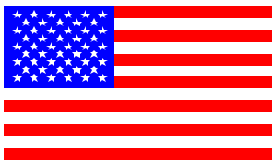

PLAN OF STUDY FOR CRITERIA REVIEW

In The

ORDERS OF APPROVAL
For

REGULATION OF LAKE ONTARIO - ST. LAWRENCE RIVER LEVELS AND FLOWS

Prepared for the International Joint Commission
By The
St. Lawrence River-Lake Ontario
Plan of Study Team

September, 1999

EXECUTIVE SUMMARY

In May 1999, a Binational Study Team was assembled by the International Joint Commission to transform the 1996 Scope of Work, which had been prepared by the International St. Lawrence Board of Control, into a detailed Plan of Study to review the operation of the structures controlling the flows and levels of the Lake Ontario – St. Lawrence system. This will require investigation of the existing criteria within the Commission's Orders of Approval for these works and a determination of what would be required to establish new criteria for improved regulation of Lake Ontario, should the Commission so desire. The 1996 Scope of Work placed emphasis on wetlands and other environmental factors, and recreational boating interests; factors not previously addressed by the original plan. The Scope of Work had also concluded that future studies should evaluate existing criteria in order to see if modifications could be made incorporating operational experience and interest preferences which have been identified since the original plan was adopted. The IJC instructed that the Scope of Work serve as the basis for this new Plan of Study. In developing this document, experts were asked to provide input on wetlands, fisheries and the environment, recreational boating, coastal processes including erosion and flood potential, commercial navigation, hydropower, industrial, municipal and domestic water intakes, public information and education, and hydrologic modeling. The Study Team then assembled these inputs and proposals into an overall Plan of Study, with costing and timelines. The following are highlights of the input provided.

Data Collection

In order to assess the various interests and criteria, extensive data collection is required. For example, information needs for environmental assessments should be centered on collection of more thorough topographic/bathymetric data at an increased number of wetland sites, concurrent collection of plant community data to reflect changes that have occurred since the Levels Reference Study data collection in 1991, and collection of data relating to fish use and accessibility to wetland habitat. The investigation of flooding, erosion and other coastal processes, requires very detailed information about the shoreline, including the shoreline geomorphology and subaqueous geology, shoreline bathymetry, shoreline elevations, bluff heights and slope, land use and property values. Understanding impacts on recreational boating requires systematic surveys of all marina operators to obtain the physical layout and operation of facilities and to obtain the current distribution of required drafts of the existing users of these facilities. Surveys are also required to determine the characteristics of water intakes and shore wells including information about those dependent upon them and changes that have occurred since 1956 to ensure that domestic and industrial water usage is catalogued.

Data collection is required at specific sites, or on a continuous shoreline basis, depending on the particular interest investigated, along both shores of Lake Ontario and the St. Lawrence River to Trois-Rivières. State-of-the-art data collection techniques are proposed, such as airborne laser-survey techniques, with geographic positioning systems (GPS), and geographic information systems (GIS).

The evaluations of impacts and effects associated with changing water levels will be based on historic recorded supply and lake level information. To the extent practical, possible future changes due to climate and demographics will be considered, and simulation techniques will also be utilized to gauge impacts and effects of possible future supply scenarios.

Evaluations

Several of the evaluations will require the development of investigative and predictive models which will assess the impact of changing levels on a particular interest. The output from each of these models will be evaluated to identify alternative approaches that meet, as nearly as possible, the needs of all interests (including the integrity of the ecosystem) while always respecting the requirements of the Boundary Waters Treaty and its Article VIII in particular.

It is proposed that new regulation plan(s) be developed and evaluated to determine to what degree they meet the new or modified criteria proposed as a result of the studies. If the regulation criteria are to be satisfied by the regulation plan for the chosen hydrologic design conditions, the criteria and regulation plan may have to be developed in concert. If the new plan does not have to fully satisfy completely each criterion, the criteria can be set prior to the plan development. If the plan cannot meet all of the criteria, a method of ranking the importance of proposed criteria, beyond that already provided for in the Treaty, must be developed to test plan changes and determine which plan best meets proposed criteria.

Since the needs and preferences of the various interests are different and at times in opposition, development of a more comprehensive set of criteria and a matching regulation plan satisfying all the interests will not be a simple task. There is a need to demonstrate what levels and flows are physically possible with the current physical regulatory works and channels, through simulation of regulation for the wide range of possible hydrologic conditions. An understanding of the reality and practicability of certain level or flow conditions could help promote better dialogue amongst the interest groups and the acceptance of the needs of others and the eventual needed compromise among the groups. It will be important that all interested parties appreciate that, within the constraints of the existing works and probable future supplies, it is highly unlikely that any new regulatory plan will be able to provide significant additional benefits to every interest group.

Project Management

It is proposed that the overall management of the multi year program of studies described herein be assigned to a Study Board created for that purpose by the Commission. The Study Board will then establish specific binational work groups which will be responsible for common data collection, as outlined in section 4.2 above, using the available expertise of the two nations and allocating resources accordingly. Study Teams will also be created for each of the “interests” identified in Part 6 of this Plan, in each case comprising a binational team from the various agencies, as a minimum, listed in Annex 1. Scheduling of their work will need to be coordinated through the Study Board. It will be the task of the overall Study Board, with input from each

Study Team and the Interest Advisory Group outlined in Section 5.1, to then consider the differing outputs of each study area and bring these together in a coherent manner that allows for public discussion of the impacts and benefits of various regulation plans and criteria, always having in mind the priorities already established under Article VIII of the Boundary Waters Treaty.

The evaluation process will be iterative, beginning early on in the study process and continuing to its completion. It will involve the development and refinement of an evaluation methodology, workshops, public meetings, regulation plan development and testing. While some portions of the overall study will require data collection extending over four to five years in order to obtain an adequate baseline, others can be split into phases with data collection in the early years and scenario testing in latter years. It is expected that the last two years of this study will concentrate heavily on the development of criteria and an acceptable regulation plan. The challenge will be to develop criteria and regulation plans that recognize the interests of all groups, and which create improved benefits for some without significant negative impacts on others. A decision support methodology specific to this situation will need to be developed as a part of the proposed studies which recognizes the complexity of the impact and benefit distribution challenge inherent in regulation of the Lake Ontario - St. Lawrence River system. It is anticipated that a number of trial regulation plans will need to be developed and considered by the Study Board, so as to allow the effects of any new or revised criteria to be described in a manner which the representatives of the various interests, the general public, and the Commission can fully appreciate.

Public Involvement

Public consultation is critical to the assessment of plan criteria. It is recognized that progress in addressing water levels issues is dependent in large part on public understanding of the causes of the water level problems, and the further understanding that most proposed solutions could have consequences for others. To achieve this understanding, it is recommended that the major interests and the relevant public be involved directly in the studies, by the formation of an Interest Advisory Group, described in section 5.1. This would allow individuals with diverse interests to find common ground on many aspects of the issues. The continuous involvement of all interests throughout the criteria review process is critical to the success of the study.

Upon completion of this work, the Study Board will then report to the Commission regarding the work carried out, its recommendations on any amendments or additions to the present criteria, and the recommended regulation plan to give effect to these criteria. The Commission, in turn, may wish to hold further public consultations prior to any decision to adopt, or otherwise, the Study Board's recommendations. Additional time for consideration of the Study Board's work by the Commission, or for further public consultations, cannot be accurately estimated at this point, and is therefore not included in the overall five year project schedule.

Cost Summary

The proposed study will define the Lake Ontario-St. Lawrence River system thoroughly as an ecosystem and hydrologically in terms of its past history and potential future benefits or impacts, though at considerable cost. The full investigation of all factors will require five years to complete and is estimated to cost **$10.07 million in U.S. dollars** ($14.80 Cdn. equivalent) for work to be carried out within the United States plus **$15.79 million in Canadian dollars** ($10.74 U.S. equivalent) for work to be carried out within Canada. This converts to totals equivalent to 30.59 million Cdn. or $20.81 U.S.. The study would be conducted, and these funds spent by a series of binational teams, comprising subject matter specialists serving in their personal and professional capacities from various federal, state and provincial agencies, academia and private consultants, and by the stakeholders impacted by Lake Ontario regulation, with overall coordination by the binational Study Board.

Acknowledgment

This document could not have been developed without the assistance of dozens of individuals who responded expeditiously providing input and quickly establishing teams to define required studies.

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in the
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1. INTRODUCTION

By letter dated April 15, 1999, the International Joint Commission (IJC) informed the governments of the United States and Canada of its establishment of a binational group to develop a Plan of Study to review the criteria which presently prescribe the way in which Lake Ontario levels are regulated. In May 1999, a binational Study Team was assembled by the IJC to transform the 1996 Scope of Work, which had been prepared by the International St. Lawrence Board of Control, into a detailed Plan of Study to review the operation of the structures controlling the flows and levels of the Lake Ontario – St. Lawrence system. Through such a review, a determination will be made as to whether or not changes to the operation of the regulatory works on the St. Lawrence River and to the criteria contained in the Orders of Approval of the IJC that govern this operation, are warranted.

In its Directive to the Plan of Study Team, the Commission also listed a number of studies or activities that would be required as a minimum. (Annex 4c)

It is proposed that to accomplish this work, study groups will be established to address each of the requirements of the Directive, as is described in detail herein. The agencies that should be involved in the study are suggested in Annex 1. In addition to consideration of possible new criteria to address areas not specifically covered in the original Orders of Approval, existing criteria will be evaluated to assess their present validity, and the manner in which the Commission's Orders and Regulation Plans have been applied historically will be reviewed.

The studies proposed include a review of the needs and preferences of all the various users or interest groups affected by water level and flow fluctuation in the Lake Ontario – St. Lawrence River system. Changes to Lake Ontario regulation will be investigated to identify and evaluate how these changes affect the various interests, and at the same time are consistent with the principles and objectives of the Treaties and other bilateral agreements between Canada and the United States.

While changes to Lake Ontario regulation will be investigated, this Plan of Study does not propose examining structural changes to the control works authorized in the IJC Orders of Approval that made Lake Ontario regulation possible. However, wherever applicable, other measures will be identified to alleviate the adverse impacts of water level and flow fluctuations.

2. **BACKGROUND**

In 1952, following requests from the governments of Canada and the United States, the IJC issued an Order of Approval for the hydropower projects in the international section of the St. Lawrence River. In 1956, the IJC issued a Supplementary Order and specified a number of criteria that would govern the Lake Ontario regulation made possible by the hydropower project. The IJC's criteria, contained in Annex 2, explicitly recognized three major interests – riparians (coastal zone interests), hydropower and commercial navigation and supplement the simple order of precedence listing among the various interests already laid out in Article VIII of the Boundary Waters Treaty; namely (1) uses for domestic and sanitary purposes, (2) uses for navigation, including the service of canals for the purpose of navigation, and (3) uses for hydropower and irrigation purposes. The regulation plans used since 1960 have been developed to meet these criteria. Currently, the plan in effect is called Plan 1958-D. A history of past studies related to Lake Ontario regulation is provided in Annex 3.

The March 1993 final report of the IJC's Levels Reference Study Board contained recommendations calling on the IJC to review and consider amending the criteria *"to better reflect the current needs of the users and interests of the system"*. These recommendations are as follows:

> *"In particular, the Board recommends that Criterion (d) of these orders be amended as follows: The regulated outflow from Lake Ontario during the annual flood discharge from the Ottawa River shall not be greater than would have occurred assuming supplies from the past as adjusted. When Lake Ontario levels and supplies allow, consideration should be given to reducing outflows from Lake Ontario during the annual flood discharge from the Ottawa River."*
>
> *"The Board recommends that the Orders of Approval for the Regulation of Lake Ontario be modified by adding the following Criteria: 'Consistent with other requirements, the outflows of Lake Ontario shall be regulated to minimize the occurrence of low water levels on Lake Ontario and the St. Lawrence River downstream as far as Trois-Rivières during the recreational boating season."*
>
> *"Criteria should be added that consider the environmental interest on Lake Ontario and the St. Lawrence River downstream as far as Trois-Rivières."*

In response, the IJC indicated in its December 1993 report to the governments that it would review the Study Board's recommendations, noting that it was bound by the "rules or principles" set out in Article VIII of the Boundary Waters Treaty of 1909.

Subsequently, the Commission in 1995 requested its International St. Lawrence River Board of Control (St. Lawrence Board) to prepare a Scope of Work outlining the investigations needed to examine the criteria contained in its Order of Approval for regulation of water levels and flows in the Lake Ontario - St. Lawrence River system. The IJC also asked that the Scope of

Work address investigations needed to respond to potential climate change/variability impacts in the system. The Board submitted its Scope of Work to the IJC in 1996, which was subsequently forwarded to governments. The Scope of Work document is contained in Annex 4(a). The study tasks outlined in this Plan of Study are follow-ups to, and an expansion of, the Scope of Work providing detailed information on what needs to be studied as well as the data to be collected. This Plan of Study also draws on Lake Ontario regulation operating experience and information obtained from recent public meetings.

The Levels Reference Study examined a number of alternative plans, some of which were investigated further by the St. Lawrence Board. Two plans were tracked along with Plan 1958-D for three years, from January 1994 to January 1997. On June 2, 1997, a report was submitted to the IJC entitled "*An Updated Regulation Plan for the Lake Ontario-St. Lawrence River System*". The report concluded that the best plan evaluated was Plan 35P and recommended that it be considered as a replacement for Plan 1958-D, and be designated Plan 1998. Plan 1998 was designed within the scope of the existing IJC criteria.

Public meetings were held regarding the adoption of Plan 1998 in October and November of 1997 at six locations: Burlington and Kingston, Ontario; Dorval, Quebec; and Brockport, Sodus Point, and Massena, New York. Public responses to the new regulation plan ranged from mild support to strong opposition.

After full consideration of issues raised during the public meetings and comment period, the IJC determined that it did not have sufficient information on the environmental impacts and that Plan 1998 would not constitute sufficient improvement over the existing situation. The IJC decided on January 12, 1999, not to adopt Plan 1998 for the regulation of Lake Ontario outflows at this time.

In its April 15, 1999 letter, the IJC then informed governments of its decision to proceed with the preparation of a detailed Plan of Study to review the Lake Ontario criteria (Annex 4b). The Commission pointed out the urgency of reviewing the regulation of Lake Ontario in view of dissatisfaction, on the part of some interests, with the working of that system and in light of environmental concerns and climate change issues. The Commission's Directive to the Plan of Study Team which it then created is contained in Annex 4c. This Plan of Study which the Team has now developed builds on the work of previous groups, including in particular the team which assembled the Scope of Work in 1996 referred to earlier, and outlines the required actions necessary to: address these issues, assess existing criteria and define time and cost estimates to accomplish the goal of improving Lake Ontario regulation for all interests.

3. PURPOSE AND SCOPE

3.1 Emphasis

During the Levels Reference Study, and since its completion, a number of interests or user groups have been identified as being directly affected by fluctuations of water levels and flows in the Lake Ontario-St. Lawrence River system. The potential impacts of the levels and outflows on the majority of these interests, documented in previous reports, are essentially understood.

Nonetheless, the work envisaged in this study will include an assessment of how water level fluctuations affect all the various interests. This will consist of a review of work previously completed, including the data, findings and reports of the 1993 Levels Reference Study, followed by additional field investigations which will include, but not be limited to, data collection, interviews and questionnaires. Where practical, studies or data already completed for other agencies or other purposes will also be utilized to minimize duplication of cost and effort. Emphasis will be placed on identifying the needs of the environmental, recreational boating and shoreline property interests as is reflected in the Scope of Work. However, in accordance with the IJC Directive, the needs of all interests will be determined. Thus, appropriate information gathered will be suitable to evaluating the effects of criteria modifications on these and any other major affected interests.

The study will be carried out within the bounds of the "rules or principles" set forth in Article VIII of the Boundary Waters Treaty of 1909 and will use the existing conditions of the 1952 Order of Approval and 1956 Supplementary Order as a starting point. These documents are contained in Annex 4(d).

3.2 Geographic Scope

Regulation of the outflows of Lake Ontario affect water level conditions on the lake and the St. Lawrence River as far downstream as Lac St. Pierre near Trois-Rivières, Quebec. It should be noted that water level fluctuations downstream of Cornwall, Ontario - Massena, New York are also affected by actions taken at the other control works as well as natural factors.. The levels and flows of the St. Lawrence River in the vicinity of Montreal can also be significantly affected by discharges from the Ottawa River, particularly during the Ottawa River freshet. The Ottawa River Regulation Planning Board coordinates the Ottawa River discharges. These discharges can at times be as significant as the outflows from Lake Ontario. However, the Ottawa River is not under the jurisdiction of the IJC, and therefore no changes will be proposed to its management. The Ottawa River will be considered only in terms of its hydrologic effect when combined with the effect of Lake Ontario regulation at Montreal and downstream.

3.3 **The Necessity of Appropriate Data**

Recent work has generated extensive information on the perceived needs of various interests in relation to water level fluctuations. However, data in a form required to quantitatively analyze the effects of different outflow regulation criteria and plans on the interests are not yet available. Useful, representative information pertaining to the environment, wetland habitats, and shore property are key examples.

The Scope of Work document recommended that efforts be undertaken to address shortfalls in information regarding erosion, flood damage estimates and wetland inventories. Since that recommendation was made several studies have been initiated and may provide useful information in terms of redefining criteria for Lake Ontario. These include:

- Lower Great Lakes Erosion Study (LGLES) directed by the U.S. Army Corps of Engineers, Buffalo District
- Lake Michigan Flood Potential Study directed by the U.S. Army Corps of Engineers, Detroit District in terms of its development of a Great Lakes shoreline recession rate model
- Lake Ontario Lakewide Management Plan (LaMP) by the U.S. Environmental Protection Agency, Environment Canada, New York State Department of Environmental Conservation and Ontario Ministry of Natural Resources
- St. Lawrence River-Lake Ontario (SLRLO) Initiative by the New York Great Lakes Research Consortium.
- Studies as part of the St. Lawrence River Action Plan by Environment Canada.
- Studies regarding the St. Lawrence-FDR Power Project Relicensing application.

Also, on May 26, 1998, the Commission conducted a teleconference in order to identify groups that were involved in studies which might relate to revisions of Lake Ontario regulation criteria. An Ad Hoc Group was established as a result of the call, which considered an incremental approach for pursuing the Scope of Work for the Lake Ontario-St. Lawrence River System. Six sub-groups were formed: environmental, recreational boating, erosion, damages, climate change/variability and water level/flow modeling. Each of the sub-groups provided information to the IJC and an Ad Hoc Group meeting to assess overall progress was held with the Commission in Ottawa on November 16, 1998.

In its April 15, 1999 letter to governments, the Commission concluded that the Scope of Work cannot be executed incrementally and thus has initiated the work outlined in this Plan of Study. However, information and data generated by the Ad Hoc Group will be incorporated into this more extensive effort as appropriate.

4. COORDINATION OF COMMON ELEMENTS BY THE STUDY BOARD

4.1 Direct and Coordinate Work of Study Teams

Given the multi-disciplinary nature of the study, it is proposed a Study Board be set-up to direct the work of the study teams. The Board's main duty is to ensure that the study remains focused and aims to address the questions raised in the IJC's Directive. The board would be composed of an equal number of members from Canada and the United States who would be appointed by the Commission to serve in their personal and professional capacities. The study teams and other groups associated with the study would also be composed of an equal number of members from Canada and the United States who would serve the Commission in their personal and professional capacities. Members of these teams and groups would be appointed by the board, with the approval of the Commission. The authority and tasks of the board would include:

a. Appoint appropriate study teams and approve work plans of the study teams.
b. Review and approve evaluation methods and data collection programs.
c. Oversee the work progress of study teams to ensure they are on schedule and to ensure that the work incorporates the ecosystem approach supported by the Commission.
d. Act as coordinator to ensure effective exchange of information among the study teams, and full use of studies or information from other sources.
e. Consult the St. Lawrence Board on Lake Ontario regulation and operating experience.
f. Conduct public meetings to gather information related to water level fluctuations.
g. Consult with experts on the subject of climate change and climate variability.
h. Propose a method of integrating the needs of all the various users including taking recreational boating and environmental needs into consideration respecting the requirements of the Boundary Waters Treaty and particularly its Article VIII.
i. Review and propose updated regulation criteria based on tasks above, while respecting the requirements of the Boundary Waters Treaty and particularly its Article VIII.
j. Recommend improvements to the Lake Ontario regulation plan.
k. Prepare progress reports and a final report to the International Joint Commission.

Participating agencies and organizations have stressed that they are unable to undertake a work program of these dimensions for the Commission without additional dedicated resources being made available. Each subject matter group contributing to this Plan of Study was therefore asked to ensure that they provided, as accurately as is possible at this early stage, an indication of the resources and time required for the work which they anticipate will be required. In addition, the magnitude and complexity of the studies and work outlined in this Plan is such as to require a full time manager in each country, the costs for which have been included in the overall Study Management figures (refer to Table 8).

4.2 **Common Data Needs**

4.2.1 Topographic and Bathymetric Data

Complete topographic/bathymetric data are required to properly assess the impacts of various water level scenarios on wetlands and assess the relationships between topography, water circulation, plant communities, and key organisms using key habitats. The wetlands/environmental interest group requires these data for the site locations chosen for study along the shores of Lake Ontario and the St. Lawrence River. In some cases, such as the shallow shoreline areas of the St. Lawrence River, there are no existing bathymetric charts because these areas are not used for marine navigation.
Topographic and bathymetric data are also required to properly predict the impacts of various water level scenarios on the coastal zone interests. Models to accurately predict erosion and flooding along the coastal zone of Lake Ontario and the St. Lawrence River will be developed, but accurate topographic and bathymetric data are an essential data input requirement.

Airborne laser mapping systems provide unprecedented potential for the mapping of coastal topography and bathymetry. Studies have been conducted by various agencies in the U.S., including the USGS Center for Coastal Geology, NASA, NOAA and the U.S. Army Corps of Engineers to test laser mapping systems for measuring nearshore bathymetry, bottom environments, and coastal topography. Similar work has been carried out in Canada by the Canadian Hydrographic Service of the Department of Fisheries and Oceans and the Canada Centre for Remote Sensing. Airborne laser systems are a state-of-the-art advancement in coastal survey technology. The helicopter or fixed-wing airplane mounted systems use Light Detection And Ranging (LIDAR) technology to collect bathymetric data in the coastal zone. Using this technology, such systems can rapidly perform hydrographic and topographic surveys over large areas, far exceeding the capabilities and efficiency of traditional survey methods.

