ontario somewhat, again with some increase in range in the levels on the lower St. Lawrence. Plan D^+ changes the frequency of the extremes by the least amount. Although the absolute peak levels are increased somewhat with Plan B^+, the frequency of those peaks is beyond the 100-year return period. The statistically determined 100-year peak of lake levels, does not change significantly, however, for any of the plans (-6 cm, Plan A^+; +11 cm, Plan B^+; +1 cm, Plan D^+). Changes in the 100-year peak levels of the St. Lawrence River in the Montreal area are somewhat larger for Plan A^+, but still relatively small for the other plans (+33 cm, Plan A^+; +10 cm, Plan B^+; -6 cm, Plan D^+). The physical flooding and erosion effects of such minor alterations of hydrologic variability can be significant at the extremes, and there are specific existing programs that deal with these unique conditions, such as the Corps of Engineers Advance Measures program. This program subsidizes the rapid upgrading of flood protection infrastructure *in advance of* predicted extreme flood conditions. The situation in the Great Lakes, and especially in the Lake Ontario-St. Lawrence River system, is one that lends itself to long-term (3-6 months) predictions of inflows, and provides adequate time for responses and adjustments.

Action Plan

Canada, as a rule, is better adapted to the hydrologic conditions on the Lake and River in terms of its regulatory criteria and land use management practices. As a consequence, the erosion damages associated with each Plan are significantly smaller on the Canadian side of the border. Flooding does not tend to be a major problem under any of the candidate plans, although there is a small increase in flooding on the lower St. Lawrence River under plans A^+ and B^+. Although the suggested mitigation pertains mostly to the U.S. side, where the anticipated damages are the most pervasive, the general principles can be applied in Canada. The mitigation plan has two components: adapting to the modified 'normal' 100-year range, and dealing with extreme events beyond the 100-year range. It should be understood, however, that shoreline and bluff erosion is inexorable, under any plan, ranging from 10 to 15 m (30-50 ft) over the next 30 years, for sandy shorelines. Ultimately, maintenance of the existing shore protection structures will not be sustainable, under any circumstance, because of erosion and undercutting of those structures. Private property owners will have to gradually set back their protection structures.

100-Year Range

The most significant and practical mitigation measure that directly addresses the flooding, erosion damage and shore protection maintenance issues is *amendment of the permitting procedures* for individual homeowners with *existing shore protection structures*. This is needed to allow homeowners to adjust, in a timely manner, to the new hydrologic regime imposed by whatever plan is selected. The current rules, regulations and procedures have adapted to the historical conditions and ranges of flows and lake levels, and there has been an accumulation of various local land use, coastal zone management and environmental regulations both for new construction and maintenance of existing structures. These types of rules and procedures have proliferated to such an extent that a comprehensive review and streamlining of them would be worthwhile under any circumstance. It is recommended that this review, consolidation and streamlining of the permitting procedures be undertaken jointly by New York State and the Corps of Engineers, under the rubric of a *General Permit* that specifically addresses those existing structures which would be affected by the new Lake Ontario regulation plan.

Extreme Flood Conditions

Public Law 84-99 (*Flood and Coastal Storm Emergencies Act*) (PL 84-99) provides the legal authority for the involvement of the Corps of Engineers in civil disaster response. Advance Measures constitute one of six response activities under PL 84-99 and cover preventive temporary works executed, prior to predicted unusual flooding, in order to protect against loss of life and damage to property. The Advance Measures program is used frequently in those regions where flood forecasts can be made sufficiently in advance to undertake preventive measures before flooding begins. This is especially true for the Great Lakes, where fairly reliable forecasts of lake levels can be made up to six months in advance of the inflows.

Given the new regulations and criteria established for the Plans, and the requirements for a probabilistic forecast for inflows into Lake Ontario, the situation lends itself to the Corps' Advance Measures program as it meets all the prerequisites established for the Program. Hence, it has been recommended by the Corps that a separate Advance Measures program be legislatively authorized to focus exclusively on the unique conditions and problems within the Great Lakes. A rough draft of such legislation is attached below. The role of the IJC would be to assist the Corps in advocating such legislation as part of the mitigation requirements for the adoption of any of the candidate Plans.

Great Lakes Advance Emergency Management Program

Draft Legislative Proposal

1. PURPOSE OF LEGISLATION: Advance Planning and Preparation for Emergency Protection and Hazard Mitigation for At-risk Communities and Homeowners Along the Great Lakes.

2. CITATION OF LAW (LAWS) BEING AMENDED: P.L. 84-99.

3. LEGISLATIVE OBJECTIVE: The objective of this proposal is to overcome substantial and repeated deficiencies and challenges in providing timely, economic and fully effective emergency protection and hazard mitigation for at-risk communities along the Great Lakes when severe storms occur during periods of record or near record high lake levels. Providing for programmatic development of contingency plans and preparations for mitigation projects during non-emergency periods would facilitate this objective. Actual construction of protection measures and employment of other mitigation measures would be deferred until such time as the next episode of high lake levels occurs.

4. EXISTING AUTHORITIES CONSIDERED AND REJECTED: Neither P.L. 84-99, as amended, nor other authorities such as for Planning Assistance to States or Flood Plain Management Services, provides the authority to develop emergency plans prior to the existence of imminent emergency conditions, especially in consideration of the expansive scope of at-risk development around the Great Lakes.

5. OTHER FACTS AND DISCUSSION: During 1997 - 1998, the Great Lakes experienced near record lake levels. High lake levels also were present in 1973-1974 and 1985-1986, with record lake levels in 1986. During each episode, property damages were severe, even though many communities had been provided limited emergency protection as part of the Corps' Advance Measures program under authority of PL 84-99. Advance Measures are being used repeatedly in the same locations in the Great Lakes when lake levels become high. Often, the sites considered for Advance Measures projects in 1997-1998 had "semi-permanent" protection measures built during the earlier periods. All previous protective work required rebuilding, strengthening, expanding and/or raising. Some projects met insurmountable delays such that they could not be completed prior to lake levels receding late in 1998. Delays were caused by inclement weather, acquisition problems, court actions, contractor problems, and difficulties with Project Cooperation Agreements. These delays could have been avoided by pre-disaster development of contingency plans and preparations in coordination with non-Federal sponsors, contractors and resource agencies.

Adequate protection and hazard mitigation has not been developed for the Great Lakes over the past 30 years through repeated application of emergency authority. Neither could it have been through non-emergency, traditional procedures. A principal reason is that although truly permanent projects are evaluated over their lifetimes for high water levels that will occur in some unknown future year, in most years, they will not be needed. Because the chance that high levels will happen in any given year is low, the probable or expected damages that the project is intended to avoid are often lower than the project costs. But when the time comes that high waters threaten those homes that could not be protected in advance, emergency measures are often taken to protect against the most immediate dangers. As emergency measures, they may not be well planned or their impacts carefully reviewed, the scale may be shortsighted, and competitive bidding from contractors may be harder to secure. Moreover, high lake levels, unlike river floods, tend to persist for a few years and may even be worse in the second or third year, requiring still more incremental emergency work. In the end, more money will have been spent than would have been required for a well-planned project that offered better protection and fewer negative impacts. The consternation induced by this dilemma revolves around predictive analysis and the "hard" nature of constructed works necessary to withstand the forces of storm induced wave action.

To resolve the dilemma, a comprehensive program is needed that would be tailored to the Lakes' unique and complex circumstances. Pre-planned, phased development is key to adapting to the multiple levels of probabilities, and their economic ramifications. Such an approach would provide for non-emergency site preparation and contingency planning, coupled with delayed, or phased construction of protective works only when and if threatening conditions eventuate.

The non-emergency phase would include acquisition of lands, easements and rights-of-way for an ultimately completed project, limited site preparation (e.g., relocation of utilities and other obstructions) and, where feasible, relocation of existing development, such that the later construction phase could proceed uninhibited under emergency conditions. Contingency planning would provide for the plans and specifications for the emergency phase, including options to construct protection only to the forecast levels.

This phased approach would greatly reduce the dependency of economic analysis on the uncertainty of base lake level probabilities, and would defer major expenditures until immediately before benefits would begin to accrue, thereby greatly enhancing economic propriety. The economic analysis could be accomplished in advance, while largely ignoring long-term lake level probabilities. Further, the first phase work and the contingency planning would greatly ease the demands on Corps capabilities and resources during emergencies of disaster proportions.

To accommodate such an approach, a general plan for all Great Lakes communities at risk would be developed, considering priorities based on degree of risk and non-Federal desire to participate. The general plan would include baseline environmental and economic assessments, such that planning for individual projects might be expedited. Upon adoption of a general plan, individual feasibility studies would be conducted for specific areas of potential flood threat, including the contingency plans for ultimate project completion during emergency periods. Both the general plan and the specific plans would be reviewed periodically to keep the plans and funding requirements current. At that point, the first phase of projects could be implemented. The contingency plans would then be implemented if certain threshold emergency conditions were met, such as a given lake level.

6. BUDGETARY IMPACT (cost, revenue, or savings): The cost of the program is estimated to be $750,000 for development of the general plan and $50,000 for each specific project plan. It is the objective to develop specific project plans for the 50 most at-risk communities, resulting in total program costs, funded through the Flood Control and Coastal Emergencies (FCCE) account over the next five years, of $3,250,000. Savings which would accrue in future years as a result of eliminating the periodically repeated rebuilding of less permanent measures could be expected to be in the order of $500,000 to $1,500,000 per project. Substantial benefits would accrue as the result of providing adequate, timely protection and other mitigation measures.

7. DRAFT LEGISLATIVE LANGUAGE: "SECTION XXX. Great Lakes Advance Emergency Management Program.

"(a) Program. The Secretary of the Army is authorized to undertake an advance emergency management program to reduce the risk of storm and flood damages at communities along the Great Lakes, and to otherwise provide hazard mitigation in accordance with a general plan to be developed by the Secretary.

"(b) General Plan. (1) The Secretary shall complete a general plan for the program authorized in subsection (a), setting forth an economically justifiable and environmentally sound program to mitigate risks and provide protection to at-risk communities along the Great Lakes. (2) The general plan shall identify those communities having high risk of extraordinary damage as a result of storms and lake levels of a magnitude equivalent to the maximum of record, and establish guidelines and criteria for subsequent development of specific project plans in accordance with subsection (c) of this Section. (3) The general plan shall include the Secretary's schedule for initiating and completing specific project plans and for implementing advance project preparations in accordance with subsection (d) of this Section. (4) No later than 18 months from the date of enactment of this section, the Secretary shall submit the general plan to Congress.

"(c) Specific Project Plans. (1) The Secretary is authorized to prepare specific project plans, provided that work on such plans shall not commence prior to submission of the General Plan to Congress. (2) Such plans shall: (i) provide for advance project preparation in accordance with subsection (d) of this Section; and (ii) include contingency plans for implementing the emergency phase completion of projects at such time as threshold risk levels occur.

"(d) Advance Project Preparations. The Secretary is authorized to undertake, during non-emergency periods, advance project preparations of project sites including, but not limited to, stockpiling of construction materials, advance arrangements with contractors, and implementation of agreements with non-Federal sponsors for acquisition of lands, easements and rights-of-way, limited site preparation including relocation of utilities and other obstructions, and relocation of existing developments, and other advance preparations as the Chief of Engineers may deem advisable.

"(e) Threshold Risk Levels. The Secretary shall establish threshold risk levels for commencing emergency phase completion of specific projects. Such threshold levels shall be no less than the still water level at the point in time when a still water level within 0.3 m (1.0 ft) of the maximum still water level of record, or higher, can be reliably forecast.

"(f) Emergency Phase Project Completion. The Secretary is authorized to undertake completion of projects for which advance preparations have been made, at such time as threshold levels established in accordance with subsection (e) of this Section have been reached.

"(g) Annual Report to Congress. The Secretary shall provide, at least annually, a report on the status, progress, and effects of work accomplished pursuant to this Section.

"(h) Appropriations. There is hereby authorized to be appropriated, to carry out the requirements of this Section, not in excess of $1,000,000 annually for the first four years subsequent to enactment of this Section.

8. DRAFT REPORT LANGUAGE.

"Section XXX establishes a mechanism for the Corps of Engineers to provide adequate storm protection and hazard mitigation for communities along the Great Lakes where repeated emergency measures have failed to provide timely and reliable protection, and where excessive costs have been incurred for rehabilitation and expansion during periods of historically high lake levels.

"The Section authorizes an advance emergency management program, based on a general plan for the Great Lakes to be developed by the Secretary. The general plan will consider priorities based on degree of risk and non-Federal desire to participate, and will include baseline environmental and economic assessments, such that planning for individual projects are expedited. Upon adoption of the general plan, specific project studies will develop advance preparation plans and contingency plans for later project completion during emergency periods. The advance preparation phase of projects will be implemented during non-emergency periods. Contingency plans will be implemented when certain threshold emergency conditions pose a risk of imminent and substantial losses.

"The phased approach will reduce the dependency of economic analysis on the uncertainty of lake level probabilities, and will defer major expenditures until immediately before benefits would begin to accrue, thereby greatly enhancing economic propriety. The advance preparation phase work and the contingency planning will ease the demands on Corps capabilities and resources during emergencies of disaster proportions. Savings will accrue in future years as a result of eliminating the periodically repeated rebuilding of less permanent measures under emergency conditions without advance preparation."

Adaptive Management Action Plan (AMAP)

This is the Plan Formulation and Evaluation Group's outline of a formal adaptive management action plan (AMAP) for the regulation of Lake Ontario. One of the Board's guiding principles was to propose solutions that could be adapted to changing conditions and knowledge. This AMAP is meant to address uncertainty in the information and models that were used to forecast benefits and costs, serving as a check to verify that the actual system outcomes are consistent with projections. The AMAP can provide the basis for revising the regulation rules as improved information becomes available, rather than waiting for a new comprehensive study. The AMAP addresses four issues the Study Board feels need to be verified and updated in the foreseeable future: Lake Ontario wetlands, damages to Lake Ontario riparians, recreational boating above the dam and forecasting water flow into Lake Ontario. The purpose of the outline is to create a tangible proposal that can be debated and improved by the Study Board and the international Joint Commission (IJC). Once they agree on a revised outline, work can proceed on a practical work plan with budgets, schedules and personnel assignments.

Management is adaptive if it changes as the managed system, or knowledge of it, changes. The adaptation can be formal or *ad hoc*. The deviations from Plan 1958-D constitute a form of adaptive management; had the IJC not deviated from 1958-D, many of the homes along the Lake Ontario shore would have been destroyed.

An adaptive management strategy is not necessary for every aspect of the regulation plan because the regulation strategy for Lake Ontario has been tested for decades and it is capable of effectively addressing multiple purposes (with clear exceptions described below). In general, the strategy for regulation of Lake Ontario is to keep sufficient water in Lake Ontario for use in long droughts, but not so much that it would cause flooding along the Lake Ontario shore. Releases are limited by conditions in Lake St. Lawrence and the St. Lawrence River. Stakeholders in the lower river, who need enough depth for boating or navigation or drinking water, benefit from this general strategy, as do multiple interests on Lake Ontario. This means that the future could bring major changes in the system demands without diminishing the wisdom of this basic regulation strategy. For example, if the Seaway closed, water would still have to be released through the Seaway channel for boating, municipal supply and shipping in Montreal Harbor.

Areas for Adaptive Management

The study team identified the following four circumstances in which changes in the system or changes in what we know about the system could provide reason to change any of the candidate plans:

- If the effect of water levels on erosion and flooding along the Lake Ontario shore is different from what the models predicted;
- If the response of Lake Ontario wetlands is different from what the models predicted;
- If recreational boaters and related groups change their vulnerability to low water or if our modeling of impacts is wrong;
- If we were able to make better forecasts of the net total water supply to Lake Ontario each fall through to the end of the next spring.

The Board of Control would be responsible for the adaptive management program. A technical advisor from the Corps of Engineers and an advisor from Environment Canada could manage the program jointly, arranging funding, scheduling work, interpreting new information, drafting reports, reformulating and re-evaluating plans and advising the Board of Control. All funding for adaptive management would be provided through existing agency programs in both countries. The agencies are unlikely to reshape their budgets and programs to provide the monitoring services needed unless the IJC actively lobbies for a better-integrated, results-oriented investment and management strategy for government and non-government Great Lakes programs.

The AMAP has three principal components:
1. Mathematical models of how water levels drive the impact;
2. A monitoring program;
3. A protocol for determining whether and how the discovery of new information would lead to changes to the model or the regulation plan.

1. Mathematical models

Tradeoffs among erosion, wetlands and recreational boating above the dam dominated the final year of the Board's deliberation. Under that scrutiny, the Board identified specific uncertainties about the erosion, wetlands and recreational boating models. Adaptive management can help resolve the remaining doubts and may lead to regulation plan revisions that reduce damages and increase overall benefits.

The following concepts shape the models:

- High Lake Ontario levels, especially in spring, fall and winter, increase the risk of flooding, hasten the loss of shore property and increase annual maintenance and replacement costs for shore protection structures. Low levels can also increase erosion and shore protection costs because wave action erodes the toe of the bank, undermining the shoreline and requiring new shore protection structures that are more expensive because they have to be extended more deeply.