The entire shoreline (Canada and U.S.) for the study area covering Lake Ontario and the St. Lawrence River to Trois-Rivières totals 4350 km (2610 miles). The required resolution is ± 25 cm vertical and ± 1 m horizontal resolution. An estimated **$ 1 million U.S.** is required to collect topographic and bathymetric data for the entire shoreline (Canada and U.S.) using an airborne laser system where appropriate. This could be split equally between Canada and the U.S. **($500 K U.S. and approximately $700 K Cdn).** This data collection exercise should take place during the **first year** of the study. This is a separate item and is not included in any other section of this Plan of Study, but is captured in Table 8.

4.2.2 Digital Elevation Model

Topographic and bathymetric data will be used to develop Digital Elevation Models (DEM) for the shoreline of Lake Ontario and the St. Lawrence River using a Geographic Information System (GIS). The DEM will be used in the modeling process for predicting impacts to the coastal zone and wetlands from various water level scenarios on a lakewide/riverwide basis. The DEM will also be valuable to the Recreational Boating impacts assessment. The

development and funding of the DEM is included in the Coastal Zone interests section of this Plan of Study.

4.2.3 Hydrodynamic Models

Computer simulations of water levels and flows of the Great Lakes - St. Lawrence River system downstream to Trois-Rivières are essential to the evaluation of Lake Ontario regulation plans, the practicality of proposed criteria, and understanding the impacts on the interests. The development and costing of these simulation models are covered in Section 7.0 of this Plan of Study.

4.3 **Climate Change**

Climate changes of the past have been shown to affect the Great Lakes in a dramatic fashion. Indeed the present Great Lakes were formed as a result of glacial and post-glacial events brought on by changing climate. Recent studies into the paleo record of the Great Lakes suggests that the lakes have indeed been much higher and much lower than during the past century of record (Thompson and Baedke, 1997; Sellinger and Quinn, 1999). Natural climatic variability will almost certainly result in future extreme high and low water supplies to the lakes.

Global warming associated with the enhanced greenhouse effect, will potentially cause further changes to the hydrology of the Great Lakes system, and the latest studies in this area will need to be reviewed. Most advanced computer models currently predict that projected climate change conditions in this region could cause a significant drop in water levels and flows throughout the Great Lakes-St. Lawrence system. Work by the Great Lakes Environmental Research Lab (GLERL) and Environment Canada for a recent study prepared for the International Joint Commission estimates the total water supply to Lake Ontario to decline by about 25% under the transient scenario which is expected to be reached by 2050. A change of such magnitude in the water supplies to Lake Ontario would make the existing regulation plan obsolete. Depending on how the outflows from Lake Ontario were regulated with these much lower supplies, climate change could lead to a decline in the lake's mean level in the order of 0.6 m (2 feet) and a reduction in the mean level of the St. Lawrence River at Montreal of 1 m (3 feet).

Significant changes to the long-term water supply to Lake Ontario would have impacts on all of the interests on Lake Ontario and the St. Lawrence River. Climate change that resulted in decreased water supplies could cause lower levels, expose sediments, and result in an increase in emergent vegetation. Low levels for extended periods could also have serious impacts on fish access to wetlands and other critical habitats. Considerably lower flows in the St. Lawrence River would have major impacts on the ecosystem from Montreal downstream. Changes in supply that lead to substantially lower levels will have significant impacts on virtually every interest in the Lake Ontario/St. Lawrence River system.

4.4 **Mitigating/Alternative Measures**

In some cases, structural and non-structural measures taken at the local area may be superior to further regulation of the levels and outflows of the Great Lakes. In this study, the Board will identify and suggest the kinds of measures that may be feasible. It is proposed that measures, such as the following, be examined:

a. Dredging and other improvements to alleviate low water level problems at commercial docks or marinas.
b. Proper land use management at the local government level to reduce flood and erosion damage.
c. Possible improvements to St. Lawrence River ice management techniques.
d. Dredging and other measures to resolve navigation problems associated with high and low water levels/flows.
e. Measures home-owners, industries and municipalities can take to enhance the reliability of intakes and shore-wells affected by water level fluctuations.

As was recommended in the Commission's December 1993 report to the governments on the work of the Levels Reference Study Board, efforts toward prudent shoreline management practices at all levels of government will be encouraged.

4.5 **Review of Regulation Criteria**

4.5.1 Basis of Current Criteria

Since 1960 when Lake Ontario regulation began, there have been a number of studies which attempted to improve Lake Ontario regulation. For example, in 1980, the International St. Lawrence River Board of Control completed a study and found that the use of Regulation Plan 1958-D in conjunction with the discretionary authority remains the best way to operate the project. Several other studies followed including those during the Levels Reference Study (1986-1993), and more recently by the St. Lawrence Board which developed Plan 35P (Plan1998). All these studies were carried out assuming no changes or additions to the IJC's regulation criteria. An understanding of the development of the criteria and other requirements specified in the IJC Orders is a pre-requisite to any review and changes to the regulation criteria.

A review of the current IJC regulation criteria would include:

a. Events leading to the issuing of the regulation criteria by the IJC in 1956. This includes: prior studies and field work, factors governing project designs and channel improvements in the international section of the St. Lawrence River, public meetings held by IJC, and government consultations.

b. A review of the 1909 Boundary Waters Treaty and other agreements between Canada and the United States governing levels and flows on the Lake Ontario-St. Lawrence River system.
c. A review of the application of the criteria in actual operations since Lake Ontario regulation began in 1960, including the use of the "Discretionary Authority" granted by the Commission.
d. Determining whether changing conditions have rendered any of the criteria obsolete, or requiring updating.

4.5.2 Evaluate and Update Criteria

The existing regulation criteria will be updated, if appropriate, to meet the needs of all the various users in the system. Emphasis will be placed on the potential to add criteria for recreational boating and environmental interests. Since the needs of the users are different and divergent, and methods to measure water level impacts are also different, guiding principles will be required to facilitate fair and equitable evaluation. These will include:

a. Suitability and consistency with the principles and objectives of the Boundary Waters Treaty (and particularly Article VIII of the Treaty), and other bilateral agreements.
b. Feasibility of the regulation criteria and regulation plan, under the defined supply scenarios.
c. Acceptability of the regulation plan by the interests along with acceptability of the costs (i.e. is it worth the cost?)
d. Rather than simply considering non-monetary evaluations, equal weight will be given to monetary and non-monetary means of evaluation, where appropriate..
e. Such other principles as may be provided by the Commission to the Study Board.

The above guidelines form the basis of a generally-accepted method of integrating the interests, and have been applied in earlier reviews. However, since the needs and preferences of the various interests are different and at times in opposition, development of a more comprehensive set of criteria and a matching regulation plan satisfying all the interests will not be a simple task. There is a need to demonstrate what levels and flows are physically possible with the current physical regulatory works and channels, through simulation of regulation for the wide range of possible hydrologic conditions. An understanding of the reality and practicability of certain level or flow conditions could help promote better dialogue amongst the interest groups and the acceptance of the needs of others and the eventual needed compromise among the groups. It will be important that all interested parties appreciate that, within the constraints of the existing works and historic supplies, it is highly unlikely that any new regulatory plan will be able to provide significant additional benefits to every interest group.

4.6 **Process Management and Integration of Work**

It is anticipated that one of the first actions of the Study Board outlined in 4.1 will be to establish specific work groups which will be responsible for common data collection, as outlined in

section 4.2 above, using the available expertise of the two nations and allocating resources accordingly. For example, the Canadian Hydrographic Service and U.S. Army Corp of Engineers will likely be requested to jointly plan and execute a coordinated topographic and bathymetric survey and data catalogue program. This work must begin at an early stage of the overall project, so as to ensure that the necessary data is available to others as the overall work plan proceeds. As is recommended in Part 5, early public involvement will also be critical, and the "Interests Advisory Group" would be established at an early date as well.

Study Teams will also be created for each of the "interests" identified in Part 6 of this Plan, in each case comprising a binational team from the various agencies with participation, as a minimum, of the groups listed in Annex 1. Scheduling of their work will need to be coordinated through the Study Board. In some cases, such as for "wetlands and environmental interests", the view of the subject matter experts is that a data collection phase of a full four to five years is necessary, so work would need to start almost immediately upon overall project approval and funding, and would continue throughout. Other groups, such as "commercial navigation" will require some early data collection, followed by analysis of the potential impacts of changed regulation criteria or plans as these become available, while still other groups such as "hydroelectric power" already believe they have adequate baseline data, and would concentrate their effort on understanding the potential impacts of changed or new criteria once these are proposed.

It will be the task of the overall Study Board, with input from each Study Team and the Interest Advisory Group outlined in Section 5.1, to then consider the differing outputs of each study area and bring these together in a coherent manner that allows for public discussion of the impacts and benefits of various regulation plans and criteria, always having in mind the priorities already established under Article VIII of the Boundary Waters Treaty. Given the considerable cost of the overall Plan of Study activities, the Study Board will also need to ensure that duplication of effort is minimized, and data collected is made widely available across all teams.

The Study Board will also need to satisfy itself that each Study Team is carrying out the required work in a satisfactory manner, and that cross – interest impacts have also been considered. Each interest needs to define what benefits or impacts have resulted from regulation of the Lake Ontario – St. Lawrence River system. And each study program outlined in Part 6 will need to evaluate how criteria which might be proposed to facilitate or benefit a specific interest group would benefit or impact on other interests.

The evaluation process will be an iterative one, beginning early on in the study process and continuing to its completion. It will involve the development and refinement of an evaluation methodology, workshops, public meetings, regulation plan development and testing. It is expected that the last two years of this study will concentrate heavily on the development of criteria and an acceptable regulation plan. The challenge will be to develop criteria and regulation plans that recognize the interests of all groups, and which create improved benefits for some without significant negative impacts on others. A decision support methodology specific to this situation will need to be developed as a part of the proposed studies which recognizes the

complexity of the impact and benefit distribution challenge inherent in regulation of the Lake Ontario - St. Lawrence system. The limitations of the Treaty, and constraints of the existing Orders of the Commission will also need to be taken into account. The Study Board will explore new methods and techniques and will develop and implement appropriate decision-support algorithms, through the use of tools such as the Analytic Hierarchy Process, the Policy Delphi process, or Multi Attribute Utility Analysis (e.g. Golden et al., 1989, Saaty, 1994). The costs of the work described in this section is covered under "Interrelations Review" in Table 8.

It will be important that all interested parties appreciate that the Study is not expected to be simply one of adding one or two regulation criteria. Since the needs of the users are different and divergent, conflicts among the criteria will invariably surface. As noted earlier, the challenge of the study is to promote understanding and acceptance of what is feasible given current institutional arrangements and control facilities. The process leading to the proposed criteria will include iterations in defining possible criteria, meeting with user groups, and meetings with the Commission, which may itself undertake in turn consultations with governments, as was the case during the 1950s.

As described in Section 7.5, it is likely that a number of trial regulation plans will need to be developed and considered by the Study Board so as to allow the effects of any new or revised criteria to be described in a manner which the Interest Advisory Group, general public, and the Commission can fully appreciate. While criteria may be stated in a number of ways, including upper and lower limits of level or flow, or restrictions on the frequency of exceeding certain conditions, their impacts can only be appreciated once they are used to frame a new regulation plan, the outcome of which can then be tested using historic data so as to allow comparisons against previous experience. The costs of this work is contained within the various components of the "Hydrologic Model and Evaluations" as shown in Table 7.

Upon completion of this work, the Study Board, again with input of the subject matter experts for each interest (the Study Teams,) the Interest Advisory Group, and the general public, will then report to the Commission regarding the work carried out, its recommendations on any amendments or additions to the present criteria, and the recommended regulation plan to give effect to these criteria. The Commission, in turn, may wish to hold further public consultations prior to any decision to adopt, or otherwise, the Study Board's recommendations.

4.7 **Progress Reports and Meetings**

It is proposed that the Study Board will meet twice a year to evaluate progress. Each of the Committees evaluating interests will meet more frequently and provide monthly status reports to the Study Board. Progress reports will be provided to the IJC on a semi-annual basis. The Study Chairmen will also be available to brief the IJC at their semi-annual hearings in Washington and Ottawa.

5. **PUBLIC INVOLVEMENT**

Public consultation is critical to the assessment of plan criteria. It is recognized that progress in addressing water levels issues is dependent in large part on public understanding of the causes of the water level problems, and the further understanding that most proposed solutions could have consequences for others. To achieve this understanding, it is recommended that the major interests and the relevant public be involved directly in the studies. This would allow individuals with diverse interests to find common ground on many aspects of the issues.

The continuous involvement of all interests throughout the criteria review process is critical to the success of the study. The study must be seen as being open, inclusive and fair. Regardless of the results of the study, the foundation for success will be laid only through effective two-way communication between governments and the users of the Lake Ontario-St. Lawrence River system. A key principle underlying the success of the studies is that the people of the basin need to be involved in a process for developing actions that will directly or indirectly affect them.

5.1 **Interest Advisory Group (IAG)**

An Interest Advisory Group (IAG) will be established to participate in the entire study process. The Group will have membership on each of the committees, and thereby have significant influence upon the direction of the study.

The Group will include members representing each of the interests, with representatives chosen through their affiliation, including, but not limited to:

- Riparian/ shore property - Lake Ontario
- Riparian/ shore property - St. Lawrence River
- Commercial navigation – Great Lakes/Seaway
- Commercial Navigation – St. Lawrence River Ports (seagoing traffic)
- Hydropower
- Recreational boating - Lake Ontario
- Recreational boating - St. Lawrence River
- Environmental - Lake Ontario
- Environmental - St. Lawrence River
- Fisheries
- First Nations
- Municipal intakes - Lake Ontario
- Municipal intakes – St. Lawrence River
- Others as appropriate

Due to the multiple facets of each of these interest groups, members of the Group are expected

to assist, through their own local contacts, with other public involvement efforts. Each may consist of subgroups that include representatives from both countries and various localities.

It is critical that the Public Consultation/Participation process begin early in the formulation of the final terms of reference for individual studies and continue throughout the process. The IAG should be established at the very start and should meet quarterly as a minimum.

Individual members of the Group should participate in each of the POS component investigations (Wetlands/Environment, Rec. Boating, Coastal Zone, etc.). These individuals would provide input on the study plans, be updated on progress/results, and review and comment on final reports and recommendations. They should participate at the front table at all public presentations of the study component results.

5.2 **Outreach to Government Officials**

A distinct and separate effort should be directed toward important/interested government officials and their staff. This effort should begin early and be continuous throughout the studies. Key contacts should be identified and 'kept in the loop'.

5.3 **Information Programs**

Public information and education efforts will be extremely important to the success of the studies. Public outreach must be mounted through different means such as Public Meetings, Open Houses, Workshops, Appearances at relevant meetings hosted by other organizations, Newsletters, and the Internet.

A separate Web page will be established and maintained for the POS effort. The Web page will have a section for comments/questions and someone must be tasked with posting responses to all questions within a day or two. The Web page will have separate sections for the component studies including project descriptions, participant listings, working documents and any progress/results summaries.

An education program will be implemented during the study regarding the causes of level changes and the actions that can be taken to adapt to the ever changing conditions of the Lake Ontario-St. Lawrence River system.

A Newsletter will be published and widely mailed on at least a semi-annual basis describing the on-going studies and their progress. A circulation list would have to be derived and continually updated. Lists similar to those used in the 1993 Levels Reference Study could be updated for this purpose. This Newsletter will also go to media outlets with news releases highlighting any interesting developments.

A wrap-up conference or symposium, with published proceedings, would be desirable during or at the end of the process wherein the results of all the underlying scientific studies are detailed/presented. The IAG will be invited to assist in proposing concepts for the organization of the symposium and would be invited to have separate sessions regarding recommendations, actions for implementation, etc.

5.4 **Costs and Schedule**

At a minimum, there should be full-time Public Relations positions for each country. These staff would work full time on writing newsletters, responding to correspondence and arranging for meetings with the public. There would be coordination and communications with government contacts and initiatives around symposia and media contacts.

Table 1. Cost Estimate for Public Involvement

Estimated costs (per year)	**U.S. ($K)**	**Cdn ($K)**
2 staff at $100,000 each including overhead	100	100
Newsletters (2 per year)	18	18
Public Meetings/ Open Houses (at least 8)	50	75
Workshops (2 per year)	25	38
Web site, per year	10	15
Out of pocket costs for IAG members (20 members, 4 meetings, airfare, hotel, etc.)	40	60
Contingency	27	34
Total per year	270	340
Symposium (last year)	50	75
Total for the Studies (over 5 years)	**1400**	**1775**

6. SPECIFIC STUDIES AND EVALUATIONS OF INTERESTS

The following sections describe each of the interests that will be investigated. For each interest, a course of action is described and the agencies that will be asked to participate are identified. Approximate schedules are outlined along with cost estimates. A list of those who contributed to the detailed evaluations, which follow, is contained in Annex 5.

6.1 Wetland/Environmental Interests

6.1.1 Relationship to Water level Fluctuations

Water level fluctuations are a natural phenomenon in the Great Lakes due to natural climatic variability. For example, over the past 3000 years, Lake Michigan was less than half its current size during the mid-Holocene warming period about 8000 years ago and over the past 3000 years has seen extreme high and low lake levels approximately every 150 years (Thompson and Baedke, 1997). Outflows through the St. Lawrence River are also affected by water supplies from the lakes, and water levels in the river thus experience natural variation. The biological communities of the Great Lakes and the St. Lawrence River have, by necessity, evolved to adapt to the range of water levels and water level changes that occur on several scales, ranging from wind-driven tides or seiches that can occur several times daily, to seasonal changes each year, to longer episodes.

The biological effects of water level fluctuations in both lake and river are greatest in shallow water where even small changes in water level can result in conversion of a standing water environment to an environment in which sediments are exposed to the air, or vice versa. The localized effects of this change in the environment are most evident in the relatively immobile plant communities that occur in wetlands. In fact, the patterns of water level change are the driving force that determines the overall diversity and condition of wetland plant communities and the habitats they provide for a multitude of invertebrates, amphibians, reptiles, fish, birds, and mammals.

Due to Lake Ontario regulation, the extreme high water levels during the high water supply periods have been lowered, and the low levels during the very dry periods raised. As a result, shrubs and upland plants become established in the wet soils above the water line, canopy-dominating larger plants such as cattails crowd out other emergent plant species in shallow water, and a few competitive submersed species dominate in slightly deeper water. High water levels kill many of the shrubs and invading upland plant species; they also kill many cattails and other canopy-dominating shallow water emergents. When water levels recede, the bare sediments are exposed to the air, and the seeds of many other emergent plants are able to germinate and grow. The dominating species also grow from seed and eventually regain dominance, but the diversity of habitat provided by a diverse plant community remains for a number of years, and the plants are able to complete their life cycles and replenish the seed

bank, awaiting the next cycle of high and low water levels. Extreme low water levels expose deeper nearshore areas to the air and kill the competitive submersed plant species; emergent plants grow from the exposed seed bank. When water levels go up again, many of the emergent species eventually die, a variety of submersed plants returns, and the competitive submersed species eventually dominate again, but habitat diversity for fish and other aquatic fauna has been increased for a number of years and the cycle of wetland rejuvenation has been repeated again. (Working Committee 2, 1993)

Variations in the seasonality of water level fluctuations (winter drying, winter flooding, lack of spring flooding), which are especially applicable to the St. Lawrence River, modify wetland species composition, abundance, and distribution. Such erratic variability is likely detrimental to wetlands, especially when water levels change in a rapid, unpredictable sequence.

Water level changes have seasonal implications for fauna that extend beyond the habitat provided by a diverse plant community. Access to habitat used by fish for spawning, adult-feeding, and rearing of juveniles may be precluded by low water levels, especially in early spring. Use of wetlands as staging areas for waterfowl may be precluded by low water levels in the spring or fall. Low water levels in the winter may restrict use of wetlands by muskrats. Although occasional low water levels may restrict fish access and wetland use by wildlife in some years, this is a natural condition that has historically resulted in differences in year-class strength and natural population dynamics. The occasional low water levels also improve habitat. However, if seasonal water levels are low every year and do not allow access to or use of critical habitat at the required time, an overall decrease in population will eventually result for all wetland-dependent species.

Changes in water levels and flows also affect fauna in open-water, fast-flowing habitats of the St. Lawrence River. These include impacts to fast-water spawning grounds resulting from siltation of gravel beds under reduced current velocities and spring flushing. Changes in water circulation, speed of currents, water-renewal time, and retention areas may also exert strong effects on the components of the pelagic zone (phytoplanktonic algae, zooplankton, and larval fish). The propagation and transmission of aquatic parasites through the food chain to fish and birds could be enhanced by low current-discharge conditions. Settlement and recruitment of zebra mussels is also favored under low current-discharge conditions. Reduction in current may also alter drift of larval and juvenile fish such as sturgeon, which rely on currents to reach to their rearing habitats.

6.1.2 Past Studies

Field studies conducted under the direction of the Natural Resources Task Group of Working Committee 2 of the IJC Levels Reference Study concluded that different wetland plant communities have developed at different topographic elevations in Lake Ontario in response to water level history. Plant communities at a higher elevation that had not been flooded since 1952 were dominated by grasses, old field plants, and shrubs; over half of the taxa growing at that elevation were upland species. Plant communities at a lower elevation that had not been

dewatered since 1964 had the lowest species richness and were dominated by several submersed species. At elevations that were alternately flooded and dewatered on a more frequent basis, species richness of wetland taxa was greatest. However, many of the dominant taxa across all elevations were introduced species (exotics) or otherwise considered undesirable because of invasive, weed-like habits. The lack of high lake levels in recent years was cited as the likely cause for dominance by invasive emergent taxa; the lack of low lake levels was the likely cause for dominance of submersed species. Altered seasonality of water level changes was also noted (i.e., exaggerated wintertime drawdowns resulting in springtime water levels too low to flood wetlands) and cited as a deterrent to fish access to wetlands for spawning in the spring.

The Natural Resources Task Group sought to develop a draft regulation plan for Lake Ontario that increased the frequency and amplitude of high and low lake levels to more closely approximate natural conditions and thus reduce environmental impacts of regulation. A preliminary recommendation for accomplishing this task was developed based on pre-regulation lake level variability. Modeling of this regulation plan was based on actual past inflows and resulted in modeled lake levels in several years in the 1970s and 1980s that would likely be considered unacceptable by other interests. Therefore, another preliminary recommendation was developed that used the highest and lowest lake level constraints of the current regulation plan but added more variability in water levels between years. When potential responses of wetland plant communities to this proposed plan were compared with other regulation plans under evaluation, the proposed plan showed some improvement in increasing the area of wetland subjected to both flooding and dewatering conditions and thus increased habitat diversity. However, development and testing of this plan was based on biological and topographic data collection at a limited number of actual field sites. In addition, the required frequency of high and low water level events was determined from the modern record, which is too short to show long-term trends. The development process for the plan was also unable to address the seasonality problem, in which many wetlands remain dewatered during the critical seasons when they are used by fish and wildlife, because the topography information was not suited to the task.

Previous studies of Lake Ontario resources and problem areas have led to the development and implementation of Remedial Action Plans, some of which (Cornwall, Bay of Quinte, Hamilton Harbour) address specific concerns over the impacts of fluctuations of water levels on wetlands and other restoration projects. St. Lawrence River and Great Lakes Action Plans comprise a number of studies that provide background environmental information that could be used to address the issue of environmental impacts of water level fluctuations, including limnological characteristics, a detailed inventory of the shorelines of the St. Lawrence that characterizes riparian habitats, and a regional atlas of sensitive zones of the St. Lawrence River corridor for the sector between Cornwall and the Gulf of St. Lawrence. Pertinent information may also be found on various environmental aspects (habitats, fish, wildfowl) in the reports released for the St. Lawrence-FDR Power project Relicensing application. The seasonal habitats requirements of many species of fish, wildfowl and mammals relying on lacustrine wetlands and fast-flowing riverine habitats for different parts of their life cycle can be documented from studies carried out

either directly within the Great Lakes-St. Lawrence Basin or indirectly derived from studies in neighboring basins.

6.1.3 New Study Scope, Data Collection Needs and Evaluation Methods

Studies required to determine the effects of past water level regulation on biological organisms and their habitats, water-depth and water-flow needs of plants, fish, and wildlife, and the potential effects of proposed new regulation plans on biota and habitat are similar on Lake Ontario, the international portion of the St. Lawrence River, and the lower St. Lawrence River. They will be approached in a similar manner in all regions. However, although similar in many respects, the specific requirements of the studies differ for the regulated water levels above the dam at Cornwall and the regulated levels and flows of the lower St. Lawrence River because they represent different types of ecosystems. Therefore, specific details of recommended studies are provided in separate subsections below for regions above and below the dam.

All Regions

In all regions, the important concerns relating to water level fluctuations are the seasonality of water levels, the range in amplitude of water levels across multiple decades, and the frequency of high and low water level events. The most important feature of water level fluctuations in shallow water areas is the resultant change in water depth, which is determined by lake or river level coupled with bathymetric and topographic data. Thus, a primary need in all regions is bathymetric and topographic maps with close contour intervals. Acquisition of these maps was addressed in Section 4.2 of this POS titled Common Data Needs, although additional detailed data collection will be required for wetland study sites in all regions. The composition and diversity of wetland plant communities in the lake and river will be studied in the field and correlated with changes in water depth through time to allow modeling and prediction of the effects of different water level fluctuation patterns on wetland habitat. The accessibility and availability of useful habitat for important fish, waterbirds, and mammals will be evaluated in both lake and river also. Critical aspects of this work are surveying the elevations of access routes between wetlands and the lake or river to identify water levels required to allow wetland access, gathering existing data on fish and wildlife use of study wetlands, searching the literature for information on the seasonal water-depth and habitat needs of various species, and evaluating the potential availability of those depths and habitats using the bathymetric/topographic data and plant community analyses.

The faunal studies will largely address the seasonality requirements of water levels. Wetland plant studies will address the multi-decadal range of water levels required to sustain viable wetland habitats. The required frequency of high and low water years across multi-decadal periods will be determined by using geological techniques to produce a long-term lake level curve for Lake Ontario. That long-term water level history can then be applied to flow characteristics in the St. Lawrence River to provide information on the natural variability of water levels and flows in the river. The influence of hydrology on wetlands has two components, amplitude and frequency. The long-term water level history is critical because it

identifies the characteristics of both components that resulted in naturally sustaining wetland communities in Lake Ontario and provides the basis for recommendations on the optimal conditions that would best maintain diverse wetland habitats and associated biological communities.

The results of the studies described above will be used to formulate water level-regulation scenarios that best meet the needs of the affected biological communities in both Lake Ontario and the St. Lawrence River in terms of amplitude, frequency, and habitat access and use. Since lake and river habitats and communities differ, their optimal scenarios may differ. Releases of water from Lake Ontario will largely dictate conditions below the dam on the St. Lawrence River; releases that are optimal for one side of the dam may not be optimal for the other side. Therefore, lake and river study teams will coordinate efforts in scenario development to generate options that can best meet the needs of both lake and river without deleterious effects on the other. This effort will require considerable assistance in hydrodynamic modeling, which is also discussed in Section 7.0 titled Hydrologic and Hydraulic Evaluation.

In addition to scenario development, the results of the studies will be used to create models for use in evaluating scenarios proposed by other interests. These models will include reference to seasonality of water level changes as required by fish and wildlife, to the amplitude of water level fluctuations that result in habitat development, and to the frequency of high and low water level/water-flow events that determine cycling of habitat changes and result in habitat diversity.

a) Lake Ontario and International Portion of the St. Lawrence River

Information needs required to assist in development of refined criteria and a new regulation plan for Lake Ontario and portions of the St. Lawrence River above the dam at Cornwall must be centered on collection of more thorough topographic/bathymetric data at an increased number of wetland sites, concurrent collection of plant community data to reflect changes that have occurred since the Levels Reference Study data collection in 1991, collection of data relating to fish, waterbird, and mammal accessibility to and use of wetland habitat, and development of a long-term lake level record that defines the natural variability and frequency of changes in water levels, thus forming the foundation for understanding the conditions under which natural systems developed and can best be sustained. Site selection for study of modern wetlands will be based on several factors: wetlands protected from wave attack by barrier beaches or in river mouths, thus retaining organic sediments and developing a flatter topographic profile; wetlands exposed to wave attack, thus having predominantly inorganic sediments and a steeper topographic profile; wetlands identified as potentially critical spawning habitat for fish such as northern pike that enter wetlands in early spring; wetlands used as major staging areas for waterfowl or as feeding areas for shorebirds; wetlands historically used by muskrats during winter; wetlands without obvious signs of other human disturbances; and, to the extent possible, wetlands distributed geographically around the lake and in the international portion of the river.

Topographic data collection will consist of developing detailed maps of small wetlands or representative portions of larger wetlands and, in the case of barrier-beach-protected wetlands

and shallow river-mouth wetlands, will include the topography/bathymetry of that portion of the wetland where hydrologic connection is made with the lake and fish access becomes critical. Plant community data will be collected by sampling along topographic contours that represent different flooding/dewatering histories associated with past lake level changes. Fish, waterbird, and mammal habitat requirements will be researched from existing literature, and available data sets on actual wetland use by those biological communities will be retrieved from cooperating federal, state, and provincial resource agencies. If critical data are not available, limited field data collections will be conducted.

Proposed new regulation plans that would benefit wetlands will be based on these data and evaluations of the amplitude and frequency of water level changes derived from long-term lake level studies. The potential response of wetland vegetation and associated habitat in Lake Ontario and the international portion of the St. Lawrence River to all new proposed regulation plans will be evaluated for both the protected/organic and the exposed/inorganic wetland types. These evaluations will be based on data that show the past response of plant communities at specific elevations to changes in lake level, which will then be overlaid on topographic/bathymetric models that allow potential distributions of plant communities to be weighted by the area encompassed by various water-depth intervals.

Seasonality of water level patterns in proposed regulation plans will be evaluated based on fish-access data derived from topographic/bathymetric surveys and area of wetland with suitable water depths for staging waterfowl, feeding shorebirds, or overwintering muskrats, each in the appropriate season. These data will be incorporated into the topographic/bathymetric model.

Reconstruction of long-term lake levels for Lake Ontario requires the collection of information that indicates past elevation of the lake and the time that the lake was at that elevation. These data may be from sites that are above water or below water. The rebound history of Lake Ontario resulting from melting of glaciers long ago is such that most of the lake level record is below water, although some above-water data exist as barrier beaches, spits, and beach ridges. Below-water data occur as sedimentary deposits in lagoons and drowned river mouths around the lake. Sediment cores will be collected to recover records of lake level history. The lake level signal within the deposits may be physical, biological, or chemical; the actual data needed vary between study sites. Data from above-water sources may consist of the elevation of specific sediments in old barrier beaches that define the lake level at the time the beach was formed; they may also be in the form of the elevation of fluvial terraces. Data from below-water sources may consist of the elevation of dateable horizons that contain indicators that can be used to approximate the water surface at the time of deposition. A long-term lake level study must collect data from several sites and use them to create individual "relative" water level curves for each site, which can then be combined by subtracting differences in rebound among sites. The result will be a lake level curve that indicates fluctuations observed at the outlet to the St. Lawrence River and long-term rates of rebound. This lake level curve will not only describe the high and low elevations of lake levels in the past, it will describe the frequencies at which Lake Ontario reached those elevations. The frequency information is required to define the timing of proposed high and low lake levels under all potential regulation plans that might benefit

wetlands. This issue will be of critical importance when all interests attempt to reach consensus on a new regulation plan. The long-term lake level curve will determine whether wetlands require periodic high and low lake levels approximately every 13 years as suggested by the modern record, every 30 years as suggested by the Lake Michigan/Huron lake level record, or perhaps some different interval. Both frequency and amplitude information will also provide important information on expected responses of lake level to future climate changes and should benefit other interests in their efforts to plan realistically for potential extreme high and low water level periods in the future.

b) Lower St. Lawrence River

Studies directly pertaining to the environmental components on the St. Lawrence River can be divided into three groups: littoral and riparian habitats (wetlands), pelagic zone habitats, and vertebrate fauna. The biological information gathered on each of these topics will be integrated with topographic-bathymetric-hydraulic information into a model allowing the response of each component to variations in water level and habitat components to be identified.

Wetlands are the areas in which the impacts are the most obvious, and they offer the greatest potential to integrate impacts on fish, amphibians, reptiles, wildfowl, and mammals; specific studies are warranted to examine critical aspects of certain species' life cycles. Wetland distribution and characteristics will be updated through the acquisition of recent remote sensing information (aerial photographs or satellite imagery) and validated with field surveys. Because submerged vegetation cannot be quantified adequately from aerial photographs, a model allowing prediction of distribution and biomass from a set of environmental variables (depth, transparency, etc.) is required. In conjunction with knowledge of the current and past distribution of wetlands obtained through aerial photographs and satellite imagery, topographic-bathymetric information and water level modeling will allow changes in surface area of riparian habitats subjected to different hydrologic regimes to be quantified. Field studies are required to determine the speed of recovery of emergent and submerged vegetation following cycles of drying and flooding, both in terms of species composition and biomass. Given the dynamic nature of fluvial hydrology and the large spatial and temporal variability of riverine wetlands, multi-year monitoring of permanent sites may be required to model the response of shoreline habitats to water level fluctuations, to assess the speed of recovery of the vegetation after episodes of flood or drought, and to document the mechanisms by which aquatic plant communities adapt to such variations. Existing monitoring surveys aimed at hydrology, water quality, fish communities, and other bio-physical indicators will be maintained since they provide a unique, long-term data series that allows past conditions to be investigated.

Impacts on open-water, fast-flowing habitats in the St. Lawrence River will be evaluated and forecast by studying the relationship between water circulation (current speed, water-renewal time) and phytoplanktonic production, biomass accumulation (algal blooms), and proliferation of blue green algae responsible for noxious smell and toxins. Similarly, the relationship between discharge and zebra mussel recruitment will be monitored to assess the discharge threshold and the critical period over which proliferation is to be expected. The effects of reduced water

circulation and lower current speed under low discharge on recruitment and habitat availability for open-water fish species such as sturgeon and walleye will be assessed. As with the information pertaining to riparian habitats, the interaction of biological information with physical characteristics of circulation will be documented by integration with a hydrodynamic model.

Certain species of vertebrate fauna (fish, wildfowl, and mammals) of particular interest (exploited, keystone, sensitive, or endangered species) may require specific studies to assess their individual responses to water level fluctuations, especially for those species that require complex combinations of seasonal flooding, temperature, and habitat requirements. The hydrologic conditions that are critical for different stages of species' life-history must be defined, including the seasonal timing, duration and frequency of flooding and dewatering of spawning, nesting, feeding, rearing, and overwintering habitats. The characteristics and locations of fish spawning and reproductive sites in the St. Lawrence River are known for a number of species; however, this information must be completed, assembled, and compared to other physical and biological data to quantify the availability (and vulnerability) of habitats for major fish assemblages. Complementary information on growth, migration patterns, and food-web processes will also be gathered, since these factors may also affect abundance, biomass, quality, and desirability of economically valuable species in the St. Lawrence River. Similar information will be assembled for waterfowl and mammals of particular interest. The surface area of habitat available for wildfowl under different water level scenarios, the carrying capacity of current habitats, and specific wildfowl requirements with respect to seasonal water levels will be assessed. This requires completion of information for each species and identification of keystone faunal assemblages for the St. Lawrence River. For each of these assemblages, habitat requirements will also be compared to current physical and biological conditions to locate and quantify the availability and vulnerability of habitats for vertebrate faunal assemblages.

The impacts of water level fluctuations on wetlands, open-water habitats, and vertebrate fauna will be quantified for different St. Lawrence River discharge scenarios, in order to assess the response of individual biological variables of interest. This will be achieved through the integration of biological and physical-environmental information using superimposition of multiple layers of information: bathymetry/topography, sediment composition, water circulation and currents, emergent and submerged aquatic plant distribution, biomass, and community types, and location of known spawning, nesting, and overwintering sites for given vertebrate species of particular interest. This requires major contributions from the information gathered under Section 7.0 (Hydrologic and Hydraulic Evaluation), especially since about 20% of the St. Lawrence River flow originates from the Ottawa River. Other physical-environmental data needs are described under the common data need section (section 4.2). Integration of biological data with physical data requires the organization of available biological information on a numerical, georeferenced basis at spatial and temporal scales that are mutually compatible and relevant to each variable. For this purpose, special emphasis will be placed on georeferenced information (aerial photographs, satellite imagery, georeferenced data bases), allowing the state of past and current resources to be mapped and superimposed on different types and levels of information through GIS applications at appropriate scales.

The next step lies in the elaboration of quantitative relationships (models) between given environmental and biological variables, allowing inference of the direction and magnitude of biological response to changes in discharge and water levels. For example, the topographic/bathymetric charts can be superimposed with maps of spawning grounds and bottom sediment composition. Water depth covering these areas over different critical periods for spawners can then be modeled from hydrologic information, thus allowing the sensitivity of known spawning sites and the availability of other potential spawning sites under various discharge scenarios to be assessed. Similar integration procedures will be used for other biological components to identify the water level/discharge conditions that maximize the surface area of wetlands, favor plant species and/or habitat diversity, maximize the surface area of different species' habitat for given (seasonal) life stages, or identify critical current conditions that minimize the proliferation of undesirable planktonic algae, parasites, and zebra mussel larvae.

6.1.4 Implications of Climate, Demographic, and Other Changes

In wetlands with wet soil and no standing water, the relative inputs of ground water will likely dictate water availability and the fate of the wetlands under climate-change conditions. Wetlands in basins restricted by steep adjacent uplands, offshore deep waters, or unsuitable substrate type will likely decrease in size; other wetlands in suitable settings might shift to lower elevations. Climate warming that resulted in decreased water supplies could force lower lake levels that have been absent from Lake Ontario since regulation began, expose sediments, and result in an increase in emergent vegetation. Low lake levels for extended periods could have serious impacts on fish access to wetlands and other critical habitats. In areas with extensive human development along the shore and armoring of the shoreline, the ability of wetland plant communities to shift position with respect to water depth would be restricted.

A lowering of freshwater flow and spring peak freshet flows in the St. Lawrence River and estuary would have major negative impacts on the ecosystem from Montreal downstream through the Gulf of St. Lawrence. The viability of the lower section of the river and the Gulf of St. Lawrence is highly dependent on the large freshwater inflow from upstream and the cyclical seasonal nature of this flow. If freshwater flow to the estuary were to be significantly reduced, upstream migration of the saltwater front and significant changes in freshwater-flow-induced currents in the lower river and Gulf of St. Lawrence would likely result and could be catastrophic to fisheries and current biological systems.

A reduction in water depth in the St. Lawrence River would result in greater pressure for additional channel dredging, which in turn would increase channelization effect, accentuate the hydraulic isolation (and the eventual drying up) of shallow areas, increase water temperature, plant biomass production, and local retention of organic matter. This would cause a further dewatering of valuable fish and wildlife habitat in the littoral areas, which are especially important in shallow fluvial lakes. These cumulative physical environmental modifications would markedly modify the surface area and the qualitative characteristics of fish and wildfowl habitats. Lower water levels would result in increased resuspension of shallow-water fluvial lakes and

riverine sediments, with consequent effects on turbidity and the resuspension of in-place pollutants, especially in navigation channels. Lower pollutant dilution and increased resuspension may result in exposure of organisms to higher levels of contaminants.

Demographic changes that result in increased shoreline development could affect the nearshore environment. When shoreline protection is constructed, natural sediment-transport processes are altered, and erosion of barrier beaches and other protected wetland environments increases. Increases in human populations can result in construction of new highways near the lakeshore or across the river floodplain. Where these highways cross riverine wetlands adjacent to the lake, flow restrictions under bridges or through culverts also disrupt sediment transport processes and can result in excessive siltation in the wetland. Encroachment can result in direct loss of nearshore environment and chemical contamination of that environment.

6.1.5 Optimal Conditions

Studies to date indicate that optimal water levels for maintaining diverse wetland habitats and associated biological communities should mimic the natural pattern of fluctuations as nearly as possible. The natural pattern will be quantified by development of a long-term lake level history for Lake Ontario that describes water level changes over the past several thousands of years, as has been done for lakes Michigan-Huron (Thompson and Baedke, 1997) and is underway for Lake Superior. This long-term history can then be compared with daily values for water levels under pre- and post-regulation regimes to generate information on expected flows in the St. Lawrence River upstream and downstream from or influenced by major tributaries (especially the Ottawa River, which produces an important seasonal signal).

6.1.6 Study Organizations, Costs, and Schedule

a) Lake Ontario and International Portion of the St. Lawrence River

The suggested leads for the Lake Ontario/international portion of the St. Lawrence River component are the U. S. Geological Survey, Great Lakes Science Center located in Ann Arbor, Michigan and Environment Canada, Ontario Region located in Toronto, Burlington, and Guelph, Ontario. Support will be provided by other agencies including Department of Fisheries and Oceans, Ontario Ministries of Environment and Energy and Natural Resources, U.S. Fish and Wildlife Service, U. S. Environmental Protection Agency, New York State Department of Environmental Conservation and other academic and environmental organizations. A listing of suggested agencies is given in Annex 1.

Table 2a gives a breakdown of costs in U. S. dollars for U. S. participation in evaluating Lake Ontario/international portion of the St. Lawrence River components.

Table 2a. Time and Cost Estimate - Wetland and Environmental Studies (U.S. $K)

Major Tasks	YR1	YR2	YR3	YR4	YR5	Total
Develop detailed plan	40					40
Historic aerial photographs	15					15
Study site selection	15					15
New aerial photography	50					50
Supplies and materials	15	5	5	5	5	35
Topographic surveys	280	30	30			340
Vegetation studies	55	160	100	30		345
Fish and wildlife studies	30	90	90	50		260
Long-term lake level studies	70	120	120	120		430
GIS component	45	80	80	80	50	335
Model development/calibration		20	80	90	20	210
Development and testing of scenarios			20	30	40	90
Report preparation	10	10	15	15	50	100
Coordination & project mgmt.	15	25	35	55	55	185
Total	**640**	**540**	**575**	**475**	**220**	**2450**

Table 2b gives a breakdown of costs in Canadian dollars for Canadian participation in evaluating Lake Ontario/international portion of the St. Lawrence River components.

Table 2b. Time and Cost Estimate-Wetland and Environmental Studies (Cdn. $K)

Major Tasks	YR1	YR2	YR3	YR4	YR5	Total
Develop detailed plan	50					50
Historic aerial photographs	15					15
Study site selection	10					10
New aerial photography	50					50
Supplies and materials	10	5	5	5	5	30
Topographic surveys	150	25	25			200
Vegetation studies	10	80	10			100
Fish and wildlife studies	20	30	30	20		100
GIS component	10	20	30	30	10	100
Model development/calibration		10	40	40	10	100
Development and testing of scenarios			10	30	30	70
Report preparation	10	10	15	15	50	100
Coordination & project mgmt.	20	40	30	30	30	150
Total	**355**	**220**	**195**	**170**	**135**	**1075**

b) Lower St. Lawrence River

The suggested lead for the lower St. Lawrence River component is Environment Canada, Quebec Region-Centre Saint-Laurent located in Montreal, Quebec with support from the Ministère de l'Environnement and Faune et Parcs Québec along with other academic and environmental organizations.

Table 2c gives the breakdown of costs for evaluation the lower St. Lawrence River component in Canadian dollars.

Table 2c. Time and Cost Estimate-Wetland and Environmental Studies for the lower St. Lawrence River (Cdn $K)

Major Tasks	**YR1**	**YR2**	**YR3**	**YR4**	**YR5**	**Total**
Biological data update, acquisition and analyses:						
Wetlands and vegetation studies	300	400	450	500	475	2125
Fish recruitment studies	30	60	85	100	100	375
Adult fish studies	30	60	75	75	60	300
Wildlife studies	90	90	100	90	90	460
Integration of biological & physical-bathymetric data (GIS-based)	50	75	100	100	25	350
Model development/calibration and testing of scenarios	10	50	50	50	50	210
Total	**510**	**735**	**860**	**915**	**800**	**3820**

Note in Table 2c: Topographic data acquisition and hydrodynamic modeling steps are not included in the budgetary estimate presented above. In addition, some of the basic biological information required for the purpose of environmental assessment is currently gathered through regular programs of Environment Canada and Faune et Parcs Québec, via the St. Lawrence Action Plan Phase III (1998-2003). Those current programs will have to be modified and adapted to answer the specific questions asked by the IJC, so as to emphasize the integration of topographic-bathymetric-hydrodynamic information with biological data.