- More natural variability in Lake Ontario levels, especially more natural extended low lake levels, will provide more diverse wetland plant communities which will favor different animals at different times. This increases the chances of having sustainable populations of many different animals, including birds that are now at risk. Greater species diversity should make the Lake Ontario ecosystem more robust and therefore better able to withstand the threats of invasive species and pollution.

- Low water problems for recreational boaters begin at water levels that are quite common. This is in part because the popularity of boating has caused people to put docks, boat ramps and marinas in marginal locations that often do not have enough water to support the boats that moor there.

There is some conflict among these three: keep levels near average to avoid erosion; keep levels lower during long droughts to help the environment, and keep levels higher to avoid boating problems. These conflicts were balanced in slightly different proportions in the three candidate plan options, which explains why Plan 1958-DD is so good for shore property but not as good for the environment as Plan B, and why Plan B is so good for the environment, but not as good as Plan 1958-DD for shore properties or boaters on Lake Ontario down to Alexandria Bay.

The Board's evaluations have highlighted some specific issues in mathematical models that are both uncertain and influential in shaping the regulation plan. The key variables most likely to change the regulation plan, if future monitoring shows model algorithms were misleading, are:

- **Erosion rates and shore protection replacements.** The three candidate plans all take slightly different approaches to minimizing coastal damages, and each causes negative impacts in some other sector. Estimates of coastal damage may not be accurate enough to guide these tradeoffs. For example, the so-called design water level used in the Flooding and Erosion Prediction System (FEPS) model is a single number for each county around Lake Ontario that represents the additional design height of shore protection structures to account for waves and surges. The number used reflects accepted engineering standards based on historical wave and surge patterns. Homeowners should have followed these specifications when building their shore protection structures, but field studies were not conducted to confirm this. Experience with the Lake Ontario shore indicates that few homeowners "overbuild" their structures, and relatively small changes in this one parameter can make a big

difference in evaluations. If, for example, the as-built shore protection structures were about 25 cm (9 in) higher than design standards on the U.S. shore, Plan B+ shore protection maintenance costs would be about the same as other plans.

- **Populations of wetland birds considered at risk.** Data collected for this study demonstrate the strong correlation between flooding history and plant mixes in coastal wetlands. Data also demonstrate correlations among bird occurrence, specific vegetation communities, and habitat flooding. There is less certainty about the degree of wetland bird response to future changes in habitat availability, especially in the case of those species considered at risk. This is because our bird models assume that habitat availability, as influenced by water level regulation, is the primary limitation to wetland bird population distribution and abundance in Lake Ontario. The models did not capture all of the factors that can affect population, e.g., the effects of pollution, predation and competition for habitat.

- **Muskrat population in the upper river.** The muskrat is important because it helps control cattails, because it is an indicator species, and because the trapping of muskrats is a traditional Akwesasne activity. Models predict that different plans will have dramatically different effects, but the models are based on limited data.

- **Fall boating activity.** Models estimate recreational benefits based on days boated in 2002 plus boaters' estimates of the number of days they would have boated if water levels were sufficient. The International Water Levels Coalition argues that boating activity declines in the fall partially because boaters fear they will not have enough water to use their boats or to get them out of the water for winter storage. This hypothesis was not tested and there is no "feedback loop" in the model to adjust boating benefits accordingly. If this does happen, the negative impacts of Plan B+ would be reduced.

- **Boating impacts in marginal areas.** Boating impacts related to insufficient depth occur when Lake Ontario is at its long-term average levels. Cornell University researchers obtained a bottom elevation measurement for every slip in every U.S. marina, and the results of that survey show that 1 to 3% of all Lake Ontario marina slips will have depth problems at average levels between May 1st and September 30th. Further problems may be experienced in entrance channels, at boat ramps and on private docks. This represents a population of over two hundred boaters who will have problems in most seasons. There were discussions during the Study about how boaters and marinas in this group could address shallow-water issues individually, but no further steps to assist them were taken.

2. Monitoring program

The key variables described above would be monitored after a new plan is put into effect. If the monitoring suggests that the system has changed or the algorithms were wrong, the protocol in the section that follows this would be used to determine what model and plan changes the IJC should consider.

The monitoring plan would consist of field studies of wetlands, at-risk wetland bird populations, Northern Pike, and muskrats, aerial and satellite photographic studies of shorelines, data collection from permit applications for new shore protection, and information collected voluntarily by boating and marina organizations.

Environmental monitoring

Purpose: Monitoring for the environment would help determine whether the impact of regulation on wetlands, birds at risk, and muskrats is consistent with the predictions of the models.

Outcome: Continuous monitoring of animal populations along with wetland conditions could provide a rationale for adjusting the regulation plan according to whether it is clearly effective or clearly not effective.

Assessment of existing programs shows that the environmental monitoring would have to be based mostly on new efforts carried out specifically for the IJC, with existing monitoring programs used solely for comparison and validation. A selected subset of the Study's 32 wetland sites would be monitored, using similar methods, to inventory plant species. Population studies of birds at risk on Lake Ontario and muskrat on the upper river would also be commissioned. Monitoring would begin as soon as possible for birds and muskrat, but could wait until after unusual water level conditions for wetlands. Monitoring could be coordinated at the IJC, with field work carried out by contractors, probably working for the New York State Department of Environmental Conservation (NYSDEC) and Environment Canada.

Funding: No sure source of funding for this work has been identified. Funding could come from a U.S. Fish and Wildlife Service grant to NYSDEC to carry out the state wildlife management plan. This plan—the Comprehensive Wildlife Conservation Strategy (CWCS)—has recently been submitted, and the portions that address the Lake Ontario shoreline highlight the need for monitoring of Least Bittern and Black Tern populations in coastal marshes.

No funds options: Failing new funding, some ongoing programs can be identified that would offer small pieces of what is needed. We know of no efforts to sample the coverage of different wetland plant types on a routine basis (the center of study modeling) and none for muskrat. The Environment Canada Durham Region monitoring program and Bird Study Canada's Marsh Monitoring Program would offer valuable information about wetland birds, but those efforts are not designed to separate the effects of water levels from other factors that have an impact on population.

On the U.S. side, New York State's Comprehensive Wildlife Conservation Strategy calls for coastal wetland monitoring, particularly for "species of greatest conservation need" like the Black Tern and Least Bittern. The Nature Conservancy is prepared to work with partners as a catalyst for coastal wetland monitoring, seeking support to carry out recommendations of the CWCS. In order to receive federal funds through the CWCS, "planning" projects (like monitoring) require a non-federal match of 25%.

Other funding issues: An endowment could generate interest income that could pay for monitoring. If a way could be found to raise $1 million, New York State already has a mechanism, through the Great Lakes Protection Fund, to invest and manage an endowment and distribute the income for specified purposes. The NYSDEC makes recommendations to the citizen representatives on the Great Lakes Basin Advisory Council concerning the awarding of grants from its existing Protection Fund endowment. A monitoring program supported by this sort of dedicated funding would be less prone to interruption by future difficulties in the politics of state and provincial budgets.

Coastal Monitoring

Purpose: Monitoring for erosion and shore protection would be used to verify the modeled damages so that regulation could be modified if the actual damages are significantly different from the damages used to support plan selection.

Outcome: If damages are clearly less significant than modeled, the IJC could consider changes to the regulation plan that would allow for lake levels that produce greater benefits to other users. If the actual damages are more significant, the IJC would consider plan changes that would lower lake levels.

There are about 5,500 homes along the coast of Lake Ontario that already have shore protection structures, and only about 1,000 more shore protection structures will be built over the next hundred years, so the greatest cost (estimated at about $15 million per year) to riparians is the maintenance and replacement of existing shore protection. The next greatest cost (estimated at about $2.5 million per year) is the construction of new shore protection to prevent damage to buildings threatened by erosion. Flooding is an order-of-magnitude less costly, about $170,000 per year on average. The FEPS evaluations show real differences in shore protection costs among the plans, amounting to millions of dollars per year. The strategy for coastal monitoring would be to gather data on recession and new and replacement shore protection structure events to determine whether the model predicts these damages well and whether the response to low, average and high water events is as expected.

The FEPS model calculates the recession in the top of bank over time and specifies the time and type of failure of each shore protection structure. The FEPS model could be run each year with real water and wave data, and the predicted recession and shore protection events could be compared with what really happened. The cheapest and most effective way to monitor the position of the top of bank is through the use of satellite imagery. Construction or replacement of shore protection requires a permit in both countries, and permit data could be used, with owner permission, to monitor shore protection failures. A review of permits for new shore protection would also provide data on the position of top of bank.

Funding: There is no known source of funding specifically for this monitoring, nor have costs been estimated. Satellite monitoring would certainly require new authorization of funding.

Recreational Boating

Purpose: Monitoring for recreational boating would be used primarily to monitor and actively support user community efforts to reduce vulnerability to low water levels. User activity could also be monitored to determine if higher fall levels increase boating activity after Labour Day.

Outcome: Better communication among boating groups and marinas will help verify, fill in and update the data that drove plan formulation. IJC active outreach through the New York State, Ontario and Quebec governments and boating groups could discourage further placement of boating facilities in marginal areas and will at least give the most vulnerable boaters and businesses more information so they can adapt individually. If fall boating activity increases because of higher fall levels, the IJC would have more reason to persist in that strategy.

Recreational boating impacts typically involve lower water levels. Research on the U.S. shore was more successful because of the availability of boat information in that country, and it provided information on the bottom elevation of every marina slip. Many slips have marginal locations and will not be serviceable unless Lake Ontario levels are fairly high. The negative impact on boating is the main reason to oppose naturally low Lake Ontario levels during long droughts, even though such lows provide significant environmental benefits in evaluations.

Monitoring would be a volunteer effort organized through a semi-formal boating advisory committee representing existing boating organizations, such as the Ontario Marine Operators Association and the Canadian Power and Sail Squadrons. The Board of Control could revise its communication strategy to formalize two-way communications with an advisory committee. The Board could provide information regarding forecasted extreme levels to the boating community via an "early-alert system." An Advisory Committee would help spread those alerts to boaters. The Board could develop a practical guidebook for marina owners that would allow marinas to factor water levels into their business planning.

An Advisory Committee could report problems with water levels to the Board. The reports could focus on the most sensitive areas (e.g., the Gananoque area, Lac St. Louis, Alexandria Bay, North Sandy Pond), answering a short list of standard questions.

Adapting the plan as better forecasts are developed

Lake Ontario tends to reach its highest levels late in the spring, after spring runoff finally makes it way down from the upper Great Lakes. Plan 1958-DD generally causes the Lake to drain from its peak faster than it would naturally, and by fall this creates storage volume on the Lake to hold water in case the winter and spring ahead are wet. Plan B brings the Lake down at a more natural rate, usually leaving Lake Ontario at a higher level in the fall, with a higher risk of flooding the following year.

Studies showed that real-time forecasts of the net total supply of water over the next year are no better than statistically based forecasts. If accurate forecasts of even the next six to eight months' net total supplies to Lake Ontario were available, any of the candidate plans could be more precisely adjusted to lower the fall elevations only if the following year was going to be unusually wet. This would preserve (for example) the environmental benefits of Plan B^+, but would reduce coastal damages while not affecting or even improving recreational boating benefits.

The issue of better forecasting ties the three conflicting outcomes together and should also be a part of the adaptive management program. It might be possible to slightly improve forecasts through more clever statistical analysis, but a breakthrough in forecasting will probably be required in order to make a significant difference in benefits. Such breakthroughs may come from the research involved in long-term ocean temperature studies. In an April 2004 issue of Science magazine, Siegfried Schubert of NASA's Goddard Space Flight Center, found that it was possible to "forecast" the thirties' Dust Bowl drought by looking at tropical Pacific Ocean surface temperatures and tropical Atlantic Ocean temperatures together. The IJC should at least publicize the need for such research and encourage its supporting agencies to fund or conduct it.

Adaptive Management Program Summary Table

Study PI/Algorithm	Monitoring Area	Monitoring Data collected	Possible links to existing programs*
Meadow marsh community surface area	Some of 32 study wetlands	Plant densities by type and elevation	1. New York State's Comprehensive Wildlife Conservation Strategy – CWCS. Requires 25% non-Federal cost sharing. 2. U.S. Fish and Wildlife Service grant to NYSDEC to implement the state wildlife management plan. 3. Environment Canada Durham Region monitoring program. 4. Bird Study Canada's Marsh Monitoring Program.
Least Bittern, Black Tern reproductive index Yellow Rail, King Rail preferred breeding habitat coverage	Lake Ontario	Marsh-nesting obligate bird populations, focus on species at risk	
Muskrat house density in drowned river mouths, Thousand Islands area.	Upper River	Populations	New program required.
Erosion	Lake Ontario	Bank recession	1. New satellite imagery capture and analysis program. 2. State and provincial permitting programs.
Shore protection	Lake Ontario	New and replacement structures	State and provincial permitting programs.
Boating benefits	Gananoque area, Lac St. Louis, Alexandria Bay, North Sandy Pond	Shallow water incidents	Would use a new network of existing boating groups.

* No existing programs will provide the monitoring needed, but they provide an authority and cost efficiencies that should be explored.

In addition, the IJC would encourage or fund research into improved six to twelve-month forecasts of net total supply to Lake Ontario.

3. The protocol for changing the regulation plan

The Board of Control would have overall management responsibility for adaptive management. The Board would issue a report every five years on the performance of the new plan. The report would include a comparison of modeled and measured impacts, the Board's conclusions on whether the plan was achieving the expected results, and recommendations for any model and plan changes. The Board would formulate and evaluate plan modifications and would present its report to the public as part of its public information program. The IJC would be free to accept, modify or reject the proposals. The Board would direct hydrologic forecasting research.

The Challenge of Funding Adaptive Management

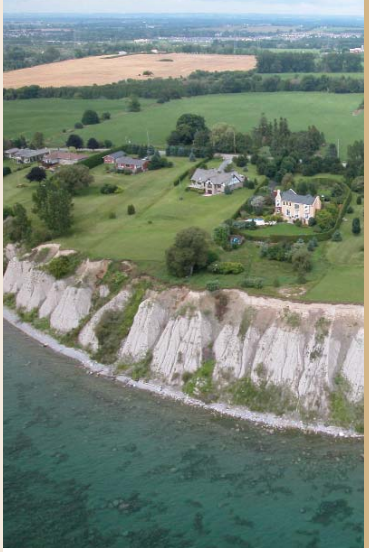
Monitoring the effects of government regulations on public resources is inherently a government obligation, but there is no readily available source of government funding for this work, and it would be an extraordinary achievement if the IJC were able to secure the funding, as modest as it is. The preliminary estimate of cost for this adaptive management plan for all three purposes and the hydrologic forecasting research is $500,000 per year.

There are several initiatives that are intended to draw U.S. and Canadian agencies together to manage the Great Lakes in a more integrated way. Nonetheless, no unified set of quantifiable, prioritized management objectives for the Lakes exists, nor is there a formal or informal attempt to measure progress towards meeting management objectives or to tie progress to overall or specific investments. This means that the agencies invest the funds they receive in accordance with their own goals.

Real integration would require a sea change in agency cultures, but all agencies support the concept in principle. The best hope for securing funding for the monitoring portion of adaptive management of Lake Ontario regulation is to work with agencies from both countries as well as the Province of Ontario and New York State to integrate existing programs in such a way that the specific needs of IJC Boundary Water responsibilities could be met. This integration would be a two-way street. For example, Study Board work has focused on the effect of water levels on wetlands, whereas most ongoing work has targeted the impacts of pollution and development. An integrated program would look at all wetland functions on the Lake and all stressors and try to focus attention where the greatest increase in wetland services could result.

Only the IJC Commissioners themselves have the stature to approach the agencies on this subject with any hope of success. Until the end of the year, the Study Board, followed by the permanent agency staffs assigned to support both the Study and the operation of the regulation plan, can draft the arguments and do some of the legwork required to support the Commissioners.

The AMAP would help the Control Board address dissatisfaction with whatever regulation plan is used by bringing hard data to bear on what has been determined as the three principle areas of conflict. Although PFEG is suggesting that the Board of Control run the program, the current Board structure would have to change to accommodate that responsibility. Such change could include the use of Ottawa and Washington-based IJC staff members to manage this work as Board liaisons.



Glossary of Terms

ABIOTIC – Non-living factors in the environment (air, water, sunlight, minerals, etc.).

ACCRETION – An increase by natural growth or addition, used in the Study in terms of increased beach area or wetland.

ACOUSTIC SOUNDINGS – Technique of determining bottom depth in a body of water by transmitting sound waves through the water and measuring the reflected signals.

ADVERSE CONSEQUENCES – Negative implication of fluctuating water levels for social, economic, environmental or political investments.

AGREEMENTS – Joint statements among two or more governmental units on (i) goals and purposes which should guide basin decision-making, (ii) processes of decision-making and (iii) authorities of governments to act. Agreements are an attempt to remedy a shared problem, and they serve to define the boundaries and constraints on choice of measures.