Table 2d. Total Time and Cost Estimates - Environment/Wetlands

	YR1	**YR2**	**YR3**	**YR4**	**YR5**	**Totals**
U.S. Totals (U.S. $K)	640	540	575	475	220	**2450**
Canadian Totals (Cdn $K)	865	955	1055	1085	935	**4895**

6.2 **Recreational Boating Interests**

6.2.1 Relationship to Water Level Fluctuations

There are 200-250 marinas on the U.S. shores from Porter, New York to Massena, New York. In Canada there are over 200 marinas including yacht clubs from Niagara-on-the-Lake on Lake Ontario to Trois-Rivières on the St. Lawrence River. In addition, there are a number of publicly accessible ramps and docks. The boating season stretches from about the first of April through to the end of October. During this period boaters are susceptible to fluctuating water levels.

When water levels are low, some boaters do not have sufficient depths to launch their boats in the spring, haul out in the fall, or operate in shallow areas and entrance channels. Other problems include increased incidence of damage to propellers, shaft, and hull. When levels are high, fixed docks and buildings may become inundated. Other problems include reduced bridge clearances and submerged water hazards.

If boaters are unhappy with their access capabilities as a result of high or low water levels, this has a direct impact on marina owners and the local tourism industry. Typical losses may include summer and winter storage, crane fees, service fees and in some cases loss of retail sales. Dredging and floating docks are corrective measures but may be too costly and time-consuming for some. Historically, boater reaction to water access constraints have included: moving to another marina or area, quitting boating, or acquiring a smaller boat that requires less depth.

6.2.2 Past Studies

The 1981 report to the IJC by the International Lake Erie Regulation Study Board contains some information on the potential impacts on recreational boating if Lake Erie were regulated. Only marinas on the United States shores were studied.

The recent Levels Reference Study (1993) examined the impacts of water levels on recreational boating. Site specific marina and boater survey information was gathered for 43 U.S. marinas in the Alexandria Bay, New York area. Stage damage curves were prepared on a reach basis based on the survey results and used to evaluate numerous measures being examined as part of the Levels Reference Study.

The 1993 Reference Study also examined eight Canadian marinas in the Kingston - Brockville reach of the St. Lawrence River which were surveyed in October 1991. On Lake St. Louis, seven Canadian marinas were surveyed in the same period. Based on the data collected, available depths corresponding to the time of the survey, optimum depths, critical maximum and critical minimum depths were identified. The investigators also derived an average operating range for the marinas at the two sites. In addition, operating ranges were also developed based on the September-December 1991 mail survey results.

A study conducted in 1998 by the Quebec Marine Trade Association and the City of Montreal examined recreational boating in Quebec and the development potential in the greater Montreal area. A 1998 report by Environment Canada, Fisheries and Oceans and the Quebec Ministry of Environment and Wildlife identified 69 marinas between Cornwall and Quebec City, 51 public ramps in the same sector and 30 docks.

6.2.3 New Study Scope, Data Collection Needs

In order to establish water level criteria for recreational boaters, it is necessary to develop a relationship between water level and boater impacts. It is proposed that some form of impacts model be developed which puts a value on the damages experienced by the recreational boating interest as a result of high or low water levels and the secondary or indirect effects on the local economy. The following outlines the tasks required to establish water level criteria for the recreational boating interest.

Task 1: Development of Water Level - Recreation Boater Impact Model

The basic premise for the impact model is that a boat has a minimum acceptable level to operate and a maximum level based on top of dock elevation or other physical parameter. There are various measurement standards and procedures to measure impacts. The evaluation method from the Levels Reference Study will be reviewed and updated as needed to develop a boater impacts model.

One practical measure of boater impacts resulting from incremental changes in water levels can be ascertained by estimating the corresponding number of boats that cannot be used due to high or low levels. Depending on the level of details and the method used to take into consideration the various interests, the impacts on recreational boating can further be expressed in monetary terms based on certain assumptions. Willingness to Pay (WTP) is a common standard used to express the monetary value of recreational outputs. Contingent valuation methods (CVM) obtain estimates of changes in recreational value by directly asking individuals about their willingness to pay (WTP) for changes in quantity of recreation at a particular site. Total WTP can be measured by aggregating individual values by summing the WTP for all users in the area. This method of evaluating impacts, among others, will be evaluated for use in this study. As a minimum, this study should evaluate boating impacts in terms of boater-days loss due to water level fluctuations.

The water level/boaters impact model can also be developed to predict financial impacts to marinas and indirect impacts to local economy.

Task 2: Physical On-Site Survey

To acquire data for the model, a field survey of all marinas on Lake Ontario and the St. Lawrence River will be conducted. Each marina's fleet mix distribution of required drafts can be ranked and matched with the marina's corresponding available depths. The number of boats

that are impacted will be measured for changes in the water level. The data will be used as the primary basis for developing water level/boater impact curves. Each marina's water level vs. number of boats impacted curve will be aggregated for each major hydraulic reach on Lake Ontario and St. Lawrence River. Among the data to be collected are the water level operating range for which each marina was designed and built, and the number of years of operation for comparison against expected reasonable conditions for marinas to operate.

Physical characteristics and usage data will also be collected for public ramps and municipal docking facilities to capture impacts to boaters not using marina facilities and to develop impact curves for this boating sector.

Task 3: In-depth Marina Operator Surveys

To augment the field surveys, a questionnaire is proposed to capture views of marina operators regarding the physical and economic impacts of fluctuating water levels, changes in fleet, perceived optimum ranges, and criteria review. The information will be used to support the impact curves and to cross-reference on-site survey results. Also included will be a determination of the number of years of operation of each marina or yacht club.

Task 4: Boater Surveys

a. Permanent Base Boaters:

To capture current boating characteristics (including days of usage, number of passengers, favourite destinations and uses, i.e. sport fishing, etc.) attitudes, opinions, perceptions and estimated boating value of the permanent base boaters, a survey questionnaire will be administered to a sample of the boating population including charter boaters and sport fishing boaters.

b. Trailer Drawn Boaters:

To capture boating characteristics of the trailer drawn boater, a short survey will be developed and conducted at public ramps, boat shows and boater magazines. Results for this survey will be used to represent the views of the small craft/casual boater that may not be represented by the marina or permanent based boater surveys.

Task 5: Regional Impacts

To establish the relationship between the boating interest and the local economy, regional impacts to the tourist industry/service sector will be assessed.

Task 6: Data Management and Analysis

All data gathered will be stored in a Geographic Information System. The data will be analyzed

to develop recreational boater impact curves. These water level/boater impact curves will form the basis for the boaters impact model.

Task 7: Model Application and Documentation

Once the data have been gathered and analyzed and impact curves have been developed, the model will be run with various water level scenarios including climate change.

6.2.4 Implications of Climate Change, Demographic and Other Changes

Water level changes brought on by climate changes could have significant impacts on the boating interest. Adaptation would be very costly and would include dredging, changing slips and docks, and relocating facilities. There may be considerable regulatory hurdles associated with adaptive measures such as dredging, particularly in areas where sediments are too contaminated to be sidecast. The proposed methodology outlined above will consider climate change scenarios through a sensitivity analysis.

The recreational boating industry has been growing steadily over the last 30-40 years. Boats are much larger and have greater drafts. Given that the number of marinas which can be built is limited, and given the effects of the demographic bubble (baby boomers) about to retire, saturation could be attained within the next 10-20 years. Growth in boat size may level off at an average length of 30-35ft. (10-12 metres), draft of 5-7ft. (1.5-2.1 m), and maximum 50ft. (15 m) at draft of 8ft. (2.4 m). Another factor is the cost of fuel. In periods when fuel costs are high, there is a tendency to deeper draft sailboats and vice versa. Whether these hold true is difficult to say, but consideration should be given to trends in the industry. The model will evaluate impacts to boaters based on future trends through a sensitivity analysis.

Since Sport Fishing and Charter Boats have different use patterns, separate impact curves will have to be developed for these activities.

6.2.5 Optimal Conditions

For each marina, there is a range of water levels where optimum conditions exist for the marina's operation and for all of its users. As water levels extend beyond this optimum range, adverse impacts will begin to occur. The optimum ranges for each marina (within a hydraulic reach) can be combined into one collective optimum range relationship which comprises a water level range where no adverse conditions exist for any marina within the reach or at least where adverse conditions are minimized. Preference indicators for the recreational boating interest were developed during the development and testing of Regulation Plan 1998, and another type of Lake Ontario regulation plans called the Interest Satisfaction Model. This information needs to be verified through comprehensive field surveys.

6.2.6 Study Organization, Costs and Schedule

The suggested agencies that will perform this work are listed in Annex 1. The following lists the proposed work items along with cost estimates and schedule. Depending on the levels of detail required of the study, the tasks will be ranked in order of importance and as to whether they help address the issues. The level of detail for field data collection should be consistent with the evaluation method and for this reason, early development and testing of the evaluation method is essential. A pilot study using several typical marinas to test the evaluation method will be conducted prior to any full scale field data collection program.

Table 3a. Time and Cost Estimates - Recreational Boating Studies (U.S. $K)

Major Tasks	**YR1**	**YR2**	**YR3**	**Total**
Task 1: Develop Levels/Impacts Model	80			**80**
Tasks 2&3: Collect/Update Physical Data and In-depth Marina Surveys	60			**60**
Task 4: Boater surveys (develop, administer, data entry) a.) Permanent base boaters survey b.) Trailer drawn boater survey		 15 25		 **15** **25**
Task 5: Regional Impacts			10	**10**
Task 6: Database and Analysis (includes development of GIS)		120	80	**200**
Task 7: Apply model (various lake levels and sensitivity analysis)			50	**50**
Coordination (meetings, travel etc.)	20	20	20	**60**
Total	**160**	**180**	**160**	**500**

Table 3b. Time and Cost Estimate - Recreational Boating Studies (Cdn. $K)

Major Tasks	**YR1**	**YR2**	**YR3**	**Total**
Task 1: Develop Levels/Impacts Model	80			**80**
Task 2&3: Collect/Update Physical Data and In-depth Marina Surveys	100			**100**
Task 4: Boater surveys (develop, administer, data entry) a.) Permanent base boaters survey b.) Trailer drawn boater survey		 15 25		 **15** **25**
Task 5: Regional Impacts			10	**10**
Task 6: Database and Analysis (includes development of GIS)		120	80	**200**
Task 7: Apply model (various lake levels and sensitivity analysis)			50	**50**
Coordination (meetings, travel etc.)	20	20	20	**60**

Total	**200**	**180**	**160**	**540**

6.3 **Coastal Zone Interests – Riparian/ Shore Property Erosion and Flooding**

6.3.1 Relationship to Water Level Fluctuations

The fluctuation of the water levels in the Great Lakes and St. Lawrence River affects most of the coastal zone interests either directly or indirectly. High levels as experienced in the mid-1940s, early 1950s, 1970s, mid-1980s and again in 1993 are of concern to those who live along the Great Lakes and St. Lawrence River shoreline since they can combine with other factors, such as storm waves or ship wakes, to cause serious flood and erosion damage. Low levels as experienced in 1934-36 and 1964-65 increase the shore area, but can also impact water intake structures, ramp and docking facilities, water quality, and can lead to the undercutting of shore protective works.

Lake Ontario is diverse geomorphically, with its shoreline falling into all shore types. The St. Lawrence River is dominated by a low plain shoreline. Both the Canadian side of Lake Ontario (particularly the western shoreline), and along the St. Lawrence River have a relatively high percentage of shore protection (10.7% and 12.7% respectively) due to intense residential and industrial development, while the U.S. side of Lake Ontario is largely unprotected with only 1.3% classed as artificial shoreline (Working Committee 2, 1993). Surveys conducted during the Levels Reference Study revealed that erosion is a more common problem than flooding to shoreline residents. Nevertheless, flooding has been a major concern, especially in several areas of the U.S. shore of Lake Ontario (particularly west of Rochester NY and along the eastern shore of the lake) and in the Montreal area of the St. Lawrence River. The percentage of property owners stating that they had experienced low water level impacts was almost the same as the percentage experiencing high water levels. This was despite the fact that these surveys were conducted following a 20-year period of above average water levels. The true impacts of below average water levels, especially for an extended period, are not well understood.

Stage damage curves used during the Levels Reference Study indicated the highest potential damages due to flooding are along the St. Lawrence River. Flood levels on the St. Lawrence River in the Montreal Region generally result from the combined effect of high St. Lawrence River flows, high Ottawa River flows and local inflows. High St. Lawrence River outflows may contribute to flooding on Lac Des Deux Montagnes and the Back Rivers (Rivière Des Prairies and Rivière Mille Iles) as well as on the main stem of the St. Lawrence.

Storms combined with high water levels were seen as the main cause of both flooding and erosion by Lake Ontario riparians. Those living along the St. Lawrence River, identified high water levels and ship wakes as the main causes identified for flooding and erosion (Working Committee 2, 1993). This is supported by a recent report (Davies, M.H. and Watson, D.A.W., 1999) that found that ship-driven waves may have substantial effects on shoreline erosion and property damages dependent on water levels relative to river banks. This is particularly the case with the islands in the St. Lawrence River, some of which have already disappeared completely.

From a geomorphological standpoint, fluctuating water levels and flooding and erosion are natural components of the lake and river dynamic processes. Although a reduction in the range of levels may reduce erosion of the back beach in some areas, accelerated erosion of the underwater portions of the nearshore profile are likely to occur. Many coastal areas will continue to erode to varying degrees regardless of changes in water level and flow regimes (Working Committee 2, 1993). The implications to coastal processes of an extended period of low water, and/or, of an increased water level range, particularly within the Great Lakes, has not been well investigated. Low water does not necessarily mean that wide sandy beaches will evolve throughout the system. During lower water levels less new sand will enter the system, and existing sand resources may, in certain areas be displaced further offshore. During low water levels, it is expected that there will be increased downcutting of the offshore cohesive bed, steepening the offshore portion of the profile. More boat grounding, greater need for dredging, increased icejam induced flooding and the mobilization of underwater contaminated sediments are other examples of low water impacts.

6.3.2 Past Studies

In 1972-73, record high water levels in the Great Lakes caused extensive shore property damages. The Government of Canada and Ontario surveyed the shoreline and subsequently prepared a report titled "*The Canada/Ontario Great Lakes Shore Damage Survey*" which compiled details of areas where flood and erosion risk are highest and recommended how future damage might be reduced (EC, OMNR, 1975).

In 1986, following another period of record high levels for this century, the governments of Canada and the United States asked the IJC to examine and report upon methods of alleviating the adverse consequences of fluctuating water levels in the Great Lakes - St. Lawrence River Basin. A comprehensive Levels Reference Study ensued and numerous studies were carried out on the impacts of water levels on the shoreline. With respect to the coastal zone, a shoreline classification was developed for the entire Great Lakes shoreline identifying the make-up of the shoreline on a reach by reach basis. Stage damage curves developed a decade earlier during the high levels of the 1970s were updated to reflect current dollar values and a critical review of these curves was completed. An extensive survey of shoreline property owners was undertaken to acquire input on damages and views for solutions to the problem. (Levels Reference Study Board, 1993).

Following the Levels Reference Study, and in response to recommendations made by the IJC, the Detroit District of the U.S. Army Corps of Engineers (USACE) initiated in 1996 a Lake Michigan Potential Damage Study to provide an extensive assessment of potential shoreline damages due to changes in Lake Michigan water levels over the next 50 years. (Nairn et. al., 1999). Likewise, the Buffalo District of the U.S. Army Corps of Engineers initiated the Lower Great Lakes Erosion Study which began in 1998 with a goal of developing a tool for the assessment of local and regional impacts associated with coastal projects on Lakes Erie and Ontario (Stewart, 1999).

No comparable basin-wide effort has been initiated on the Canadian side of Lake Ontario. However, a number of shoreline Conservation Authorities in Ontario have developed comprehensive shoreline management plans for addressing the flooding and erosion issue which may be of great benefit in conducting such a task.

In Quebec, detailed maps now allow the identification of sectors most prone to erosion in the St. Lawrence, from Cornwall to downstream of Quebec City (ARGUS for Environment Canada, 1996, Argus 1991), together with a variety of restoration techniques for different situations. Erosion studies were conducted for the Varennes Islands (Panasuk 1987) and the Contrecoeur Islands (Davies and Watson, 1999).
However, a commensurate understanding of climatic conditions (wind, discharge, ice) and human activities (boating, shipping, shore activities) on erosion is still lacking. The relative contribution of these factors must be established in order to identify which human activities can be managed to control/reduce flooding and erosion in the lakes and river.

In the U.S., a number of detailed studies have recently been carried out in association with the St. Lawrence - FDR Power Project Relicensing. These studies need to be carefully reviewed to determine their relevance and usefulness to this process. Wherever possible, efforts will be made to draw upon existing knowledge.

6.3.3 New Study Scope, Data Collection Needs and Evaluation Methods

To properly examine the criteria contained in the Order of Approval for the regulation of water levels and flows in the Lake Ontario-St. Lawrence River system and to respond to potential climate change/variability, it is necessary to be able to provide accurate erosion and flood predictions and be capable of predicting regional sediment transport and sediment budgets. To do this, flood and erosion prediction models need to be developed which account for shoreline geology, structures, sand supply, and environmental conditions such as still water levels, wind and ship waves, currents, vegetation, and ice cover. Various components to the modelling process will have to include the development of a detailed coastal zone database and/or digital terrain model; the development of relationships between still water level and wave propagation on shorelines for various hydraulic scenarios and vegetation distribution/state of growth; the quantification of the relative amounts of energy produced by currents, natural waves, commercial navigation and recreational boating waves; the determination of associated recession rates; wave runup, flooding and hydrodynamic predictions; longshore sand transport and sediment budget analysis; sandy and cohesive shore erosion predictions; predictions of the transport of eroded material from shorelines and potential redeposition/resuspension along shores and/or riverbed; and slope stability assessments. All of these components must be integrated and linked to translate input data into flood, erosion and low water level impact predictions.

The U.S. Army Corps of Engineers has already initiated development of a modeling and data management system for the U.S. shorelines of Lakes Michigan, Ontario, Erie and the St. Lawrence and Niagara River. No such work has been initiated on the Canadian side of Lake

Ontario or the Niagara Rivers. Some models are being developed by the Canadian Coast Guard in partnership with Environment Canada and the Canadian Hydraulics Centre as pilot studies for the riverine environments of the St. Lawrence River.

Key data inputs to the various analytic procedures for Canada and the U.S. include:

- Topographic and bathymetric data (Digital elevation model)
- Coastal Zone Database and/or Digital Terrain Model
- shoreline geomorphology
- shore protection quality and quantity
- nearshore/sub-aqueous
- Planimetric features (e.g., roads, buildings)
- Digital orthophotos
- Land use and land use trends
- Property values, facilities and infrastructure elements
- Surficial and subsurface information for the lake/river bed
- Wave runup and flooding
- Sediment budget
- Historic estimates of recession rates
- Bluff height, slope, and the frequency of gullies
- Historic blufflines and shorelines
- Ice coverage and ice jams
- Ship wave climates
- Vegetation
- Hydrodynamic variables

In addition, point data are required which include:

- Ground level photos
- Sediment characteristics
- Borehole logs
- Dredging records
- Beach nourishment history
- Nearshore profiles
- Measured, hindcasted, and forecasted deepwater and transformed wave data
- Measured and forecasted water level data

As is evident, the analysis requirements are very data intensive. The following outlines the steps required to fully develop, populate and run a coastal flood and erosion prediction system so that accurate predictions of damage as a result of flooding, erosion and the impacts of changes in water level regimes can be made.

Step 1: Coastal Zone Database and/or Digital Terrain Model

A shoreline classification was developed during the Levels Reference Study in the early 1990s and revised and improved for Lake Michigan and the U.S. shores of Lake Erie and Ontario through the Lake Michigan Potential Damage Survey and Lower Great Lakes Erosion Study. The original classification was developed on a reach by reach basis. Work needs to be done to update this classification scheme for the Canadian shoreline of Lake Ontario, St. Lawrence and Niagara River to an appropriate resolution (e.g. 1x1 km or finer). The classification needs to be revised to improve the detail of information and provide more confidence in the nearshore geology and to add emergent and aquatic vegetation. This task includes reviewing more current information (e.g. erosion classification developed for the St. Lawrence River - Argus for EC, 1996), and holding a workshop with coastal experts. Data requirements include aerial photos (less than 1:10,000), nearshore profiles, bathymetric charts, topographic maps, video of the shoreline, any inventory of shore structures and mapping of bluff stratigraphy. The existing Geographic Information System (GIS) database system will be updated with the revised information. *{Note: Required topographic and bathymetric data is addressed in section 4.2, Common Data Needs}*

Step 2: Define Driving Forces for Erosion (Historic and Future)

This task has two purposes, the first is to quantify the relative amounts of energy contributing to the erosion process (including the effects of water levels, natural and boat-related waves, ice and vegetation) to provide model calibration and the second is to establish conditions for future scenarios. The task includes the development of water levels as influenced by river flows, ice effects and wind generated surge. Currents and ice cover and ice jams must be assessed and included in the modelling process where appropriate. Nearshore wind waves must be predicted. This can be done by using hindcast deepwater wave (hourly), water level (hourly where possible) and ice data. There is also a need for the development of a method for estimating ship wave climates on the St. Lawrence River. Previous studies by the Canadian Coast Guard and Public Works Government Services Canada to estimate ship wave climates will be reviewed along with more recent models being developed by the Canadian Coast Guard in partnership with Environment Canada and the Canadian Hydraulics Centre.