ALGAE – Microscopic organisms found in or near water, classified as plants and capable of photosynthesis but having no roots, flowers or seeds. These constitute the primary producers in lakes. Freshwater and marine algae are found in many forms and are therefore a diverse group of photosynthetic plant organisms that vary widely in size, shape and color. Algae form ranges from the substance on rocks that it attaches to, to the froth on the water surface, to the seaweed on the shore.

ALTERNATIVE DISPUTE RESOLUTION (ADR) – A process aimed at reaching a consensus agreement in order to end a dispute or reduce conflict among interest groups that have some stake in and can influence the outcome of decisions or actions related to the water level issue. The distinguishing characteristics of alternative dispute resolution are that: (1) interest groups are actively included in developing and assessing alternatives and making tradeoffs between alternatives, and (2) issues are decided on their merits rather than on the interest's access to the decision-making process. Policy dialogues and negotiation are types of alternative dispute resolution processes.

ANTHROPOGENIC HABITAT LOSS – The loss of habitat due to human activities.

AQUIFER – Any subsurface material that holds a relatively large quantity of groundwater and is able to transmit that water readily.

AREA OF NATURAL AND SCIENTIFIC INTEREST (ANSI) – An area of land and water which, due to its natural landscapes or features, has been classified as having life science or earth science values related to protection, scientific study or education.

ARCHIPELAGOS – Expansive water with many scattered islands or a group of islands.

AUTHORITY – The right to enforce laws and regulations or to create policy.

AVERAGE WATER LEVEL – The arithmetic average of all past observations (of water levels or flows) for that month. The period of record used in this Study commences January 1900. This term is used interchangeable with monthly-mean water level.

AWNED SEDGE – An endangered species in New York State that is known as Carex atherodes or sedge.

BARRIER BEACH – An offshore ridge of unconsolidated material (sand, pebbles, etc.) that runs parallel to a coastline, is formed in part by high tides and acts as a natural barrier.

BASIN – The rounded depression of a lake bed.

BASIN (LAKE ONTARIO – ST. LAWRENCE RIVER) – The surface area contributing runoff to Lake Ontario and the St. Lawrence River downstream to Trois Rivières, Quebec.

BASIN; WATERSHED – The region or area of which the surface waters and groundwater ultimately drain into a particular course or body of water.

BATHYMETRY – The measurement and charting of water depths in large bodies of water; also information derived from such measurements.

BEACH – The zone of unconsolidated material that extends landward from the average annual low water level to either the place where there is marked change in material or physiographic form, the line of permanent vegetation, or the high water mark.

BENEFICIAL CONSEQUENCE – Positive implication of fluctuating water levels for social, economic, environmental or political investments.

BENTHOS - The plants and animals that live at the bottom of a body of water (ocean, river, lake, pond, etc.) either attached or unattached to substrate (sediment, rock, plant, etc.).

BIOTA – All plants and animals living in a given area.

BIRD GUILD – 1. A group of birds that have similar breeding habits. 2. A group of birds, not necessarily of the same species, that depend on the same environmental resources.

BLUFF – A steep bank or cliff or variable heights, composed of glacial tills and lacustrine deposits consisting of clay, silt, gravel and boulders.

BOAT LAUNCHING RAMP – A sloping structure allowing small recreational water craft and trailers access to water.

BOUNDARY WATERS TREATY OF 1909 – The agreement between the United States and Canada that established principles and mechanisms for the resolution of disputes between the two countries related to water. The International Joint Commission was created as a result of this treaty.

BREAKWATER – A barrier built offshore to protect a harbor or a beach from the force of waves.

BUFFER ZONE – The minimum amount of land needed between a structure and an eroding shoreline before shoreline protection is needed.

CHART DATUM – The water level used to calculate the water depths that are shown on “navigation charts” and are a reference point for harbour and channel dredging.

CLIMATE – The prevalent weather conditions of a given region (temperature, precipitation, windspeed, atmospheric pressure, etc.) observed throughout the year and averaged over a number of years.

COAST – The land or zone adjoining a large body of water.

COASTAL EROSION – The wearing away of a shoreline as a result of the action of water current, wind and waves.

COASTAL PROCESSES TECHNICAL WORK GROUP – A scientific and technical work group for the International Lake Ontario-St. Lawrence River Study that is investigating the impacts of water level fluctuations on shore property, with particular attention to erosion and flood processes.

COLONIAL BIRDS – Birds that nest in groups.

COMMERCIAL NAVIGATION TECHNICAL WORK GROUP – A scientific and technical work group for the Study that is investigating the impacts of water levels on cargo shipping, including tug and barge operations.

COMPUTER MODELLING – The use of computers to develop mathematical models of complex systems or processes.

CONNECTING CHANNELS – A natural or artificial waterway of perceptible extent, which either periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. The Detroit River, Lake St. Clair and the St. Clair River comprise the connecting channel between Lake Huron and Lake Erie. Between Lake Superior and Lake Huron, the connecting channel is the St. Marys River.

CONSERVATION – The planned management of a natural resource, with the goal of protecting and carefully preserving it from exploitation, destruction or neglect.

CONSUMPTIVE USE – The quantity of water withdrawn or withheld from the Great Lakes and assumed to be lost or otherwise not returned to them, due to evaporation during use, leakage, incorporation into manufactured products or otherwise consumed in various processes.

CONTROL WORKS – Hydraulic structures (channel improvements, locks powerhouses, or dams) built to control outflows and levels of a lake or lake system.

COSMOS MODEL – Name of the erosion prediction numerical model used in this Study for the Lake and upper river.

CRITERIA – A principle or standard by which a judgement or decision is made. Criteria are conceptual but must have operational (measurable in principle) components. Any single criterion can be used to compare the merit of measures or policies along the dimensions encompassed by the criterion. Criteria are used to assess measures and criteria are used to assess the decision-making process (for example, group access to the decision-making bodies).

CRITERIA, CORE – The broad principles upon which the overall value of any measure can be assessed relative to other measures. They include economic sustainability, environmental integrity, social desirability, uncertainty and risk, political acceptability and implementability, and equitability.

CRITERIA, OPERATIONAL – These criteria are subsets of the core criteria. These sub-criteria are quantified on the basis of the application of specific group rules to data or estimates of impacts of the measure. Impact assessments used to score sub-criteria are ultimately used to compare the profiles of measures.

CURRENT – The flowing of water in the lakes caused by the earth's rotation, inflows and outflows, and wind.

DESIGN RANGE – The range of factors (including expected water levels) taken into consideration when making an investment decision.

DIGITAL ELEVATION MODEL (DEM) – A digital image of geographical features consisting of a grid, in which the colour of each cell reflects an average elevation above or below sea level.

DIGITAL ORTHOIMAGERY – Computer-assisted cartography technique allowing representation of surface features with the positional accuracy of a map, through elimination of errors due to camera or sensor orientation and terrain relief.

DIGITAL ORTHOPHOTO – A computer-rendered image representing surface features, in which inaccuracies due to camera or sensor orientation and terrain relief have been removed. Such an image combines the positional accuracy of a map with the image quality of a photograph.

DIKE – A wall or earth mound built around a low lying area to prevent flooding.

DIVERSIONS – A transfer of water either into the Great Lakes watershed from an adjacent watershed, or vice versa, or from the watershed of one of the Great Lakes into that of another.

DRAINAGE BASIN – The area that contributes runoff to a stream, river, or lake.

DROWNED RIVER MOUTHS (also known as estuaries) – The place where lake and river waters mix. They provide valuable habitat for spawning fish, nesting and migrating birds, and many rare or specialized plants. These wetlands typically have deep organic soils that have accumulated due to deposition of watershed-based silt loads and protection from coastal processes (waves, currents, seiche, etc.).

DUNE – a mound or ridge of sand formed by the action of wind or waves.

ECOLOGY – The science which relates living forms to their environment.

ECOSYSTEM – A biological community in interaction with its physical environment, and including the transfer and circulation of matter and energy.

ECOSYSTEM INTEGRITY – A state of health, or wholesomeness of an ecosystem. It encompasses integrated, balanced and self-organizing interactions among its components, with no single component or group of components breaking the bounds of interdependency to singularly dominate the whole.

EMERGENTS – Plants rooted in soil under water but which emerge partially above the surface.

ENDANGERED SPECIES – A species threatened with extinction.

ENVIRONMENT – Air, land or water; plant and animal life including humans; and the social, economic, cultural, physical, biological and other conditions that may act on an organism or community to influence its development or existence.

ENVIRONMENTAL INTEGRITY – The sustenance of important biophysical processes which support plant and animal life and which must be allowed to continue without significant change. The objective is to assure the continued health of essential life support systems of nature, including air, water, and soil, by protecting the resilience, diversity, and purity of natural communities (ecosystems) within the environment.