Step 3: Determine Recession Rates (Includes aerial photography)

To determine consistent recession rates for the shore, the current shoreline taken from aerial photos and/or airborne laser profiling systems should be compared with a historical shoreline. Historic aerial photos exist for the entire Lake Ontario - St. Lawrence River shoreline. The entire shoreline needs to be flown again to provide a recent shoreline coverage. This aerial photography/imagery coverage could also assist with the shoreline classification outlined above and in determining current land use and land use trends, and to develop recession rates representing different historic combinations of lake and river levels, natural and boat-related waves, ice and vegetation coverages. Airborne data can also be used for the evaluation of wetland impacts. The costs for flying the shoreline are covered in 4.2. The development of the Digital Elevation Model, the defining of historic and current bluff lines and the estimation of recession rates through the modelling process are considered here.

The historical recession rate database developed in the Levels Reference Study (Working Committee2, 1993) and based on existing literature, will be reviewed, updated and used to identify areas requiring additional recession rate development.

It may be that the shoreline classification completed in Step 1 can be used to identify those areas where recession is more likely. In a cost saving effort, these areas could be concentrated on. If accessing new shoreline data is not possible, older information may be utilized to help determine recession rates. This will, however, not provide a definition of the modern conditions, nor would it result in a consistent base for analysis.

Step 4: Determine Land Use/Zoning and Land Use/Zoning Trends:

a. Land Use and Land Use Trends:

Using existing land use maps, documentation, and aerial photographs of the shoreline, land use types will be determined at an appropriate resolution along the shoreline. Building on findings from the Levels Reference study and utilizing historic and current aerial photographs, meeting with planning officials and resource groups and reviewing planning documents, land use and land use trends will be determined along the shoreline and input to a digital database.

b. Hazard Zones:

Current municipal flood and erosion zoning requirements and other management practices in force will be documented and added to the GIS coastal zone database along with any plans for zoning changes. This data will be gathered at the same time as the land use data. The number of properties within zoned areas will be determined using existing digital basemaps and an assessment of the effectiveness of the zoning requirements will be made.

Step 5: Monitoring and Analysis of Test Sites on Lake Ontario and the St. Lawrence River to Support Numerical Model Investigations

To test/calibrate the flooding, erosion, sediment transport, and economic models, detailed site studies need be carried out. Detailed information will be complied for the study sites at or less than 1 km in length, including the shoreline geomorphology and subaqueous geology, shoreline bathymetry, topography, bluff heights and slope, sediment characteristics and distribution, property values etc.

Depending upon the characteristics of the site and the availability of previously collected data, the tasks required at the test sites may include:

- complete physical model erodibility tests of undisturbed samples of cohesive sediments
- estimate detailed recession rates for the study sites (i.e. for several snapshots in time) through development of digital orthophotos within the GIS

- complete hydrodynamic measurements, hydrographic surveys, and jet probing to determine sand thickness (reoccupying historic lines wherever possible) and grain size
- analysis of beach and nearshore sediments and geologic stratigraphy
- review role of bluff stability issues at sites with bluffs to determine lakewide methodology for considering the impact of bluff failure cycle on error band associated with predicted bluff positions
- complete numerical modeling of erosion to test capability of the model to predict (hindcast) erosion at each of the sites and along longer reaches over several kilometres or miles (considering longshore and cross-shore transport) and make any necessary modifications
- determine aquatic plant evaluations for various combined water levels and temporal and spatial variations
- consider impacts of shore protection (with different ages and design life) on future erosion rates
- near shore wave climatology for various water levels and periods of the year

Step 6: Lakewide-Riverwide Implementation - GIS

This task requires establishing the linkages between the modelling tools and a Geographic Information System (GIS). This will allow lakewide/riverwide implementation of the models. The task consists of setting up the system with the required GIS data layers (elevation data including topography and bathymetry, recent and historic bluff lines, digital land use data and planimetrics, orthophotos, and geological data).

Although there may be alternatives to lakewide-riverwide implementation of the system, any alternatives would require careful review in order to be fully justified and defensible.

Step 7: Application for Future Scenarios

a. Flooding

Assess flooding potential for a range of conditions considering static lake level, surge, wave runup and overtopping at an appropriate level of resolution. On the St. Lawrence River factors will include a variety of conditions for the Ottawa River and local inflows and ice jams.

b. Erosion

Sediment budget information is required for cohesive and sandy shorelines in order to link the coastal analysis per site to a lakewide basis. Sediment budget analysis includes considering the impact of changing sand cover due to both natural and human influences on past and future erosion rates. This is a key issue to consider in order to assess future “what if” scenarios. A preliminary review of the impact of harbors and related structures on sand bypassing must be conducted.

Recession rates will be developed and analyzed on a lakewide-riverwide basis using the historic

and recent bluffs through a comparison of predicted (hindcast) and determined actual recession rates. Any necessary adjustments will be made to reasonably represent actual rates. The coastal erosion models will then be applied to determine recession rates for future water level scenarios including climate change scenarios. Transport of eroded material and potential redeposition/resuspension along shoreline and/or riverbed will be simulated for expected future conditions.

c. Low Water Impacts

Very little information exists on the implications of low water to the coastal system of the Great Lakes - St. Lawrence River system. The modelling tools developed will be applied to consider the full range of possible future level scenarios. Determining the implications of lower water levels is a key component to this study, especially in consideration of possible climate change scenarios.

Step 8: Damage Assessment

Once predictions of flooding, erosion and low water impacts can be made, an assessment of total potential damages will have to be determined. It is generally accepted that existing stage-damage curve relationships are no longer adequate and must therefore be updated, or, a new impact assessment methodology developed and applied. Site studies, damage curves, land use information, existing digital data on structures, or some combination of these will be used.

6.3.4 Implications of Climate, Demographic and Other Changes

Isostatic rebound or the vertical uplifting of the earth's surface after the removal of the tremendous weight of glaciers, has occurred since glacial time. On Lake Ontario, the eastern outlet end is rising with respect to the western inlet end at a rate of about 17 centimetres per century (EC, 1993). The result is that the shore at the western end of the lake is experiencing a gradual increase in water level. In addition, there may be tectonic warping of the basin causing differential subsidence. This has implications for Great Lakes datum and to the regulation plan which bases its criteria on datum levels. Isostatic rebound should be considered in any revised regulation plans.

The shoreline is a desirable place to live. The demographics of the shoreline continue to change particularly on Lake Ontario where population levels continue to rise. Land use trends, land use zoning and other management techniques used along the shoreline will be addressed in the proposed studies. Considering this desirability, and as was recommended in the Levels Reference Study, prudent coastal management practices are encouraged at local, as well as higher, agency levels.

Climate change scenarios and the potential impacts to flooding, erosion, sediment transport and sediment budgets will be evaluated.

6.3.5 Optimal Conditions

Erosion: The Levels Reference Study (Working Committee 2, 1993) made some attempt to determine whether a reduction in the range of lake levels would significantly effect recession rates. Preliminary results did conclude that about 45% of the Lake Ontario shoreline and as much as 63% of the St. Lawrence River shoreline would experience some reduction in recession as a result of a 50% reduction on water level range. However, these estimates are quite coarse and reflect only a very significant reduction in water level range which would never be operationally achievable, nor desirable from an environmental view point. An optimum range was not determined, but could be estimated using the described refined coastal data base and flooding and erosion analysis system.

Flooding: A reduction in maximum Lake Ontario and St. Lawrence River levels - particularly during the spring and fall storm season and the Ottawa River freshet - will reduce the probability of flooding. Maximum and minimum levels have been established in the current Criteria for Lake Ontario (Criteria (h), (i) and (j)). The current criteria do not provide maximum and minimum levels for the St. Lawrence River, however, condition (i), which contains the criteria, does state that the project works shall be operated "*in such a manner as to provide no less protection for navigation and riparian interests downstream than would have occurred under pre-project conditions and with supplies of the past as adjusted, defined in criterion (a)*"… This has been interpreted and applied by the board and the Commission over the past 40 years as establishing specific limits, in terms of levels and flows, for supplies as they occurred in nature.

6.3.6 Study Organization, Costs and Schedule

The agencies that could undertake these evaluations are listed in Annex 1. The following outlines estimated costs to undertake the proposed methodology for predicting flood and erosion damages to Lake Ontario - St. Lawrence River shoreline interests.

Table 4a. Time and Cost Estimates - Coastal Zone Studies (U.S. $K)

Major Tasks	**YR1**	**YR2**	**YR3**	**Totals**
Step 1: Coastal Zone Database	70			**70**
Step 2: Define Driving Forces for Erosion	200	100		**300**
Step 3: Determine recession rates	50			**50**
Step 4: Determine Land Use/Zoning and Land Use/Zoning Trends	80	70		**150**
Step 5: Numerical Model Investigations and Related Activities for Test Sites	270	380	250	**900**
Step 6: Lakewide/Riverwide Implementation (GIS)		150	100	**250**
Step 7: Application for Future Scenarios	50	250	200	**500**
Step 8: Damage Assessments		30	70	**100**
Other: Reporting, Meetings, Travel, Miscellaneous	50	50	50	**150**
Total	**770**	**1030**	**670**	**2470**

Table 4b. Time and Cost Estimates - Coastal Zone Studies (Cdn. $K)

Task	YR1	YR2	YR3	Totals
Step 1: Coastal Zone Database/DTM	120			**120**
Step 2: Define Driving Forces for Erosion	200	100		**300**
Step 3: Determine recession rates	100			**100**
Step 4: Determine Land Use/Zoning and Land Use/Zoning Trends	75	175		**250**
Step 5: Numerical Model Investigations and Related Activities for Test Sites	175	375	150	**700**
Step 6: Lakewide/Riverwide Implementation (GIS)		150	100	**250**
Step 7: Application for Future Scenarios	50	250	200	**500**
Step 8: Damage Assessments		30	70	**100**
Other: Reporting, Meetings, Travel, Miscellaneous	50	50	50	**150**
Total	**770**	**1130**	**570**	**2470**

6.4 **Commercial Navigation Interests**

Commercial navigation, for the purpose of this study, includes vessel operations associated with the movement of commercial cargoes, commercial fishing, tug and barge operations, cruise/tour operations, ship construction/repair operations and government vessel operations.

From a quick review of the needs and nature of commercial navigation in the Lake Ontario-St. Lawrence River system, it is recognized that there are three distinct sections :

a) The commercial traffic on Lake Ontario which is affected to a limited degree by water level fluctuations. The level fluctuations on the lake are relatively long term and in small increments and the Seaway/Great Lakes traffic is limited to Seaway draft (U.S. & Canada).
b) The traffic within the Seaway limits; captive traffic, influenced more by Lake Ontario outflows and river level fluctuations than traffic on Lake Ontario (U.S. & Canada).
c) The deep sea traffic to and from Montreal to the Atlantic. This sector includes mainly sea-going traffic. As well, the ship channel to Montreal is open year-round and is impacted by water level fluctuations, a factor of Lake Ontario outflow and flow from the Ottawa River. Ice in the St. Lawrence River can also affect the levels in the area.

This section follows the approach of splitting the area and activity to be studied into three zones.

6.4.1 Relationship To Water Level Fluctuations

a) Lake Ontario

Changing water levels on Lake Ontario affects two major transportation interests: vessel owners and port/dock operators. Vessel owners affected would include all U.S., Canadian and foreign vessel owners whose vessels would have to use Lake Ontario in their commodity movement. Port/dock operators affected are those (U.S. or Canadian) located on Lake Ontario. These interest groups may also be associated with related transportation interests that comprise part of the regional transportation infrastructure, including truck, rail and barge systems. The major concern of these two most directly affected interest groups is to avoid adverse changes in expected long-term levels of net commercial income of shippers and ports.

Related issues such as marginal changes in transport times, additions or deletions to the commercial navigation fleet required to move the expected commodity volumes, change in the level of use of locks, channels or terminals resulting from impacts of measures to deal with water level changes are additional impacts of water level changes.

b) St. Lawrence River - Seaway

The St. Lawrence River from just above Montreal to Kingston can be divided into three sections with distinct hydraulic characteristics. The water level for the upper section of the St. Lawrence River from Kingston to Moses-Saunders Power Dam near Massena/Cornwall is primarily influenced by water levels on Lake Ontario and the outflow through the power dam, and may also be influenced by the gates open settings at the Iroquois dam. The level in the middle section from Massena/Cornwall to Beauharnois Canal is affected primarily by the flow from upstream (the Moses-Saunders plant) and releases at the Beauharnois-Cedars complex. The downstream section of the St. Lawrence River from Beauharnois to St. Lambert is further affected by the outflow from the Ottawa River which enters Lake St. Louis upstream of South Shore Canal.

Two factors are critical to safe and efficient navigation; the available depth of water, and the currents created by water flow. Within each of these sections of the St. Lawrence, navigation conditions are impacted by both the absolute water levels, and the flow rates at any moment. Above Cornwall, depths in the various sections of the river are largely a function of the level of Lake Ontario, and the volume released. Flow rate, and the currents generated in various sections of the river, are in turn dependent on the slope of the river, which is affected by the open setting of the various control structures, at Iroquois, Cornwall/Massena, & Beauharnois-Cedars. Higher flow rates require greater slopes on the river, and may actually result in lowering water levels on Lake St. Lawrence just above Cornwall/Massena, even when Lake Ontario levels may be high. Low flow rates, which would often be the case at periods of low Lake Ontario levels, may actually produce higher than normal depths on Lake St. Lawrence, though the Port Montreal would be at low levels. Thus, there is a complex relationship in these reaches of the St. Lawrence River between Lake Ontario levels and flows and the water depths and currents with which shipping must contend.

The other major factor affecting the water level fluctuation, particularly in Lakes Ontario, St. Lawrence, St. Francis and St. Louis is the speed and direction of prevailing wind. For instance, a strong and steady easterly or northeasterly wind during the fall when the river level is normally low is of particular concern in Lake St. Lawrence because the water level could easily drop up to 20-25 cm.

The Seaway navigation channel was originally designed and constructed to handle a maximum flow of 8800 cms (310,000 cfs) without exceeding the maximum ship maneuvering velocity of 1.22 mps (4.0 fps). Water supplies for Lake Ontario for the period 1860-1954 were used in the project design. However, there has been some experience with operations at higher flows at periods of very high Lake Ontario levels. As a practical means of determining the velocity in various reaches of the St. Lawrence River, the water level differentials between gauges are regularly monitored during the high outflow period.

As a result of favorable water level conditions during the certain periods of the year coupled with some subsequent channel dredging and vessel speed reduction, in certain reaches of the St. Lawrence River, the Seaway entities increased the maximum permissible draft from 7.92m to

8.00m in 1992. The annual benefit to the shipping industry for this draft increase has been estimated to be $3.0 million (Cdn.). In addition, the Seaway navigation season is now routinely extended beyond what was expected, both at the opening of navigation, in the latter part of March and at the closing of navigation in the latter part of December. This requires careful coordination with other interests, particularly during the critical period of ice formation each year.

c) St. Lawrence River - Port of Montreal & Downstream

The deep sea traffic arriving and departing the Port of Montreal and other ports on the St. Lawrence River downstream of Montreal, is affected primarily by the following factors :

i.) the outflow from Lake Ontario
ii.) the outflow from the Ottawa River, and
iii.) local tributary flows.

In the open-water season, the main factors affecting water level fluctuations are the outflow from Lake Ontario and the Ottawa River. The Ottawa River outflows are regulated to a minor degree so that the regulation of that river does not play a significant role in the water level fluctuations in the Montreal area, as the primary intent in that case is to provide short-term storage of the upstream reservoirs; the river flows are essentially determined by the basin supplies. The river flow, however, can fluctuate greatly, influenced by the freshet in the spring and local basin precipitation. Therefore, the primary focus in this instance will be on the water level fluctuations caused by flow changes from Lake Ontario, but including consideration of the impact of Ottawa River flows. As a rule of thumb, a change in the Lake Ontario outflow of 1,000 m^3/s will result in approximately 40 cm water level fluctuation in the Port of Montreal.

In the winter, the traffic to and from the Port of Montreal continues, supported by ice cover management, including ice booms and ice breaking operations.

The Port of Montreal, and others such as Sorel, Trois-Rivières and Bécancour are inland river ports and, therefore, the traffic to these ports must make use of the full depth available at the time of their voyage. Additionally, the deep sea traffic in the St. Lawrence River ports does have some seasonality which must be taken into consideration.

The levels in the Port of Montreal generally react to Lake Ontario outflow changes within 18 to 24 hours. This will have to be better understood, particularly given the micro-management strategies frequently being adopted by the Board in the last few years, as well as when operating under Criterion (k) conditions or other critical situations.

Finally, the operations of Hydro Quebec at the Beauharnois/Cedar facilities can impact the water levels in Montreal. While the storage capacity on Lake St. Francis is rather limited, again, given micro-management of recent years, there could be instances where levels in the Port would be affected significantly. This situation needs to be better defined.

Any Criteria additions or revisions resulting in extreme low/high Lake Ontario outflows could impact significantly on the Port of Montreal area and downstream. The impacts must be analysed and the need for appropriate measures will be assessed/determined.

The traffic to the Port of Montreal depends extensively on adequate foreknowledge of the water level conditions. A significant portion of the traffic comes from overseas destinations and requires loading and schedule planning to ensure that, on arrival, the vessels will have adequate water depth to accommodate their passage safely. The Port of Montreal in particular depends significantly on one-to-four-week forecasts provided by the Canadian Coast Guard to define the maximum allowable drafts to which large deep draft ships may load. These large vessels loaded to the anticipated capacity of the waterways can suffer significant disruption, and consequently economic losses, as a result of rapid and unexpected fluctuations in the water levels. As a minimum they may encounter delays in their arrival schedules, but more likely they could be required to offload in other ports such as Halifax, Sorel or Quebec. The negative impact of inadequate knowledge of the water level conditions therefore, is not only on the performance of shipping lines but also on the Port. The Port of Montreal is currently completing a major channel deepening project which will provide an additional one foot depth for traffic to and from the Port. Stability and predictability of the water levels is vital to the commercial shipping activity in this major international waterway and must be managed as best as possible with the necessary information and technical tools.

6.4.2 Past Studies

a) Lake Ontario

A wide range of studies have dealt with Lake Ontario commercial navigation interests, either as a component of a larger study, or as a study of Lake Ontario alone. A number of these studies are listed below.

(1) "*Levels Reference Study, Great Lakes-St. Lawrence River Basin*", submitted to the International Joint Commission by the Levels Reference Study Board, 1993.

(2) Task Group 4, Working Committee 3, "*Commercial Navigation Work Group Report*" , Levels Reference Study, International Joint Commission, July 1993.

(3) "*The Economic Impacts Of The Great Lakes/Saint Lawrence Seaway System*", prepared for the St. Lawrence Seaway Development Corporation by Martin O'Connell Associates, Sept. 1992.

(4) "*The Great Lakes, An Environmental Atlas and Resource Book*", by Environment Canada, U.S.E.P.A., Brock University, Northwestern University, 1987.

(5) "*The Economic Impact Study of Major Marine Initiatives*", prepared for the

Canadian Coast Guard by Hickling Corporation and Booz Allen Associates, December 1996.

b) St. Lawrence River - Seaway

There are numerous past studies and/or reports related to the river hydraulics and its effects to the commercial navigation.

The Power Entities maintain seven (7) water level gages, namely, Kingston, Ogdensburg, Cardinal, Iroquois, Morrisburg, Long Sault and Saunders along the upper St. Lawrence River. In addition, there are CHS gages in Summerstown in Lake St. Francis and Pointe Claire in Lake St. Louis. Alert and minimum elevations for commercial navigation at each gage locations are fully described in a report entitled;

(1) "*A Compendium on Critical Water Level Elevations in the Lake Ontario-St. Lawrence River System*" by the International St. Lawrence River Working Committee, December 31, 1994.

In addition, there are a number of other reports available, including;

(2) "*St. Lawrence River Direction and Velocity Measurements*" Report#1, #2 and #3 by SLSDC, 1976/77, 1978, 1982 and by SLSMC.

(3) "*St. Lawrence River Discharge Measurements*" by COE, Detroit District, 1976 and 1987

(4) "*Vessel Speed and Wave Studies (7 volumes)*" by St. Lawrence Seaway Authority, 1970-1974

(5) Sounding/Sweeping results by SLSMC/SLSDC

(6) Annual Seaway Traffic Reports (1959-1998)

c) St. Lawrence River - Port of Monteal & Downstream

Some of the more important/recent past studies in which the subject of commercial navigation has been addressed are :

(1) *Montreal Harbour Satisfaction Curves*. Ed Eryuzlu, February 25, 1994. Unpublished.

(2) *A report on 1998 water levels of the Great Lakes and the St. Lawrence River*.

Environment Canada, Cornwall. January 1999.

(3) "*A Compendium on Critical Water level Elevations in the Lake Ontario-St. Lawrence River System*" dated December 31, 1994 (as above).

(4) "*The Economic Impact Study of Major Marine Initiatives*", prepared for the Canadian Coast Guard by Hickling Corporation and Booz Allen Associates, December 1996.

(5) *Canadian Waterways National Manoeuvring Guidelines : Channel Design Parameters*. Waterways Development, Manrine Navigation Services. November 1998.

(6) *Stage Discharge Relationships in the reach of the St. Lawrence River, Montreal to Trois-Rivières*. Department of Transport, March 1968.

6.4.3 New Study Scope, Data Collection Needs, and Evaluation Methods

To the extent feasible, compatible methodology will be used in all three zones of the system.