ENVIRONMENTAL TECHNICAL WORK GROUP – A group of scientific and technical experts that is investigating impacts of water level variations on fish, birds, plants and other wildlife in the Lake Ontario-St. Lawrence River system, with particular attention to ecological effects on wetlands.

EQUITABILITY – The assessment of the fairness of a measure in its distribution of favorable or unfavorable impacts across the economic, environmental, social, and political interests that are affected.

EROSION – The wearing away of land surfaces through the action of rainfall, running water, wind, waves and water current. Erosion results naturally from weather or runoff, but human activity such as the clearing of land for farming, logging, construction or road building can intensify the process.

ESTUARIES – The place where lake and river waters mix. They provide valuable habitat for spawning fish, nesting and migrating birds, and many rare or specialized plants. These wetlands typically have deep organic soils that have accumulated due to deposition of watershed-based silt loads and protection from coastal processes (waves, currents, seiche, etc.).

EUTROPHIC – Waters high in nutrient content and productivity arising either naturally or from agricultural, municipal, or industrial sources; often accompanied by undesirable changes in aquatic species composition.

EVALUATION – The application of data, analytical procedures and assessment related to criteria to establish a judgment on the relative merit of a measure, policy or institution. Evaluation is a process which can be conducted both within formal studies and by separate interests, although different data, procedures and criteria may be employed in the evaluation by different interests.

EVALUATION FRAMEWORK – A systematic accounting of the criteria considered and methodologies applied in determining the impact of measures on lake levels, stakeholders, and stakeholder interests.

EVAPOTRANSPIRATION – Evaporation from water bodies and soil and transpiration from plant surface.

EXOTIC SPECIES – Non-native species found in a given area as a direct or indirect result of human activity.

FEEDBACK LOOP – Feedback loops are circular cause and effect relationships dominating some interaction of particular sets of system's key variables. Feedback loops belong generally to one of two types. "negative feedback loops" which act to maintain the value of a particular variable around a given level, and "positive feedback loops" which act to cause the value of a particular variable to increase or decrease in a self-amplifying manner; and, usually at a geometric rate.

FISH GUILD – 1. A group of fish that have share similar breeding habits. 2. A group of fish, not necessarily of the same species, that depend on the same environmental resources.

FLOOD AND EROSION PROTECTION SYSTEM (FEPS) – A series of numerical models including COSMOS that compile and evaluate shoreline data to compute flood and erosion damages.

FLOODING – The inundation of low-lying areas by water.

FLOODPLAIN – The lowlands surrounding a watercourse (river or stream) or a standing body of water (lake), which are subject to flooding.

FLOW – The rate of movement of a volume of water over time.

FLUCTUATION – A period of rise and succeeding period of decline of water level. Fluctuations occur seasonally with higher levels in late spring to mid-summer and lower levels in winter. Fluctuations occur over the years due to precipitation and climatic variability. As well, fluctuations can occur on a short-term basis due to the effects of periodic events such as storms, surges, ice jams, etc.

FLUVIAL – Related to or living in a stream produced by a river.

FRAZIL ICE – Stream ice with the consistency of slush, formed when small ice crystals develop in super-cooled stream water as air temperatures drop below freezing. These ice crystals join and are pressed together by newer crystals as they form.

FRESHET – The sudden overflow or rise in level of a stream as a result of heavy rains or snowmelt.

FUNGIBILITY – Something that is exchangeable or substitutable. In this Study, fungibility refers to the degree to which performance indicators are measured in the same units and are comparable.

GABION – An open-ended, cylinder-shaped wire mesh container which is sunk into a bottom and filled with rocks to form a structure such as a dike used to prevent erosion.

GENERAL CIRCULATION MODEL (GCM) – A three-dimensional computer representation of climate and its various components, used to predict climat scenarios.

GEOGRAPHICAL INFORMATION SYSTEM (GIS) – An information system used to store and manipulate (sort, select, retrieve, calculate, analyze, model, etc.) geographical data.

GEOMORPHOLOGY – The field of earth science that studies the origin and distribution of landforms, with special emphasis on the nature of erosional processes.

GLOBAL POSITIONING SYSTEM (GPS) – A navigation system based on the transmission of signals from a network of satellites, which allows users anywhere on the planet to determine their exact location at all times.

GOVERNANCE SYSTEM – The complex, dynamic mosaic of governmental and non-governmental entities having some authority to manage, or the ability to influence the management of Basin resources.

GREENHOUSE EFFECT – The warming of the earth's atmosphere associated meteorological effects due to increased carbon dioxide and other trace gases in the atmosphere. This is expected to have implications for long-term climate change.

GROUNDWATER – Underground water occurring in soils and in pervious rocks.

GULLIES – Deep, V-shaped trenches carved by newly formed streams, or groundwater action, in rapid headward/forward growth during advanced stages of accelerated soil erosion.

HABITAT – The particular environment or place where a plant or an animal naturally lives and grows.

HABITAT HETEROGENEITY – Habitat encompasses the diverse characteristics of the environment that define an area where specific biota live and is necessary for life functions.

HABITAT SUITABILITY INDEX (HSI) – A relative weighting (usually between 0 and 1) of the suitability of a particular environmental characteristic or combination of characteristics based on a particular biota's requirements.

HAZARD LAND – An area of land that is susceptible to flooding, erosion, or wave impact.

HYDRAULICS – The study of the mechanical properties of liquids, including energy transmission and effects of the flow of water.

HYDRAULIC MODELING – The use of mathematical or physical techniques to simulate water systems and make projections relating to water levels, flows and velocities.

HYDROELECTRIC POWER – Electrical energy produced by the action of moving water.

HYDROELECTRIC POWER GENERATION TECHNICAL WORK GROUP – A group of technical experts for the Study that are evaluating how different regulation plans affect power generation.

HYDROLOGIC ATTRIBUTES – Statistics on water levels and stream flows.

HYDROLOGIC CYCLE – The natural circulation of water, from the evaporation of seawater into the atmosphere, the transfer of water to the air from plants (transpiration), precipitation in the form of rain or snow, and runoff and storage in rivers, lakes and oceans.

HYDROLOGIC MODELING – The use of physical or mathematical techniques to simulate the hydrologic cycle and its effects on a watershed.

HYDROLOGY – The study of the properties of water, its distribution and circulation on and below the earth's surface and in the atmosphere.

HYDROLOGY AND HYDRAULICS MODELING TECHNICAL WORK GROUP – A scientific and technical work group for the Study that is developing models to predict water levels and flows in the Lake Ontario-St. Lawrence River system, based on various regulation plans and climate scenarios.

HYDROPERIOD – The length of time (and seasonality) that water is present over the surface of the wetland.

ICE JAM – An accumulation of river ice, in any form which obstructs the normal river flow.

IMAGERY – Representation of objects as images through electronic and optical techniques.

IMPERIAL CONVERSION FOR FEET TO METERS – 1 foot = .305 meters.

IMPERIAL CONVERSION FOR INCHES TO CENTIMETERS – 1 inch - 2.54 centimeters.

IMPLEMENTABILITY – The ability to put into effect a measure considering factors of engineering, economic, environmental, social, political and institutional feasibility.

IMPLEMENTING AUTHORITY – Any governmental agency at any level having appropriate authority to authorize and execute the implementation of any particular action and the jurisdiction to enforce an action.

INFILTRATION – Movement of water through the soil surface and into the soil.

INFORMATION MANAGEMENT TECHNICAL WORK GROUP – A scientific and technical work group for the Study that is collecting and updating information on depths and elevations (bathymetric and topographic data) in critical areas of the Lake Ontario-St. Lawrence system and sharing findings with other work groups.

INSTITUTION – An organization of governmental units which have the authority and ability to facilitate and/or make decisions affecting the water levels issue.

INTEGRATED ECOLOGICAL RESPONSE MODEL (IERM) – Establishes the framework for evaluating, comparing, and integrating the responses for the environmental performance indicators.

INTERESTS – Any identifiable group, including specialized mission agencies of governments which (1) perceive that their constituents'/members' welfare is influenced by lake level fluctuation or policies and measures to address lake level fluctuation, and which (2) are willing and able to enter the decision-making process to protect the welfare of their constituents/members.

INTERNATIONAL JOINT COMMISSION (IJC) – An international federal government agency formed in 1909 by the United States and Canada as an application of the Boundary Waters Treaty to oversee the resolution and prevention of disputes with regard to all bodies of water shared by the two countries, and to provide recommendations on such water management issues as water quality and water levels.

INTERNATIONAL LAKE ONTARIO - ST. LAWRENCE RIVER STUDY – A study sponsored by the IJC to examine the effects of water level and flow variations on all users and interest groups and to determine if better regulation is possible at the existing installations controlling Lake Ontario outflows.