The studies discussed below in detail will naturally take into account other interests, recognizing however, that all other identified interests will be covered in the Plan of Study.

a) Lake Ontario

The scope of work relating to commercial navigation on Lake Ontario (U.S. and Canadian) will rely heavily on existing information with respect to Lake Ontario port infrastructure, vessels used in moving commercial tonnage (U.S., Canadian and Foreign vessels) on Lake Ontario, historical Lake Ontario tonnage levels, origin/destination routes for lake Ontario ports, vessel operating characteristics, vessel operating limitations (Coast Guard Load Line Limits, maximum vessel operating draft on the Seaway system, etc.).
In addition to the material already available additional data will be required to allow assessment of the impacts of various flow regimes.

i.) Information on the physical commercial navigation system needs to be collected/updated (ports, channels, locks). Information on all commercial ports involved as origin or destination points for waterborne commerce using Lake Ontario will need to be developed. Port data would include controlling depths, dredging needs, dock locations, depth at dock and loading capabilities/rates, etc. The maintained depths and widths of all connecting channels/locks on the various trade routes will also be needed, as these are effectively restricting depths/widths for all ships in the system.

ii.) Meetings/interviews/surveys will be needed with the vessel operators and port/dock operators to identify key linkages between changes in water levels and resulting major

impacts on their operations. These data will quantify the impact of changing water levels/flows on their operations.

iii.) Sources of data, needed for the characterization and development of an evaluation, model will need to be identified. A range of potential data sources will be contacted. A source of information on the currently maintained channel depths at U.S. ports would be the U.S. Army Corps of Engineers. Sources of data on maintained depths at various port docks would be from the dock owners themselves, "*Greenwoods Guide To Great Lakes Shipping*" or the United States Coast Pilot 6. Again, parallel data sources will be needed for all Canadian ports, channels and docks.

iv.) Major commodity traffic and trade routes will need to be identified. Vessel movements for a representative season will need to be collected for all vessels transiting Lake Ontario. The level of detail needed on waterborne commerce movements would include the vessel name, the commodity carried, the number of tons of commodity carried, the origin port, the destination port, the origin port date and the destination port date. Potential sources of these waterborne commerce movements would be the U.S. Waterborne Commerce Statistics Center in New Orleans, La. And Statistics Canada.

v.) Vessel characteristics such as length, width, maximum vessel draft by time of season, tons of various commodities (iron ore, coal grain) carried at mid summer draft, tons per inch immersion factors, presence of bow or stern thrusters and type of vessel power plant would be needed.

vi.) Information on port infrastructure, dock locations and maintained channel depths at the various docks would be needed to develop port/dock impacts for fluctuating water levels

The methodology for evaluation will be based on existing commercial navigation transportation cost models and regional impact models. A Levels Impacts
Transportation Model will be developed which will concentrate on identifying the change in net commercial income of shippers and port/dock operators between an established base condition and alternative water level regimes. One component of the model will concentrate on developing changes in vessel operating costs due to changing water levels. The second component would concentrate on developing changes in income/utilization to port/dock operators due to changing water levels.

b) St. Lawrence River - Seaway

In order to allow for review of the potential to alter, or add to, the existing criteria governing operation of the present works, and to understand the effects on commercial navigation, additional information will need to be developed, and a methodology designed to allow assessment of the impact of various flow regimes,

i.) Data needs to be developed to better understand the relationships between water depths and flows in the St. Lawrence from Lake Ontario to Montreal, and the currents that are created within the shipping channels, particularly during high flow periods. Time series of levels and currents at various key locations (including those already equipped with gauges) need to be developed, over a multi-year period, so as to encompass all seasons in which commercial navigation operates, including periods of high flow conditions (over at least two, and preferably 3 years). This program will be integrated with the work to be undertaken in Section 7.1, to develop a 2-D hydrodynamic model for the Kingston to Cornwall/ Massena area.

ii.) Hydrodynamic phenomena, such as squat and bank suction, are generally well understood, but additional work is required to fully appreciate the impact of such factors on ships maneuvering in these specific channels, particularly during low water periods. Literature review will be undertaken to determine if similar situations elsewhere have been evaluated in the necessary depth, but it may also be necessary to instrument and record the motions of a number of typical ships which are regular traders through this area. The database thus obtained will allow evaluation of adequacy of present or proposed side and bottom clearances during transit.

iii.) Maneuvering characteristics of modern ships have changed considerably since the Seaway system first opened, and considerable experience has also been gained in control of ships passing through these channels. Officers and pilots of ships using the channels on a regular basis will be surveyed to determine their views with respect to any difficulties caused by the present range of depths, and of currents, experienced over the past years of operation, including both high levels and flow and low levels and flow conditions.

Using the data thus gathered, as well as economic indicators such as efficiencies per inch of immersion and timeliness of cargo delivery, a methodology similar to the Lake Ontario model will then be developed to allow for consideration of the impact on levels and flows in these sections of the St. Lawrence River as a result of the introduction of new criteria or the amendment of existing criteria. This analysis will include specific consideration of (as a minimum);

- The examination of the potential to raise or lower alert and minimum navigation elevations by varying incremental amounts along the entire St. Lawrence River under the existing channel conditions, and the related impacts on all interests,

- Impact to navigation in Lakes St. Francis and St. Louis reaches of the St. Lawrence River under the extreme low outflow conditions, including the potential for amended Seaway operating procedures for the management of such situations, and the resulting impact on industry.

- Impact to commercial navigation in the upper St. Lawrence River and South Cornwall Channel under the extreme high outflow conditions. Remedial works/measures including

physical improvements to increase channel capacity, required to maintain acceptable commercial navigation conditions (i.e. current velocity and minimum water level) will not be considered at this stage, but amended Seaway operating procedures may be considered.

Rather than carrying out such evaluations for all possible combinations of levels and flows, the final analysis of impacts should await the development of proposed criteria amendments or proposed new criteria, which can then be tested and evaluated to determine the impact on Seaway operations. Therefore, the data collection and development of an analysis framework will proceed within the first three years, but testing of possible new or amended criteria will be carried out, once these have been proposed, in the fifth year of the overall review.

c) St. Lawrence River - Port of Montreal & Downstream

In the case of the St. Lawrence River deep-draft traffic, there is a need to address:

i.) The seasonal patterns of deep-draft traffic to the Port of Montreal for the proper assessment of revisions to criteria and their impact on the Port of Montreal. The traffic patterns in the Port have changed significantly in comparison to that at the completion of the project;

ii.) The volume of the traffic that is impacted by limited water depths, i.e. there is no need to gather data on all commercial traffic to the port but traffic that requires, say 25' draft and more;

iii.) Approximations of lost business resulting from inability to make full use of loading capacity to/from the St. Lawrence Ports, and approximations of added benefit experienced when levels above datum and mean levels are available.

iv.) The effects of short-term Lake Ontario outflow changes on levels in the Port of Montreal area.

v.) The effects of Hydro Quebec operations at Beauharnois-Cedars on levels in the Port of Montreal, in relation too short-term water storage on Lake St. Francis.

vi.) The impact of winter operations of Lake Ontario regulations on the water levels in the St. Lawrence River in the Montreal area and downstream. This will include risk of flooding of the Port facilities and surrounding areas, including downstream.

vii.) Means to reduce the risk of extremely high Lake Ontario outflows impacting the Port of Montreal operations and downstream areas.

viii.) Options and means to reduce the impact in the Port of Montreal during extreme low flows from Lake Ontario.

ix.) The limitations/constraints impacting requirements of Port of Montreal and Seaway traffic, and potentials for constraints resulting from operations of the Seaway.

Studies and appropriate data and information on these issues will be essential not only in minimizing possible adverse impacts in the Port of Montreal area but also may facilitate better management of Lake Ontario outflow fluctuations, including any changes in the current operational criteria.

An evaluation methodology compatible with that developed for the upper portion of the system will be developed which allows for consideration of the impacts on Port of Montreal and downstream commercial navigation activity, which might be caused by new criteria, or the amending of existing criteria.

6.4.4 Implications of Climate, Demographic and Other Changes

Changes in climate (global warming) or demographics (population location, population increases) can have impacts on the levels and flows of the Great Lakes - St. Lawrence River system.

Most advanced computer models currently predict that water supplies to the Great Lakes and St. Lawrence River will be reduced over the next century(refer to the Section 4.3).

The water supply estimations provided by these climate models need to be looked at as a plausible range of conditions that could prevail in the future. Whatever future scenarios are utilized in this study to address climate change will be evaluated for their impact on Lake Ontario, the Seaway, and the Port of Montreal operations using the analytical approaches described herein.

6.4.5 Optimal Conditions

a) Lake Ontario

The Levels-Impacts Transportation Model could be developed to provide outputs that would indicate various optimal conditions from the perspective of commercial navigation users. For example outputs could be developed that would indicate what percent of commercial navigation traffic would have no impacts from various water level regimes (i.e. if Lake Ontario water levels were maintained at chart datum, what percent of the commercial navigation fleet servicing Lake Ontario would have excess carrying capacity.). Alternatively, the model could be configured to determine what is the maximum water column that could be utilized by vessels carrying various commodities. This maximum water column could then be converted to a lake level. Other optimal indicators for commercial navigation could be developed as they become identified in the study process.

b) St. Lawrence River - Seaway

Generally, constant water levels near the maximum annual mean would give the most satisfactory result in terms of the trade-offs between levels and currents, but this is an overly simplistic approach, as there are also seasonal variations impacting significantly on water levels in Lake St. Lawrence, Lac St. Louis and Lake St. Francis. Detail on the optimal conditions in the St. Lawrence River sections from the perspective of commercial navigation users operating in the Seaway system will be described by the proposed subcommittee Study Team, within the first year of the project, so as to provide necessary guidance to other working committees.

c) St. Lawrence River - Port of Montreal & Downstream

In general terms, high water levels tend to favor the use of deeper draft, and hence more economic vessel loads. The Port of Montreal has generally been able to rely on water levels that are at least at or above chart datum, and there have been significant periods in which the water levels over the period of regulation have allowed for several feet additional draft for large ships, while maintaining safe under keel clearance limits. The Port of Montreal market their services aggressively throughout much of the world, with one of their strongest selling points being consistent and reliable service, year round. Therefore, the predictability of water levels in the St. Lawrence River becomes as important as the actual level. Considerable effort is put into forecasting water levels for days and even weeks in advance, but if the actual levels encountered upon arrival are substantially below those expected, large container ships may be to diverted to Halifax or make an extra stop at Sorel or Quebec City to partially offload their cargo. This may add significantly to the costs of the overall shipping operation and makes the St. Lawrence River ports less attractive, so forecasting accuracy is essential.

6.4.6 Study Organization, Costs and Schedule

The three study teams (or representatives), in each of the sections a), b) and c) below, will come together as a single binational Commercial Navigation Study Team to consider all aspects of the work.

While there are normal differences in the nature of the commercial navigation activities in the three zones in the system, there is a need to provide compatible outputs of the studies. This will include identification of the interests that depend on commercial navigation on the Lake Ontario - St. Lawrence River system and how they would be affected under various scenarios. Therefore, the studies will not be limited to economics, but will include other types of outputs where appropriate.

a) Lake Ontario

Work will be overseen by a binational Study Team. Representatives for this section will include the Corps of Engineers, The Canadian Coast Guard, Transport Canada, one U.S. and one

Canadian port manager, and the Great Lakes Pilotage groups. Contracted resources may be used in some cases such as in data collection, but it is envisaged that the Corps of Engineers would carry out the main Transportation Model development, with input from Canadian authorities represented on the steering committee. Table 5 a and b give estimates of the cost associated with evaluating criteria in terms of commercial navigation interests located at Lake Ontario ports.

Table 5a. Time & Cost Estimate - Commercial Navigation, Lake Ontario (U.S. $K)

Major Tasks	YR1	YR2	YR3	YR4	YR5	Total
Review of other Models, Literature	8	16	16			**40**
Develop Levels - Impacts Transportation Model	16	32	40	32	20	**140**
Collect/Update Physical Data	20	20	20			**60**
Surveys/Interviews- Develop, Administer, & Analyze			24	32	24	**80**
Evaluate Development Of An Information System				15	10	**25**
Report Writing-Data preparation, other processing				5	15	**20**
Coordination (Meetings and Travel)	5	5	5	5	5	**25**
Total	**49**	**73**	**105**	**89**	**74**	**390**

Table 5b. Time & Cost Estimate - Commercial Navigation, Lake Ontario (Cdn. $K)

Major Tasks	YR1	YR2	YR3	YR4	YR5	Total
Review of other Models, Literature	3	6	6			**15**
Develop Levels - Impacts Transportation Model	6	12	15	12	8	**53**
Collect/Update Physical Data	8	8	8			**24**
Surveys/Interviews- Develop, Administer, & Analyze			9	12	9	**30**
Total	**17**	**26**	**38**	**24**	**17**	**122**

b) St. Lawrence River - Seaway

The identified work will be overseen by the binational Study Team. Representatives for this section will include from the Seaway Entities, the U.S. Army Corps of Engineers, the Canadian Coast Guard, local Pilotage representatives, and the Environment Canada Great Lakes Regulation office in Cornwall. Actual development of the required data including conduct of tests and measurements, can be conducted through private sector contractors.

Estimated Cost:

1. Data collection and analysis for levels, flows and currents at critical point; of information on underkeel and channel side clearances at critical points; review of literature, and development of reports **$550K Cdn**

2. Development of models to permit consideration of impacts of changing levels and flow conditions on cargo carriage by regular users of the system, including consideration of changes to present "alert levels" and **$300K Cdn**

minimum navigation elevations, and of the impact to commercial navigation under extreme low flow and extreme high flow conditions

3. Analysis of the impact of new or revised criteria proposed as a result of the work of other interests included in the overall Study **$150K Cdn**

Total $1,000K Cdn

Table 5c. Time and Cost Estimate-Commercial Navigation, St. Lawrence Seaway

Canadian Estimates (Cdn $K)	YR1	YR2	YR3	YR4	YR5	Total
Tasks as Listed Above	80	120	350	250	200	1000

c) St. Lawrence River - Port of Montreal & Downstream

As with the St. Lawrence and Lake Ontario reaches, a binational Study Team will oversee the work. Representatives for this section will include the Port of Montreal, the Canadian Coast Guard, Environment Canada, and the Laurentian Pilotage Authority, and the U.S. Army Corps of Engineers. The identified work (listed in Section 6.4.3 c) can best be performed by a private consultant. This may be combined with all or parts of other works identified under this Study Plan. As well, another important assumption is that the evaluations of the interests will not be done in terms of purely economic values; since that approach has not led to meaningful results in the past. Finally, the work/studies identified here are designed to help the principle objective of facilitating criteria review, including the potential of new criteria being introduced.

The costs estimated are :

	Cdn. $
1. Reviews of other models, other literature and data:	$ **50 K**
2. Evaluation of seasonal patterns, volume of traffic impacted by limited water depths, and benefit or loss based on levels:	$**100 K**
3. Evaluation of short-term effects of Lake Ontario outflow changes or Beauharnois/Cedars operations:	$**200 K**
4. Impact of winter operations:	$**100 K**
5. Impact of extreme high/low flows:	$**400 K**
6. Montreal traffic vs Seaway:	$**100 K**
7. Data preparation in specific formats and other processing :	$ **20 K**
8. Misc., contingency & travel :	$ **30 K**
Total :	**$1000 K**

Table 5d. Time and Cost Estimate-Commercial Navigation, Montreal & Downstream

Canadian Estimates (Cdn $K)	YR1	YR2	YR3	YR4	YR5	Total
Tasks as Listed Above	100	250	250	100	300	1000

Table 5e. Total Time and Cost Estimates for Commercial Navigation

	YR1	YR2	YR3	YR4	YR5	Totals

U.S. Totals (U.S. $K)	49	73	105	89	74	390
Canadian Totals (Cdn $K)	197	396	638	374	517	2122

6.5 **Hydroelectric Power Interests**

6.5.1 Relationship to Water Level Fluctuations

a) Power from the River

Although water level changes effect hydropower generation, power generated depends on several factors - head, flow, continuity, and efficiency.

- Head is the vertical distance that water falls across the turbines to create power. Higher head, (i.e. the greater distance for the water to fall), means higher power.
- Flow is the amount of water that falls through the turbines, which converts potential energy to electrical energy.
- Continuity can be described as the reliability of the river flow.
- Efficiency is the percentage of the potential energy of the water transformed to electrical energy. Given the history of the other three values above, turbines at hydropower stations are designed to minimize the waste of energy and are carefully shaped for high efficiency.

b) Lake Ontario – St. Lawrence River Flow Relationships

In the Lake Ontario – St. Lawrence River system the following relationships must be understood as they relate to Lake Ontario water levels as explained below.

- Relatively higher water levels on Lake Ontario means relatively higher flows as directed by the regulation plan. This translates into more electricity generated. However, as the flow increases at the power stations, the headwater level (water elevation at the upstream side of the powerhouses) must decrease since the slope from the lake to the powerhouses will increase. At the same time the tailwater (water elevation at the downstream side of the powerhouse) increases. Effectively, this lowers the head for which to generate electricity.

- Relatively lower water levels on Lake Ontario means relatively lower flows as directed by the regulation plan. This translates into less electricity generated. However, as the flow decreases at the power stations, the headwater increases. At the same time the tailwater decreases. Effectively, this increases the head.

- When flows increase or decrease too much, adverse impacts can result. When flows increase too much, the efficient use of the water is lessened. In fact, a point is reached when an increase in flow does not increase the electricity generated. Higher flow will result in lower efficiency and may result in the powerhouse capacity being exceeded, necessitating spillage. When flows are too low, the total electricity generated is much lower, and cannot meet the demands of the power system. Thus electricity needs to be obtained from other

sources at higher prices.

The hydro plant operators understand these changing relationships and attempt to maximize the efficient use of the water from regulation. The fact that the St. Lawrence River is one of the most dependable flowing rivers in the world is due to the huge surface area of the Great Lakes that form the largest series of reservoirs in the world. Any changes in regulation may not have a very large impact on hydropower from year to year. However, the timing of the flow distribution within the year has the greatest effect on impacts to the hydro plant operators. From a power generation standpoint, it is ideal to generate electricity to meet electricity demand. Typically the highest demand has been in the winter months. However, an increase in the summer peak demand over the last decade has moved the summer peak closer to the winter peak.

c) Lake Ontario – St. Lawrence River Ice Management

The regulation plan, controlling Lake Ontario outflows and the economics of power production, depend upon the capability of the critical sections of the international section of the St. Lawrence River to pass the prescribed volume of water through the channels during the winter months. This capability is achieved through the establishment of a smooth and stable ice cover by reducing velocities in the various channel reaches. This in turn requires a reduction in the outflow of Lake Ontario, sacrificing power generation on the short-term, while the ice cover forms, for the sake of greater reliability in power production and regulation on the long-term.

Winter operations are influenced by the hydrologic conditions on the Great Lakes basin and the meteorologic, hydraulic and physical conditions of the International Rapids Section of the river. Experience gained over the period since regulation began, has demonstrated the need to maintain the hydraulic capacity of this section of the river in order to meet the extraordinary requirements placed upon the system by hydrologic supply conditions. Although the Plan 1958-D restricts Lake Ontario mean outflows of no more than 6230 m^3/s in January, from 6800 m^3/s to 7930 m^3/s in February and 7930 m^3/s in March, the Board has directed discretionary flows well in excess of these values under favourable ice conditions in order to deal with the high supply conditions that have occurred since regulation began. Although recorded outflows higher than Plan have demonstrated the capacity of the channels, under favourable conditions, the resulting head losses and related inefficiencies remain a serious concern to the hydropower interest, as do the risks to the other users of the system.

6.5.2 Past Studies

"Winter Operations – International Rapids Section of the St. Lawrence River", proceedings of the International Symposium on Ice, International Association of Hydraulic Research. Bartholomew, J., T.E. Wigle, and C.J.R. Lawrie. 1981

"Ice & River Control", Journal of the Power Division American Society of Civil Engineers, Bryce, J.B. November 1968.

"Effects of Peaking and Ponding Within the St. Lawrence Power Project Study Area – Analysis of Historic Data", report to International St. Lawrence River Board of Control, Ontario Hydro and the New York Power Authority. Carson, R.K., and R.P. Metcalfe. March 1994,

"Hydropower Evaluations for the Mainstem Projects in the Great Lakes-St. Lawrence Basin", reports to Working Committee 3, Levels Reference Study. Irvine, Leonard and Taylor. March 1993 and addendum May 1993.

"Regulation of Great Lakes Water Levels, Appendix F, Power", International Joint Commission. 1973.

"Studies to Improve the Regulation of Lake Ontario", status report of the International St. Lawrence River Board of Control Working Committee to the St. Lawrence Board. 1975.

"*Update of Studies to Improve the Regulation of Lake Ontario, report to the International Joint Commission*", International St. Lawrence River Board of Control. January 1980.

"*An Updated Regulation Plan for the Lake Ontario – St. Lawrence River System, report to the International Joint Commission*", International St. Lawrence River Board of Control. June 1997. (This report cites preference indicators supporting hydropower interests. These indicators will be further examined in the study).

Levels Reference Study Board, March 1993a, *"Hydropower Evaluation for the Mainstream Projects in the Great Lakes - St. Lawrence River Basin"*, report to Working Committee 3, Existing Regulations, System-Wide Regulation and Crisis Conditions.

6.5.3 New Study Scope, Data Collection Needs, Evaluation Methods

It is felt that sufficient information is available to evaluate the hydropower interest. New studies or additional data collection are not required.

Evaluation of alternate regulation plans or regulation studies will be performed using existing in-house computer models. The models utilize flow, head, and turbine-generator efficiency to simulate power plant operation. The resultant energy production is compared to base case scenarios.

The hydropower entities have developed operational evaluation models. These models could be adapted to evaluate the impact of different regulation alternatives on the hydropower industry. Costs associated to impact evaluation are related to the model set-up, execution and interpretation, and presentation of results.

6.5.4 Implications of Climate Change, Demographics, and Other Changes

Climate change, whether resulting in lower or higher available flow, will impact hydropower production. Rehabilitation of power plants anticipates higher inflow into the 21st century. As a result, turbine best efficiency flow capacities are being increased 5-10%.

Climate change can not only effect the supply of electricity, but also the demand for electricity. In addition, changing demographics have altered the demand for electricity. Increased temperatures result in lower winter demand for electricity, offset by higher summer demands. Increased populations in general increase electricity demand throughout the year. Higher summer peak load demands might be attributed to increases in the overall population, increases in air-conditioning, as well as the increase in the number and use of dual residences in the summer for recreation.

From a power generation standpoint, it is necessary to generate electricity to meet electricity demands. The cycle of annual electricity demand at the beginning and during the early life of the project produced peak demands during the winter months, December through March. Recent demand forecasts suggest that Great Lakes basin utilities will be facing a shift from a winter peaking system to a summer peaking system.

6.5.5 Optimal Conditions

a) Lake St. Lawrence – New York Power Authority & Ontario Power Generation

i.) Minimize the frequency of flows above best efficiency.
- Efficiency flow varies with head. In addition, modifications to turbine machinery result in changes to the efficiency flows. Average operating head at the Moses-Saunders power plant over the past 37 years is 24.8 metres. A long-term modification program will change the 24.8 metre efficiency flow from approximately 7840 m^3/s to approximately 8400 m^3/s by 2012. Currently, the efficiency flow at 24.8 metre head is 8200 m^3/s.

ii.) Minimize the frequency of flow/level combinations that result in Long Sault levels above 73.9 metres.
- Generally, elevations above 73.9 metres require Iroquois Dam to be operated to reduce the Lake St. Lawrence level.
- An approximation of this would be to minimize the frequency of flows below 6000 m^3/s.

iii.) With ice cover, minimize frequency of flows above 7400 m^3/s.
- Flows generally less than 7400 m^3/s are preferred to reduce the risk of ice cover failure. Maintenance of a strong ice cover allows flow capacity to be maintained throughout the winter period.
- The physical condition of the ice plays an important role in the capacity under ice cover conditions. Stronger ice has allowed flows higher than the nominal 7400 m^3/s to be released while weak ice has limited flows to less than this amount in a few cases.

iv.) Minimize the frequency of flows above 6230 m^3/s (220,00 ft^3/s) during ice cover

formation.

- To permit ice formation, channel enlargements were designed to ensure the maximum velocity in any cross-section of the channel between the Lotus Island and Iroquois Point, and from above Point Three Points to below Ogden Island, does not exceed 0.69 m/s (2.25 feet/s) at an outflow of 6230 m^3/s (220,000 ft^3/s).
- Although the start of the ice cover formation period has been recorded each year since 1960, the duration of the formation period has not been recorded. As a result, determining this period for each year is not possible. Each winter, ice first begins to form downstream of the International Section and then progresses upstream. This timing is highly variable depending on the weather. Ice in the International Section has begun to form anytime from early December to late January.

v.) Minimize the magnitude of average week to week flow changes, except as needed for ice management.

- Hydro plant equipment requires periodic servicing. Normally, the servicing is scheduled during the low flow periods in order to avoid spillage. Large week to week flow changes or fluctuations can disrupt a planned outage schedule and power production plan. In some cases, the flow changes may cause unnecessary spillage.
- Large week to week flow changes can cause large fluctuations in the level of Lake St. Lawrence. The largest week to week changes in elevation have occurred during the winter and are due to ice restrictions and winter regulation flow changes.

vi.) Pass relatively higher flow in the high demand periods of the winter and summer.

- Annual electricity demand curves, at the beginning and during the early life of the project, peaked during the winter months of December through March.
- Changing demographics and changing climate in the Great Lakes basin over the later part of the century have resulted in a growth of the summer demand for electricity. It is anticipated that by 2005 Ontario will shift from a winter peaking to a summer peaking system on a weather normal basis.

vii.) Maximize the energy production

- The St. Lawrence River is one of the most dependable flowing rivers in the world due to the size of the watershed. Any change in the regulation may not have a very large impact on hydropower from year to year. However, the timing of the flow distribution within the year has the greatest effect on impacts to the hydro plant operators. It is more beneficial to generate more power when power demand is greatest. Typically highest demand has been in the winter months. However, an increase in the summer peak demands over the last decade has moved the summer peak closer to winter peak demands.

b) Beauharnois-Cedars Complex

The Beauharnois-Cedars Complex is composed of two powerhouses. The complex is not located within the international section of the St. Lawrence River and therefore is not subject to

the authority of the IJC. However, water that flows through the St. Lawrence control works for Lake Ontario run downstream through this complex. Thus, there is a downstream impact of the Beauharnois-Cedars Complex caused by Lake Ontario regulation.

The head is 24 metres at Beauharnois and 12 metres at Cedars. The best efficiency flow at Beauharnois, with all the units available (36 units), is 7300 m^3/s and the production factor is 0.20 MW/ m^3/s. The maximum flow capacity is 8200 m^3/s. Between 7300 and 8000 m^3/s, the average incremental flow efficiency is approximately 0.10 $MW/m^3/s$ (50% of the best efficiency point), which is similar to the best efficiency of the Cedars powerhouse (0.10 $MW/m^3/s$). Between 8000 and 8200 m^3/s at Beauharnois, the incremental flow efficiency is close to zero. The minimal flow at Cedars is 300 m^3/s. The maximum flow with the 17 units available at Cedars is 1700 m^3/s.

In summary, with 36 units available at Beauharnois and 17 at Cedars, best efficiency is obtained up to a maximum inflow of 7600 m^3/s (7300+300). The efficiency falls to 50% for the incremental flow between 7600 and 9700 m^3/s and the flow is spilled above 9700 m^3/s.

Because of the large number of units and the limited capacity of Beauharnois, the maintenance program has an important impact on the capacity of the powerhouses. The number of units available is 32-33 at Beauharnois and 14 at Cedars and should be considered to be more representative of the normal conditions. In practice, the production factor is 0.2 $MW/m^3/s$ for inflow from Moses-Saunders up to 7000 m^3/s and 0.1 $MW/m^3/s$ for incremental inflow between 7000 and 8400 m^3/s and 0.0 $MW/m^3/s$ above 8400 m^3/s.

As the local inflow to Lake St. Francis varies typically between 0 and 1500 m^3/s during the year, with an average of 200 m^3/s, these inflows have an important impact during the freshet.

These characteristics of the Beauharnois-Cedars Complex have two main impacts on the requirements to maximise the production:

- flows must be as stable as possible throughout the year (except as required during the formation of an ice cover). For example, it is much more efficient to pass 7000 m^3/s all the time than 6000 m^3/s and 8000 m^3/s 50% of the time each.
- accurate flow forecasts for the longest period possible is very important in reducing the impact of the maintenance program.

c) Ice Management at Beauharnois-Cedars

The ice cover at Beauharnois begins about one week earlier than at Moses-Saunders. During the ice cover formation, the flow in the Beauharnois canal must be lowered to an average of 4500 m^3/s for about two weeks (including a maximum of 4000 m^3/s for 1 day) and the maximum safe flow at Cedars is 1800 m^3/s (maximum flow which can be managed with gates under remote control). In practice, the maximum flow of 6230 m^3/s used for ice formation at Moses-Saunders is valid also as an average for Beauharnois-Cedars. Under lower Lake

Ontario supply conditions, the value of 6100 m^3/s is more adequate. In any case, the flows are subject to daily adjustments. After the ice cover formation, the ice restriction limits the flow at about 7000 m^3/s in the Beauharnois canal for the rest of the winter.

In conclusion, the following typical conditions must be taken into consideration:

a. Minimize the frequency of flows above 8400 m^3/s.
b. Minimize the frequency of flows below 6000 m^3/s.
c. Minimize the frequency of flows above 6100 m^3/s during ice cover formation.
d. Pass relatively higher flow in the high demand periods of the winter and summer.
e. Minimize the magnitude of average week to week flow changes, except as needed for ice management.
f. Flexibility in the regulation plan to vary the timing of flow reductions for ice formation.
g. Flexibility in the regulation plan to vary the timing of flow increases to meet energy demands.
h. Flow must be foreseeable several weeks in advance.

6.5.6 Study Organization, Cost & Schedule

The studies and evaluations would be conducted by the power entities listed in Annex 1 and results evaluated by the overall Study Team. Study organization, cost and schedules are highly dependent on the number of evaluations required by the criteria review study. Each time a regulation plan is developed and resultant outflow and head determined, a coordinated assessment of the impact to hydropower would need to be undertaken. It is anticipated that a response time for an impact evaluation would be in the order of two months with an estimated cost of $20,000 U.S. and $60,000 Canadian per evaluation. For budget purposes, a total of ten evaluations, spread over years 4 and 5 of the Study was assumed.

6.6 **Domestic, Industrial and Municipal Water Uses**

6.6.1 Relationship to Water Level Fluctuations

In general, municipal water supplies are unaffected by fluctuating water levels in the Lake Ontario-St. Lawrence River system. The reason for this is that most, if not all, municipal water intakes are located such that the depth of water over them ranges from 20 to 40 feet. This affords them a measure of protection from damages resulting from both commercial and recreational boating activities. It also protects them from damage caused by icing conditions and floating materials. It has been found that the quality of water supplies taken from these depths is far superior to that taken from shallow water depths.

During the fall (low water period) of 1998, individual "shore well" water supplies along the shores of eastern Lake Ontario experienced problems which required expensive corrective action by the owners in order to provide adequate potable water. The problem was noted on both sides of the border as well as the Thousand Islands section of the St. Lawrence River. Similar experiences have occurred in the Lake St. Lawrence area during periods of high discharges from the system.

On the U.S. side of the system, the New York State Department of Health strictly regulates municipal water intakes. The Ontario Ministry of the Environment and Energy and the Ministère de l' Environnement du Quebec , Quebec, as well as local conservation authorities are responsible on the Canadian side. Current regulations require that new facilities be installed at depths which make them unaffected by fluctuating water levels in the system, even levels that could exceed those set by the Orders of Approval.

6.6.2 Past Studies

The report to the governments by the International Joint Commission titled "*Great Lakes Diversion and Consumptive Uses*" issued in January 1985 addressed the issue of "*Domestic, Industrial and Municipal Water Uses*". In addition, the "*Levels Reference Study, Great Lakes-St. Lawrence River Basin*" submitted by the Levels Reference Study Board to the IJC in March 1993 touched on the same subject to a degree. However there has never been a complete study of the potential problems that water level fluctuations might cause to domestic, industrial or municipal uses.

6.6.3 New Study Scope, Data Collection Needs and Evaluation Methods

To adequately assess the potential for problems caused by the fluctuation of the levels of Lake Ontario and the St. Lawrence River as far as Trois-Rivières, Quebec, a complete inventory of the municipal and industrial water intakes and treatment facilities (locations) must be undertaken. Private domestic water intakes present a more serious problem that will be discussed separately.

a) Municipal and Industrial Supplies

A typical inventory of a municipal or industrial supply must, of necessity, include the following steps:

i.) Identification of the facility having water supply intakes in either Lake Ontario or the St. Lawrence River. This will require multiple meetings with regulatory agencies, review of any files and/or information available in New York, Ontario and Quebec.
ii.) Site visit to include acquiring pertinent data and available maps of the facility and intake. At this time, it is estimated that there are approximately 100 sites to be visited, and information from each to be gathered and cataloged.
iii.) Interview with the facility operator to determine any past or potential problems caused by fluctuating water levels.
iv.) Inclusion of acquired data into database.
v.) Cataloging of all maps, plans and/or diagrams for future reference.

b) Private Domestic Supplies

As previously stated, identification and inventory of private domestic water supplies would be a cost prohibitive exercise due to their unregulated nature as well as the sheer number of private users. Rather than attempt to identify and catalog users, a more effective procedure would be to interview known parties with recorded problems from water level fluctuations. From the results of those interviews, guidance could be provided to them and others through pertinent agencies or municipal governments for possible corrective measures and/or proper methods of installation of private supplies to minimize effects from water level fluctuations.

After all data is collected and duly recorded into a database, evaluation of the affects of wide swings in the levels of the pertinent bodies of water can be analyzed. Suggested corrective measures can be made for those systems that could possibly be adversely affected. The database could be used by other agencies having cogent interests in the results of the study. Some of those agencies might be:

- The New York State Department of Health
- The New York State Department of Environmental Conservation
- The U.S. Army Corps of Engineers
- Local Municipal jurisdictions of New York
- The Ministries of the Environment of Ontario and Quebec
- Environment Canada
- Fisheries and Oceans Canada
- Local Municipal Jurisdictions of Ontario and Quebec

6.6.4 Implications of Climate, Demographics and Other Changes

The importance of domestic, and sanitary water uses is recognized in the Boundary Waters Treaty which accords them a certain preference. Climate change could have a significant impact on the intakes that facilitate this use. Scenarios, which predict that lower water levels will occur, will affect the ability of intakes to draw water. However, each site will be affected differently and the inventory which will take place will determine the extent of the impact.

Demographics may increase water use which can have two affects in terms of water intakes: lower levels can reduce the ability of the intake to draw water and increased demand for water may stress the capacity of existing intakes to supply water. The inventory will include an itemization of intake characteristics that will allow the assessment of demographic impacts to be made.

6.6.5 Optimal Conditions

Since each intake and municipality is different, optimal conditions will be assessed on a case-by-case basis. Once each site is assessed, generalities will be identified and an optimal condition for overall use will be defined.

6.6.6 Study Organization, Costs and Schedule

Because of the great amount of time required to accomplish the large number of site visits, the study organization for those tasks perhaps should be private consulting engineering companies in New York State, as well as in Ontario and Quebec provinces, and other agencies as listed in Annex 1, the results of which will be evaluated by a binational Study Team.

Table 6a. Time and Cost Estimates - Water Uses Studies (U.S. $K)

Major Tasks	YR1	YR2	YR3	Total
Research necessary to identify all Municipal and industrial systems utilizing water from Lake Ontario or the St. Lawrence River	10	3		13
Research necessary to identify known individual systems with a history of problems caused by water level fluctuations	5			5
Site visits to achieve data collection. Estimate a minimum of 100 sites	50	50		100
Travel time to and between sites	6	6		12
Establish and compile data base		6	6	12
Catalog/file acquired maps, drawings, diagrams		6	6	12
Prepare and distribute final report			12	12
Travel expenses	8	8	8	24

Total	**79**	**79**	**32**	**190**

Table 6b. Time and Cost Estimates - Water Uses Studies (Cdn. $K)

Major Tasks	**YR1**	**YR2**	**YR3**	**Total**
Research necessary to identify all Municipal and industrial systems utilizing water from Lake Ontario or the St. Lawrence River	12	7		19
Research necessary to identify known individual systems with a history of problems caused by water level fluctuations	8			8
Site visits to achieve data collection. Estimate a minimum of 100 sites	75	75		150
Travel time to and between sites	10	10		20
Establish and compile data base		10	10	20
Catalog and file all acquired maps, drawings & diagrams		10	10	20
Prepare and distribute final report			20	20
Travel expenses	11	12	12	35
Total	**116**	**124**	**52**	**292**

7. HYDROLOGIC AND HYDRAULIC EVALUATION

7.1 Integrated Great Lakes – St. Lawrence River Model

The evaluation of Lake Ontario regulation plans, the practicality of proposed criteria, and the hydrologic impacts on the interests, require computer simulation of water levels and flows of the Great Lakes–St. Lawrence River system downstream as far as Trois-Rivères, Quebec. In its 1993 final report to the IJC, the Levels Reference Study Board recommended among other things, that work continue on upgrading models used for simulation, forecasting and regulation to formulate a comprehensive water supply and routing model that includes the whole basin through Trois-Rivières, Quebec and includes the influence of the Ottawa River. While separate computer models exist for different parts of the system, and substantial progress has been made in the development of a coordinated routing and regulation model for the upper lakes, additional work is required to develop and integrate Lake Ontario regulation plan(s) and St. Lawrence River components into the model to simulate water levels and flows of the entire system. As the focus of the work is on Lake Ontario outflow regulation and since Lake Ontario outflows are regulated on a weekly basis, it is proposed that the simulation time-step be quarter-monthly, which approximates a week and is the period of much of the available hydrologic data. With this time step it is possible to ignore short-term effects such as those caused by winds and transients set up by flow changes. The completion of the coordinated, system-wide regulation and routing model will enable simulations, at a quarter-monthly time scale and an appropriate degree of accuracy for this study, under different regulation scenarios and hydrologic conditions.

To examine the short-term effects (i.e., within a quarter-month) of regulation on the St. Lawrence River upstream of Cornwall-Massena, a 2-D hydrodynamic model will be developed of the river from near Kingston to the Moses-Saunders dam. This model will be used to investigate detailed and short-term effects of flow changes on levels and velocities that would be needed to answer commercial navigation, recreational boating and environmental questions as well as operational hydraulic, hydropower generation and ice formation questions. *{Topographic and bathymetric data needed for such a model will be collected as a separate part of the work as described in section 4.2}*

7.2 Modeling of the St. Lawrence, Ottawa River and Other Tributaries

Regulation of the outflows of Lake Ontario affect water levels and flows of the St. Lawrence River well downstream of the project. The existing IJC regulation criteria require that water level and winter ice conditions at the Port of Montreal and operations during the annual flood discharge from the Ottawa River be taken into account in regulating Lake Ontario outflows. Operating experience has shown that ice conditions on Lac St. Pierre and spring runoff from downstream tributaries can also affect Lake Ontario regulation. Questions have been posed about the potential impacts that flow variations resulting from Lake Ontario regulation may have on the natural environment downstream. To assess the effects of Lake Ontario regulation and

potential changes to the regulation criteria, sufficiently accurate water level and flow modeling of the St. Lawrence River downstream to Trois-Rivières is essential.

A review of the available methods to simulate the hydraulic relationships of the Montreal archipelago and the river downstream to Lac St. Pierre and the development of possible improvements within the coordinated routing model will be conducted. Factors to be examined include the modeling of ice and aquatic vegetation growth on the hydraulics of the channels. Environment Canada, Quebec Region has completed much of the development of a detailed 2-D hydrodynamic model for the St. Lawrence River downstream of Cornwall including the Montreal archipelago. The fine spatial resolution of about 60 m of the existing configuration of the model would entail significant resources for long-term simulations, however, this resolution may be able to be increased for more efficient hydraulic routing. It may be possible to vary the resolution of this model whereby selected critical supply periods could be simulated at a high resolution for flood or habitat impact modeling. To use this model for floodplain delineation, habitat and possibly other criteria review studies, a digital elevation model (DEM) (vertical resolution of ±25cm) needs to be developed of the floodplain of the St. Lawrence River between Beauharnois and Trois-Rivières. The DEM would be needed for more accurate modeling of the flow-level relationship in the river as needed for habitat studies and in the delineation of flooded areas under the spectrum of expected hydraulic conditions. *{This DEM will form part of the work described in section 4.2}.* The applicability of this hydrodynamic model will be investigated and, if appropriate, adapted for use in this study.

The time series of hydrologic data needed by the downstream routing model needs to be generated. To accomplish this, sets of recorded and/or simulated outflow data need to be obtained or developed to simulate Ottawa River and downstream tributary outflows consistent with those generated for Lake Ontario water supplies. For the climate change case, a suite of hydrologic models for the tributaries to Lake St. Francis, the Ottawa River, the Richelieu River and several other major tributaries downstream of Montreal need to be obtained or developed to translate the precipitation and temperature data from the climate models into outflows to the St. Lawrence from these basins. The models that are used by one or more of the agencies involved with the Ottawa River regulation group can be used to facilitate the process.

7.3 **Great Lakes Supply Scenarios**

7.3.1 Generation of Hydrologic Sequences for the Existing Climate

Lake Ontario Regulation Plan 1958-D was developed and tested using historical water supplies to Lake Ontario for the period 1860-1954 adjusted to the then current diversion and hydraulic conditions. Since regulation began in 1960, more extreme supplies have been recorded. They include the low supplies in the mid-1960s, and higher supplies in the 1970s, mid-1980s and parts of the 1990s. As a result, level and flow conditions outside the design range that is reflected in the existing IJC criteria were experienced. With the existing criteria, these situations lead to regulation under criterion (k) with outflow management through discretion of the Board

of Control and the Commission.
Since the climate factors that produce supply sequences are random in nature, it is unlikely that the historical sequence will ever be repeated. Periods of higher and lower supplies will occur in the future due to the natural variation in climate, even without the effects of anthropogenic increases of greenhouse gases in the atmosphere. To design a regulation plan that would be more useful under a wider range of supplies, a different design approach is needed. To account for this natural variability in supplies, it is proposed that extensive set of synthetic hydrologic sequences be developed based on the statistical properties of existing historical supply and related data sets. A similar approach was used with success in a recent study by Hydro Quebec (Rassam et al, 1992, GLERL 1992) to analyze the spillway facilities at the outlet of Lake St. Francis, however, that work did not include the Ottawa River or downstream tributaries. The Hydro Quebec study synthesized a sample equivalent to 50,000 years. It is proposed that this synthetic data set, that represents the distribution of the potential hydrology, be used for the design and evaluation of the proposed new criteria and Lake Ontario regulation plans.

The first step in this work would be to update (through 1999) the coordinated historical supplies for each of the Great Lakes, flows for the Ottawa River and other downstream tributaries, flows through the major diversions, and flow retardation factors for ice and aquatic vegetation in the connecting channels and the St. Lawrence River. Some of these data (e.g. tributaries between Cornwall and Trois-Rivières) may need to be simulated by hydrologic modeling based on existing precipitation and temperature data. The next step would be to conduct statistical analyses of the structure (e.g., mean, standard deviation, autocorrelation, cross-correlations) of the data series and review the stochastic models developed for the Hydro Quebec study to determine if they are still appropriate (assuming that work would be made available). New stochastic models that can be used to synthesize the outflows from the Ottawa River and other downstream tributaries, and other needed sample series, will need to be developed. The recent work for Hydro Quebec was conducted by their staff, with the advice and assistance of a group of experts from INRS-Eau and Canadian and U.S. universities.

7.3.2 Climate Change

Water supplies and related hydrologic variables representing the most current climate change scenario(s) resulting from atmospheric change research will be generated and used to test the regulation plan and proposed criteria. A similar effort, now nearing completion for the Great Lakes as part of an IJC reference study, can be used if appropriate. Lacking from the existing work is modeling of the hydrologic impacts of climate change on the St. Lawrence tributaries downstream of Cornwall (e.g., Ottawa River basin). The proposed study would use the hydrologic models obtained or developed as part of section 7.1 to simulate the hydrologic effects of climate change on these basins.

A qualitative assessment of changes due to demographic and other possible factors will be made to illustrate how such changes may affect water supplies and related hydrologic factors and their potential impact on regulation. The development of water supply series that simulate the effects of climate change will be carried out by the agencies (e.g., Environment Canada,

GLERL) with experience in this field.

7.4 **Review Existing Regulation Plan, Investigate New Techniques**

Plan 1958-D, the regulation plan presently in effect, was developed using the recorded sequence of water supplies to Lake Ontario for the period 1860-1954. This same sequence of supplies and a similar regulation plan were used in the mid-1950s to design the channel excavations and structures in the upper St. Lawrence River that would provide the needed levels and flows for navigation, ice management and satisfy the criteria in the IJC orders. It was anticipated at the time that more extreme high or low supplies would lead to level and flow conditions outside the criteria. This has been evident since the mid-1960s, and it has not been possible with the existing plan and channel capacities to satisfy all of the existing regulation criteria with the more recent and different sequence of supplies. The recent review of the regulation plan by the St. Lawrence Board (ISLRBC, 1997) showed that Lake Ontario levels outside the range stipulated by criteria (h) and (j) would occur regardless of the regulation plan, given the extreme supplies experienced in the past 40 years and the other constraints in the IJC orders.