INTERNATIONAL REACH – The portion of the St. Lawrence River that is between Lake Ontario and the Moses-Saunders Dam.

INTERNATIONAL ST. LAWRENCE RIVER BOARD OF CONTROL – Board established by the International Joint Commission in its 1952 Order of Approval. Its main duty is to ensure that outflows from Lake Ontario meet the requirements of the Commission's Order. The Board also develops regulation plans and conducts special studies as requested by the Commission.

INVESTMENT – Expenditure made by an interest to capture benefits. The investment decision reflects available information and understanding about the system, government responsibilities and risks.

JURISDICTION – The extent or territory over which authority may be legally exercised.

LAKEBED DOWNCUTTING – Progressive erosion or deepening of the water depths in front of riparian property.

LAKE OUTFLOW – The amount of water flowing out of a lake.

LEACHATE – Contaminated liquid resulting from the percolation of water through pervious rocks and soils at a waste site or landfill.

LIDAR – A remote-sensing system similar to radar, in which laser light pulses take the place of microwaves.

LITTORAL – Pertaining to or along the shore, particularly to describe currents, deposits and drift.

LITTORAL CELL – An area under the continuous influence of specific longshore currents.

LITTORAL CELLS – Closed sediment compartments that define the limits of all sand movements, both along the shore and onshore/offshore.

LITTORAL DRIFT – The movement of gravel, sand and other beach material along the coast, which is caused by waves and currents.

LITTORAL ZONE – The area extending from the outermost breaker or where wave characteristics significantly alter due to decreased depth of water to: either the place where there is marked change in material or physiographic form; the line of permanent vegetation (usually the effective limit of storm waves); or the limit of wave uprush at average annual high water level.

LOCATION BENEFIT – Positive effect on the welfare of an interest derived from shore location and water level situation.

LOCATION COST – Negative effect on the welfare of an interest derived from shore location and water level situation.

LOW WATER DATUM – An approximation of mean low water, used for harbour-dredging purposes.

LOWER ST. LAWRENCE RIVER – The portion of the St. Lawrence River downstream of the Moses-Saunders Dam is called the lower St. Lawrence in this Study. It includes Lac St. Francis, Lac St. Louis, Montreal Harbour, Lac St. Pierre and the portions of the River connecting these lakes as far downstream as Trois Rivieres.

MARINA – A private or publicly-owned facility allowing recreational watercraft access to water, and offering mooring and other related services.

MARSH – An area of low, wet land, characterized by shallow, stagnant water and plant life dominated by grasses and cattails.

MEASURE – Any action, initiated by a level(s) of government to address the issue of lake level fluctuations, including the decision to do nothing.

MEASURE, NON-STRUCTURAL – Any measure that does not require physical construction.

MEASURE, STRUCTURAL – Any measure that requires some form of construction. Commonly includes control works and shore protection devices.

METADATA – Data (information) about the characteristics of data such as content, quality (condition, accuracy, etc.), date of capture, user access restrictions and ownership.

META-DATABASE – A database used to store information about data (metadata).

METEROLOGICAL – Pertaining to the atmosphere or atmospheric phenomena; of weather or climate.

METRIC CONVERSION FOR CENTIMETERS TO INCHES – 1 centimeter = 0.4 inch.

METRIC CONVERSION FOR METERS TO FEET – 1 meter = 3.28 feet.

MICRO-ORGANISM – An organism that is too small to be visible without the aid of a microscope.

MODEL – A model may be a mental conceptualization; a physical device; or a structured collection of mathematical, statistical, and/or empirical statements.

MODEL, COMPUTER – A series of equations and mathematical terms based on physical laws and statistical theories that simulate natural processes.

MODEL, HYDRAULIC – A small-scale reproduction of the prototype used in studies of spillways, stilling basins, control structures, riverbeds, etc.

MODEL, VISUAL SITUATION – A pictorial display linked to an automated information/geographic information system(s) which connects the problems associated with fluctuating water levels whith the stakeholders and their interests that are impacted by the problems, with an emphasis on overlapping or interacting relationships.

MONTHLY MEAN WATER LEVEL – The arithmetic average of all past observations (of water levels or flows) for that month. The period of record used in this Study commences January 1900. This term is used interchangeably with average water level.

NEGOTIATION – The process of seeking accommodation and agreement on measures and policies among two or more interests or agencies having initially conflicting positions by a "voluntary" or "non-legal" approach. This is often considered a part of an alternative dispute resolution process.

NET BASIN SUPPLY (NBS) – The net amount of water entering one of the Great Lakes, comprised as the precipitation onto the lake minus evaporation from the lake, plus groundwater and runoff from its local basin. The net basin supply does not include inflow from another Great Lake.

NO NET LOSS – A working principle by which a department or agency strives to balance unavoidable habitat losses with habitat replacement on a project-by-project basis so that further reductions to Canada's fisheries or U.S. wetland resources due to habitat loss or damage may be prevented.

OPERATING PLAN – A list of procedures to be followed in making changes to the lake levels or their outflows for the specific purpose or to achieve certain objectives. Operation of regulatory facilities on the Great Lakes are carried out by their owners and operators under the supervision of the IJC and in accordance with Plan 1977 (Lake Superior) and Plan 1958-D (Lake Ontario).

OUTFALL – The place or structure where a sewer, drain, conduit or stream discharges into the surface water.

OUTFLOW – The quantity of water flowing out of a lake through surface rivers or streams, measured in time units at a given point.

OXIC – To expose to oxygen.

OZONATION – The application of a substance or compound with ozone as a possible remedy for the occasional taste and odor problems experienced in some municipal water supplies that withdraw water from the lower river.

PEAKING – The variation of hourly water flows above and below the daily average flow (for instance, midday flow higher than evening and night flows), primarily due to hydroelectric generating operations during which water is stocked during periods of off-peak demand in order to increase hydroelectric power generation at peak periods.

PERFORMANCE INDICATOR – A measure of economic, social or environmental health. In the context of the Study, performance indicators relate to impacts of different water levels in Lake Ontario and the St. Lawrence River.

PHOTOSYNTHESIS – The process through which the cells of green plants and certain micro-organisms convert energy from sunlight into stored, usable chemical energy.

PHYSICAL IMPACT SURVEY – A characterization study of the impact of water level fluctuation on infrastructure use or constraints.

PHYSIOGRAPHY – A descriptive study of the earth and its natural phenomena, such as climate, surface etc.

PLAN 1958-D – A plan used by the International St. Lawrence River Board of Control since April 1963 that specifies outflows from Lake Ontario in order to satisfy the existing set of criteria established by the IJC and related to interests on Lake Ontario and the St. Lawrence River.

PLAN FORMULATION AND EVALUATION GROUP – A group established as part of the Study to develop alternative water level regulation plans, establish performance indicators for such plans, and to measure the effectiveness of such alternate criteria and operating plans.

PLAN FORMULATION METHOD – A method involving a multi-objective, multi-stakeholder evaluation procedure used to evaluate factors not previously considered in determining whether a revised operating plan performs better than an existing plan.

PLANIMETRIC CAPABILITIES – The capability of a system to measure areas.

POLICY – The position adopted by a government on an issue which is expected to structure and guide the decision-making process.

PONDING – The variation of daily water flows above and below the weekly average flow (for instance, average weekday flow higher than average weekend flow), primarily due to hydroelectric generating operations.

POSITION OF INTERESTS – The perceptions, beliefs and preferences of interests regarding fluctuating water levels, implications of those levels, and acceptability of a measure or policy to an interest. Positions may be directly stated or may be inferred from supporting or opposing activities taken by the interest in the decision-making process.

PRIORITY CONSERVATION SPECIES – A species protected by federal, state, or provincial laws.

PUBLIC COMMUNICATIONS – Activities where the purpose, design, and plan intends for two-way communication for a defined period of time between Study personnel and the public or various publics.

PUBLIC INFORMATION – Activities where the purpose, design, and plan intends to deliver information to the public or various publics. Examples: press releases and articles in the Study Newsletter, Ripple Effects.

PUBLIC INTEREST ADVISORY GROUP (PIAG) – The group of volunteers from the United States and Canada working to ensure effective communication between the public and the International Lake Ontario-St. Lawrence River Study Team.

PUBLIC INVOLVEMENT – Activities where the purpose, design, and plan is such that members of the public or various publics are engaged in the Study on a continuing basis with other "expert" resources.

PUBLIC PARTICIPATION – Activities where purpose, design, and plan intends that members of the public have an opportunity to participate for a defined period of time in a Study activity.

QUARTER-MONTHLY MEAN WATER LEVEL – This is the average water level that would occur during a quarter-month period. A quarter-month is seven or eight days depending on the number of days in the month.

RAPIDS – A turbulent and swift-flowing section of a river.

REACH – A length of shore with fairly uniform onshore and offshore physiographic features and subject to the same wave dynamics.

REBOUND (CRUSTAL MOVEMENT) – The uplift or recovery of the earth's crust in areas where a past continental glaciation had depressed the earth's crust by the weight of the ice.

RECESSION – A landward retreat of the shoreline by removal of shore materials in a direction perpendicular or parallel to the shore.

RECREATIONAL BOATING AND TOURISM TECHNICAL WORK GROUP – A group of technical experts that will investigate the impacts of water levels on individual boaters, marinas, and boating-related tourism for the Study.

REGULATION – Artificial changes to the lake levels or their outflows for specific purpose or to achieve certain objectives.

REGULATIONS – Control of land and water use in accordance with rules designed to accomplish certain goals.

RELIABILITY – While ranking plans, it is the percentage of time that a criterion is met (i.e., 4,848 out of 4,848 quarter-months = 100%).

RESILIENCE – During plan ranking, it is the average amount of time it takes to get back in compliance (how long). It is calculated as the total number of quarter-months of failure divided by the number of failures.

RESILIENCY – The ability to readily recover from an unexpected event, either because costs were not significantly affected by changing levels, another source of income provided a cushion to levels induced costs, and/or a conscious effort was made on the part of the interest.

RESERVOIR – A place where water is collected and kept for use when wanted, as to supply a fountain, a canal, or a city by means of aqueducts, or to drive a mill wheel, or the like.

REVETMENT – A natural (grass, aquatic plants, etc.) or artificial (concrete, stone, asphalt, earth, sand bag, etc.) covering (facing) to protect an embankment (raised structure made of soil, rock or other material) or other structure (such as a cliff) from erosion.

RIPARIAN – Of, relating to or found along a shoreline.

RIPARIANS – Persons residing on the banks of a body of water.

RIVERINE – Of or relating to a river or a riverbank.

RUNOFF – The portion of precipitation on the land that ultimately reaches streams and lakes.

SCOURING – Erosion, generally in the form of downcutting in front of shore protection or other coastal structures that may be temporary or permanent.

SEDIMENT BUDGET – An accounting system for all of the sand and gravel within a defined study boundary (spatial extents).

SHARED VISION MODEL – A decision-making tool used to develop a collective representation (image or view) of the future a group aspires to create.

SHOALS (SCANNING HYDROGRAPHIC OPERATIONAL AIRBORNE LIDAR SYSTEM) – A LIDAR system that uses a green laser to profile underwater terrain and an infrared laser to detect water surfaces. The system is used to obtain bathymetric and topographic data.

SHORELINE – Intersection of a specified plane of water with the shore.

SILLS – Underwater obstructions placed to reduce a channel's flow capacity.

SOCIAL DESIRABILITY – The continued health and well-being of individuals and their organizations, businesses, and communities to be able to provide for the material, recreational, aesthetic, cultural, and other individual and collective needs that comprise a valued quality of life. The satisfaction of this objective includes a consideration of individual rights, community responsibilities and requirements, the distributional impacts of meeting these needs, and the determination of how these needs should be achieved (paid for) along with other competing requirements of society.

SOCIO-ECONOMIC SURVEY – A survey measuring the basic characteristics of a community, from which statistics can be compiled.

SPATIAL EVALUATION FRAMEWORK – The classification and delineation of terrestrial, wetland and aquatic environments in spatial units meaningful to an assessment of fluctuating levels and measures.

STAKEHOLDER – An individual, group, or institution with an interest or concern, either economic, societal or environmental, that is affected by fluctuating water levels or by measures proposed to respond to fluctuating water levels within the Lake Ontario – St. Lawrence River Basin.

STANDARDIZED HYDROLOGIC STATIONS (SHS) – Water level measurement stations operated by a governmental agency where water depth that was measured at specific geographical locations is translated into International Great Lakes Datum as updated in 1985 equivalent data.

STEADY STATE – No change over time.

STOCHASTIC SUPPLIES – Simulated sequences of water supply conditions that reflect climate variability.

STRATEGY – A general conceptual framework for guiding action based upon a particular purpose and selected means for achieving agreed upon ends.

SUBMERGED MACROPHYTES – Plant species that grow under water during their entire life cycle (not including algae).

SUBSTRATE COMPOSITION – Categorical assignments of the lake/river bottom from silt to bedrock size classes.

SURFACE WATER – Water open to the atmosphere including lakes, ponds, rivers, springs, wetlands, artificial channels and other collectors directly influenced by surface water.

SYSTEM DYNAMICS – A simulation modeling methodology developed at Massachusetts Institute of Technology for the study of the behavior of complex systems. System dynamics is based upon the identification of key system variables, the interactions between them and the study of the effects of these interactions over time.

SYSTEMS APPROACH – A method of inquiry which complements the classical analytical method of science by emphasizing the concept of "whole systems" and the irreducible properties of whole systems that result from the interactions among individual components.

TECHNICAL WORK GROUP (TWG) – A team of scientific and technical experts formed to study each of the following areas: the coastal processes, commercial navigation, common data needs, the environment, hydrology and hydraulics modeling, water uses, hydroelectric power generation, and recreational boating and tourism for the International Lake Ontario-St. Lawrence River Study.

TOPOGRAPHY – The representation on maps or charts of the surface features of a region in such a manner as to illustrate their relative positions and elevations.

TROPHIC – Of, or related to, nutrition.

UNCERTAINTY AND RISK – The evaluation of a proposed measure in terms of the unpredictability and magnitude of the consequence which may follow, the detectability of anticipated or unanticipated consequences, and the ability to reverse, adapt, or redirect the measure, depending on the effects.

UPPER ST. LAWRENCE RIVER – The portion of the St. Lawrence River upstream of the Moses-Saunders Dam is called the upper St. Lawrence in this Study. It includes the entire River from Kingston/Cape Vincent to the power dam and locks at Cornwall-Massena, including Lake St. Lawrence.

URBANIZATION – The change of character of land, due to development, from rural or agricultural to urban.

VULNERABILITY – The average amount of failure when a plan does not meet criterion during ranking (how bad it performs). So if it goes over a criterion in two quarter-months, once by 10 cm (3.9 inches), the other by 20 cm (7.89 inches), the vulnerability is 15 cm (5.9 inches).

VUSILIENCE – How poorly a plan performs multiplied by how long it performs poorly (the product of vulnerability times resilience).

WATER LEVEL – The elevation of the surface of the water of a lake or at a particular site on the river. The elevation is measured with respect to average sea level. Several different types of water levels are used in the Study. In the case of Lake Ontario, the water level is assumed to be the calm water level without wind effects or waves included. In the erosion and flood analysis, these wind effects are added to the calm water level. Many of the analyses done in the Study use the quarter-monthly mean water level. This is the average water level that would occur during a quarter-month period (approximately a week).

WATER SUPPLY – Water reaching the Great Lakes as a direct result of precipitation, less evaporation from land and lake surfaces.

WATER USES TECHNICAL WORK GROUP – A technical and scientific team of the Study that is investigating impacts of water level variations on industrial, municipal, and domestic water intakes and treatment facilities.

WATERFOWL – Birds that are ecologically dependant on wetlands for their food, shelter and reproduction.

WATERSHED; BASIN – The region or area of which the surface waters and groundwater ultimately drain into a particular course or body of water.

WAVE – An oscillatory movement in a body of water which results in an alternate rise and fall of the surfaces.

WAVE CREST – The highest part of a wave.

WAVE DIRECTION – The direction from which a wave approaches.

WAVE PERIOD – The time for two successive wave crests to pass a fixed point.

WEATHER – The meteorological condition of the atmosphere defined by the measurement of the six main meteorological elements: air temperature, barometric pressure, wind velocity, humidity, clouds, and precipitation.

WEIGHTED SUITABLE AREA (WSA) – The aggregate sum of the areas within a region, or larger area, that have been weighted by habitat suitabilities (see Habitat Suitability Index).

WETLAND – An area characterized by wet soil and high biologically productivity, providing an important habitat for waterfowl, amphibians, reptiles and mammals.

WETLAND OBLIGATE BIRD SPECIES – Birds that require wetland habitats for breeding purposes (such as nesting and/or food sources).

WETLANDS – (marshes, swamps, bogs, and fens) – lands where the water table is at, near or above the land surface long enough each year to support the formation of hydric soils and to support the growth of hydrophytes, as long as other environmental variables are favorable.

WILLINGNESS TO PAY (WTP) – The maximum amount that a consumer will pay for a given item or service.

YACHT CLUB – A member-owned facility allowing access to docks or mooring to recreational boaters, and often offering complementary services.