During the Levels Reference Study, a number of changes to Plan 1958-D were investigated. Following completion of the Levels Reference study, further investigations on improved regulation plans to replace to Plan 1958-D were carried out by the International St. Lawrence River Board of Control and in 1997 a new regulation plan called Plan 1998 (previously referred to as Plan 35P) was recommended by the Board. The changes incorporated into Plan 1998 attempted to improve the levels and flows for the major users or interests in system, without causing adverse effects on other interests, all within the constraints of the existing IJC regulation criteria. Since the needs of the recreational boating interests and the environment are not explicitly recognized in the IJC criteria, the regulation plan changes attempted to meet these recreational boating and environmental needs insofar as they did not conflict with the existing regulation criteria. While Plan 1998 was not adopted by the IJC due to insufficient information on the environmental impacts and the Commission's judgement that the plan did not provide sufficient improvement over the existing situation. Nevertheless, Plan 1998 did contain new methods that incorporate the knowledge gained from operating experience and several other technical improvements which should be assessed as to their utility.

To compare water levels and flow conditions with regulation to those that would have occurred without regulation, a model of the pre-project or unregulated Lake Ontario outlet hydraulic relationship will be used along with existing downstream hydraulic conditions. As both ice and relative crustal movement affect the relationship between lake levels and unregulated outflows, these two factors will be considered, in a quantitative manner where possible, in the unregulated condition model. This model will demonstrate the extent that Lake Ontario regulation has affected water levels and flows in the Lake Ontario - St. Lawrence River system.

Plan 1958-D is based on the traditional rule-curve method. New techniques are available in operating multi-purpose water control works. For example, the St. Lawrence Board developed

and tested a regulation plan using an optimization technique to take into consideration the needs or preferences of a number of users in the Lake Ontario – St. Lawrence River system. In that model, the Lake Ontario outflow is determined each week based on optimization of the degree of satisfaction for each of the interests with the expected hydrologic conditions.

It is proposed that investigation be made into new potentially advantageous outflow regulation techniques in addition to those considered by the St. Lawrence River Board of Control in their recent work. This work would include a review of regulation methods that use forecasts of supply in their operation and the existing supply forecast methods that are available. Ideally, this will result in a more proactive approach towards regulation.

A review of available hydrologic forecasting techniques for the Great Lakes and the Ottawa River and other downstream tributaries will be made to support the investigation and development of new regulation plans, as well as to assist in the regulation of outflows by the Board of Control under discretionary and extreme conditions development. The existing work and expertise in this area from a number of government agencies (e.g. NOAA, USACE, Env.Can., DFO Hydro Quebec etc.) will be investigated. Adaptation of one or more forecast methods to use in making outflow regulation decisions may be made and tested. The ability to assess the accuracy and usefulness or benefit of forecasts will depend upon the availability of historic data required by the forecast method.

7.5 **Iterative Evaluation of Regulation Plans and Criteria**

It is proposed that new regulation plan(s) be developed and evaluated to determine to what degree they meet the new or updated criteria developed in the study. If the new regulation criteria are to be satisfied by the regulation plan for the chosen hydrologic design conditions, the criteria and regulation plan may have to be developed in concert. If the new plan does not have to fully satisfy the criteria, the criteria can be set prior to the plan development. If the plan cannot meet all of the new criteria, some method of determining the relative importance of criteria must be developed to use to test plan changes and determine which plan best meets these new criteria. The Analytic Hierarchy Process, for example, could be used to weight the criteria. This would allow the quantitative comparison of different plans. Sensitivity analyses could then be applied to the weights to determine the robustness of the comparisons.

With a larger design supply set using the extensive synthetic hydrologic series, the nature of the criteria may more appropriately be in terms of minimizing or maximizing the frequencies of specific conditions. For example, a hydropower criterion might be to minimize the frequency or total amount of spillage. This approach would be different than setting absolute threshold values that are not to be exceeded.

Since the needs and preferences of the various interests are different and at times in opposition, development of a comprehensive set of criteria and a matching regulation plan satisfying all the interests will not be a simple task. There is a need to demonstrate what levels and flows are

physically possible with the current physical regulatory works and channels, through simulation of regulation for the wide range of possible hydrologic conditions. An understanding of the reality and practicability of certain level or flow conditions could help promote better dialogue amongst the interest groups and the acceptance of the needs of others and the eventual needed compromise among the groups. This would be an iterative process likely involving workshops, public meetings, and regulation plan development and testing.

7.6 **Study Organization, Costs and Schedule**

It is recommended that the Great Lakes – St. Lawrence Regulation Office of Environment Canada and the Buffalo District of the U.S. Army Corps of Engineers be requested to lead this study. These two offices have extensive operating experience related to Lake Ontario regulation.

Other agencies having expertise for this work and recommended to be involved are:

- the Great Lakes Environmental Research Laboratory of NOAA to assist in the area of climate change and Great Lakes hydrologic supply simulation,
- hydrology staff from Quebec Region of Environment Canada, Department of Fisheries and Oceans Canada and Quebec Ministère de l' Environment to assist with development of models of Ottawa River and downstream tributary hydrology and St. Lawrence hydraulics,
- staff from Hydro Quebec with expertise to develop or guide the stochastic models of supplies and flows. Consultants with appropriate expertise could also be used, but the experience that Hydro Quebec has in this field would be most valuable.

Table 7a. Time and Cost Estimate - Hydrologic Model and Evaluations (U.S. $K)

Major Tasks	**YR1**	**YR2**	**YR3**	**YR4**	**YR5**	**Total**
Develop/ Operate Routing Model	10	15	15	10	10	**60**
Hydrodynamic 2-D Model of the St. Lawrence River	40	80	60			**180**
Great Lakes & St. Lawrence tributaries supply synthesis	10	30	25	10	10	**85**
Climate change supplies	10	10	15			**35**
Review existing plan	10					**10**
Investigate/ adapt new regulation techniques	10	30	30	20	10	**100**
Hydrologic Forecasting	30	30				**60**
Develop pre-project conditions	20					**20**
Modify and evaluate regulation plans with criteria	10	10	20	20	20	**80**
Travel and Meetings	10	10	10	10	10	**50**
Reporting			10	10	15	**35**

Totals	**160**	**215**	**185**	**80**	**75**	**715**

Table 7b. Time and Cost Estimate - Hydrologic Model and Evaluations (Cdn $K)

Major Tasks	**YR1**	**YR2**	**YR3**	**YR4**	**YR5**	**Total**
Develop/ Operate Routing Model	10	20	15	15	10	**70**
Hydrodynamic 2-D Model of the St. Lawrence River	10	20	20			**50**
Ottawa River/ tributary modeling	50	100	150	20	10	**330**
Great Lakes & St. Lawrence tributaries supply synthesis	30	50	60	10	10	**160**
Climate change supplies	20	10	5			**35**
Review existing plan	10	0				**10**
Investigate/ adapt new regulation techniques	10	20	30	20	20	**100**
Hydrologic Forecasting	50	50	50			**150**
Develop pre-project conditions	20					**20**
Modify and evaluate regulation plans with criteria	10	10	30	30	30	**110**
Travel and Meetings	15	15	15	15	15	**75**
Reporting			10	10	20	**40**
Totals	**235**	**295**	**385**	**120**	**115**	**1150**

8. SCHEDULING AND COSTS

The entire Study would take five years to complete with various interests taking two to four years to evaluate their particular interest. Data collection and existing criteria substantiation will make up a major initial step in the study process during the first two years, but some interests such as "Wetlands / Environment" and "Coastal Erosion & Flooding" will require a full four to five years of data collection

The possibility of condensing the overall project to fit within a three year time frame was considered, but the advice of subject matter experts was that to do so would risk a repetition of the situation associated with the St. Lawrence Board's recommendation to adopt a new Regulation Plan 1998, wherein the Commission determined *(inter alia)* that it did not have sufficient information on the environmental impacts associated with the proposed plan. The overall project is therefore predicated on a full five year period, but it is recognized that the Commission will itself require some additional time after receipt of the Study Board's report before a decision can be made on the adoption or otherwise of the Board's recommendations.

A cost summary, based on the five year implementation period, with phasing of various activities as is outlined in the preceding report, is presented in the table below.

Table 8a. Cost Summary U.S.

U.S. Estimates (U.S. $K)						
Interest Evaluated or Task Undertaken	**YR1**	**YR2**	**YR3**	**YR4**	**YR5**	**Total**
Common Data Needs	500					500
Wetland /Environmental	640	540	575	475	220	2450
Recreational Boating	160	180	160			500
Riparian/Shore Property	770	1030	670			2470
Commercial Navigation	49	73	105	89	74	390
Hydroelectric[1]				120	80	200
Domestic, Industrial and Municipal Uses	79	79	32			190
Hydrology, Hydraulic and Regulation Plans	160	215	185	80	75	715
Public Involvement	270	270	270	270	320	1400
Interrelations Review	50	50	50	50	50	250
Study Management	200	200	200	200	200	1000
Grand Total	**2878**	**2637**	**2247**	**1284**	**1019**	**10065**

Table 8b. Cost Summary Canada

Canadian Estimates (Cdn $K)						
Interest Evaluated or Task Undertaken	**YR1**	**YR2**	**YR3**	**YR4**	**YR5**	**Total**
Common Data Needs	700					700
Wetland /Environmental	865	955	1055	1085	935	4895
Recreational Boating	200	180	160			540
Riparian/Shore Property	770	1130	570			2470
Commercial Navigation	197	396	638	374	517	2122
Hydroelectric[1]				360	240	600
Domestic, Industrial and Municipal Uses	116	124	52			292
Hydrology, Hydraulic and Regulation Plans	235	295	385	120	115	1150
Public Involvement	340	340	340	340	415	1775
Interrelations Review	50	50	50	50	50	250
Study Management	200	200	200	200	200	1000
Grand Total	**3673**	**3670**	**3450**	**2529**	**2472**	**15794**

Note: [1]Hydropower costs are "per evaluation". The above numbers assume 10 evaluations would be made.

ANNEX 1
STUDY ORGANIZATION

The following governmental agencies could assist the Study Board with the Evaluations and Committees Listed Below. Volunteer organizations and industry associations should also be considered.

Committees

Coastal (Erosion Processes & Flood Potential) Criterion

United States

U.S. Army Corps of Engineers, Buffalo District
U.S. Army Corps of Engineers-Waterways Experiment Station
N.Y. State Department of Environmental Conservation
U.S. Geological Survey
The Nature Conservancy

Canada

Environment Canada, Ontario Region
Environment Canada, Quebec Region
Faune et Parcs Québec
Ministère de l'Environnement du Québec
Ontario Ministry of Municipal Affairs and Housing
Ontario Ministry of Natural Resources

Recreational Boating Criterion

United States

U.S. Army Corps of Engineers, Buffalo District
U.S. Coast Guard

Canada

Ontario Ministry of Natural Resources
Environment Canada, Ontario Region
Faune et Parcs Québec
Ministère de l'Environnement du Québec
Ministère des Affaires Municipales, Direction du Loisir et du Sport
Canadian Coast Guard
Marina Operators Association
Canadian Hydrographic Service

Environmental Criterion

United States

U.S. Geological Survey
U.S. Army Corps of Engineers, Buffalo District
U.S. Army Corps of Engineers-Waterways Experiment Station
N.Y. State Department of Environmental Conservation
Environmental Protection Agency

U. S. Fish & Wildlife Service
The Nature Conservancy

Canada

Environment Canada, Ontario Region
Environment Canada, Quebec Region
Faune et Parcs Québec
Ministère de l'Environnement du Québec
St. Lawrence Institute of Environmental Sciences
Ontario Ministry of Natural Resources
Ontario Ministry of Environment and Energy

Commercial Navigation Criterion

United States

U.S. Army Corps of Engineers, Buffalo District
U.S. Army Corps of Engineers, Institute for Water Resources
St. Lawrence Seaway Development Corp.
U.S. Coast Guard

Canada

Canadian Coast Guard
St. Lawrence Seaway Management Corporation
Port of Montreal
Transport Canada
Laurentian and Great Lakes Pilotage Authorities

Hydroelectric Power Criterion

United States

New York Power Authority

Canada

Hydro Quebec
Ontario Power Generation
Transport Quebec

Municipal Interests – Domestic and Sanitary Water Uses Criterion

United States

N.Y. State Dept. of Health
Public Works/ Municipality Representatives or A/E Consultants

Canada

Environment Canada
Faune et Parcs Québec
Ministère de l'Environnement du Québec
Ontario Ministry of Environment and Energy
Public Works/ Municipality Representatives or A/E Consultants

Hydrology & Climate Change/ Variability- Modeling

United States

U.S. Army Corps of Engineers, Buffalo District

U.S. Army Corps of Engineers -Institute for Water Resources, Ft. Belvoir
Great Lakes Environmental Research Lab
U.S. Geological Survey

Canada

Environment Canada, Great Lakes-St. Lawrence Regulation Office
Environment Canada, Atmospheric Environment Service
Environment Canada, Quebec Region
Environment Canada, Ontario Region
Ministère du l'Environnement du Québec
INRS-EAU

Communications- Public Information

United States

U. S. Army Corps of Engineers, Buffalo District
International Joint Commission

Canada

Canadian Coast Guard
International Joint Commission
Environment Canada, Ontario Region
Ministère du l'Environnement du Québec

Interest Advisory Group

Binational representation from the interests identified in Section 5 of this document

ANNEX 2
CRITERIA FOR THE REGULATION OF LAKE ONTARIO OUTFLOWS
from the Orders of Approval for Lake Ontario Regulation
of the International Joint Commission

The criteria are part of condition (i) of the Commission's orders. Condition (i) also states that the outflows from Lake Ontario should be regulated to meet the requirements of conditions (b), (c) and (d) of the orders; that the lake should be regulated within a range of 74.15 m (navigation season) to 75.37m "*as nearly as may be*"; that the criteria are "*standards which would be maintained with minimum variation*"; and that regulation should "*provide no less protection for navigation and riparian interests downstream than would have occurred under pre-project conditions and with supplies of the past as adjusted*". Also this condition states that the regulation plan should not result in velocities or levels in the international section channel more critical than specified in Appendix A. Appendix A states that the maximum mean velocity in any cross-section of the channel to be used for navigation should not exceed 4 ft/s (1.22 m/s) and that the maximum mean velocity in the Ogden Island channels should not be greater than 2.25 ft/s (0.69 m/s) at the stage and flow permitted on 1 January to enable ice cover formation. Supplies of the past refers to 1860-1954 supplies adjusted as defined in Criterion (a). All values have been converted from the original British Standard unit (International Great Lakes Datum (IGLD), 1955) to metric units and IGLD, 1985.

Criterion (a): "The regulated outflow from Lake Ontario from 1 April to 15 December shall be such as not to reduce the minimum level of Montreal Harbour below that which would have occurred in the past with supplies to Lake Ontario since 1860 adjusted to a condition assuming a continuous diversion out of the Great Lakes Basin of 88 m^3/s at Chicago and a continuous diversions into the Great Lakes Basin of 142 m^3/s from the Albany River Basin."

Criterion (b): "The regulated winter outflows from Lake Ontario from 15 December to 31 March shall be as large as feasible and shall be maintained so that the difficulties of winter power operations are minimized."

Criterion (c): "The regulated outflows from Lake Ontario during the annual spring break-up in Montreal Harbour and in the river downstream shall not be greater than would have occurred assuming supplies of the past as adjusted."

Criterion (d): "The regulated outflow from Lake Ontario during the annual flood discharge from the Ottawa River shall not be greater than would have occurred assuming supplies of the past as adjusted."

Criterion (e): "Consistent with other requirements, the minimum regulated monthly outflow from Lake Ontario shall be such as to secure the maximum dependable flow for power."

Criterion (f): "Consistent with other requirements, the maximum regulated outflow from Lake Ontario shall be maintained as low as possible to reduce channel excavations to a minimum."

Criterion (g): “Consistent with other requirements, the levels of Lake Ontario shall be regulated for the benefit of property owners on the shore of Lake Ontario in the United States and Canada so as to reduce the extremes of stage which have been experienced.”

Criterion (h): “The regulated monthly mean level of Lake Ontario shall not exceed elevation 75.37 metres with the supplies of the past as adjusted.”

Criterion (i): “Under regulation, the frequency of occurrence of monthly mean elevations of approximately 75.07 metres and higher on Lake Ontario shall be less than would have occurred in the past with the supplies of the past as adjusted and with present channel conditions in the Galops Rapids Section of the St. Lawrence River” (“present channel conditions” refer to conditions as of March 1955).

Condition (j): “The regulated level of Lake Ontario on 1 April shall not be lower than elevation 74.15 metres. The regulated monthly mean level of the lake from 1 April to 30 November shall be maintained at or above elevation 74.15 metres.”

Criterion (k): “In the event of supplies in excess of the supplies of the past as adjusted, the works in the International Rapids Section shall be operated to provide all possible relief to the riparian owners upstream and downstream. In the event of supplies less than supplies of the past as adjusted, the works in the International Rapids Section shall be operated to provide all possible relief to navigation and power interests.”

ANNEX 3
HISTORY OF LAKE ONTARIO REGULATION

Introduction

Beginning about 1913, the possibility of power development on the St. Lawrence River began to assume considerable importance. In 1920, studies on the proposed St. Lawrence Deep Waterway revealed that it was economically desirable to combine the navigation and power developments in the International Section of the St. Lawrence River. Although the interests of power and navigation in any regulation plan do not necessarily conflict, the requirements for power are more complicated. Navigation interests are concerned primarily with the maintenance of water levels, whereas power interests are concerned with both water levels and discharges, as well as successful operation under ice conditions.

The high Lake Ontario levels of 1952 resulted in a strong demand for the regulation of the levels of the lake to benefit the property owners on its shores in the United States and Canada by reducing the extremes of stage which were being experienced. The June 1952 Reference to the International Joint Commission by the two governments (Docket 67) requested the Commission *". . . to determine, having regard to all other interests, whether measures can be taken to regulate the levels of Lake Ontario for the benefit of the property owners on the shores of the Lake in the United States and Canada so as to reduce the extremes of stage which have been experienced . . . "* The Commission was asked to study the factors affecting the fluctuations of water levels, including Gut Dam and diversions into and out of the basin, and to determine whether a more beneficial range of stage could be brought about having regard to the impending St. Lawrence Power Application. The Commission set up the International Lake Ontario Board of Engineers which submitted special reports from time to time on specific aspects of the investigation, such as Gut Dam, regulation, etc.

The Criteria

The plans proposed for the improvement of the river and for the regulation of Lake Ontario were set forth in the 30 June 1952 Applications of the governments of the United States and Canada to the International Joint Commission for the development of power in the International Rapids Section of the St. Lawrence River. The Application was considered during the summer and autumn of 1952 and public hearings were held, during the course of which it was indicated that then proposed regulation system, referred to as "Method of Regulation No. 5", did not provide the improvements in control of water levels and flows desired under the Reference by the lakeshore interests. Method No. 5 had been prepared in 1940 by the Director, Special Projects Branch, Department of Transport, Canada, along the lines of the method proposed by the Joint Board of Engineers in its report of 10 November 1926, and updated to 1952. Nevertheless, the Commission's subsequent Order of 29 October 1952 (Docket 68) approving the Application, referred specifically to Method No. 5. Moreover, all works connected with the power and navigation scheme, including the channel excavations and backwater computations,

had been based on the levels and flows that would have resulted from that method of regulation which had, as its prime objective, the development of power in the International Rapids section of the river. The regulation requirements on which Method No. 5 was based, were as follows:

(a) Maintain the fluctuations of the levels of Lake Ontario within the levels that would have resulted in the past, assuming a continuous diversion of 3,200 cfs at Chicago and present outlet conditions.
(b) Maintain, without impairment, the low water levels of Montreal Harbour.
(c) Maintain low flows during the winter period, December 15 to March 31, in order that the difficulties of winter power operation are not aggravated.
(d) Maintain flows during the first half of April no greater than would naturally occur, in order to avoid the danger of aggravating the Spring rise in levels during the break-up of the ice below Montreal.
(e) Avoid any material increase in the amount and duration of the high discharges during May, in order not to aggravate high water levels in Lake St. Louis during the times of high flow in the Ottawa River.
(f) Maintain the monthly mean discharges within the limits as existed in nature.
(g) Retard the natural excess outflow during the early summer months, in order to raise the ordinary levels of Lake Ontario.
(h) Secure the maximum dependable flow throughout the year for power operation.

In order to assess the performance of regulation plans to satisfy the Reference of 25 June 1952, the Lake Ontario Board drafted the following criteria:

(a) The regulated outflow from Lake Ontario during the navigation season must be such as not to reduce the minimum level of Montreal Harbour below that which would have occurred in the past assuming a continuous diversion out of the Great Lakes basin of 3,000 cfs at Chicago and a continuous diversion into the Great Lakes basin of 5,000 cfs from the Albany River basin.
(b) The regulated winter outflows from Lake Ontario from 15 December through 31 March should be as large as feasible and should be maintained so that the difficulties of winter power operation are minimized.
(c) The regulated outflow from Lake Ontario during the annual spring break-up in Montreal Harbour and in the river downstream should not be greater than would have occurred in past assuming the diversions as stated in (a).
(d) During the annual flood discharge from the Ottawa River, the regulated outflow from Lake Ontario should not be greater than would have occurred in the past assuming the diversions as stated in (a).
(e) The minimum regulated monthly outflow from Lake Ontario shall be as large as possible consistent with other requirements to secure the maximum dependable flow for power operation.
(f) The maximum regulated outflow from Lake Ontario should be maintained as low as possible to keep channel excavation to a minimum.

(g) The low water level under regulation should be maintained as high as is consistent with other requirements.
(h) Lake Ontario should be maintained throughout the year at as high a level as is consistent with other requirements.

Trial regulation plans within the following ranges of stage on Lake Ontario were developed by the Lake Ontario Board to satisfy the foregoing criteria: 244.0 and 248.0; 243.0 and 247.0 and, 244.0 and 248.8 (U.S.L.S datum). These ranges in stage bracketed the limits of regulated lake levels suggested by the various interests. The maximum level under the latter range would have been almost equivalent to that which would have been recorded had Gut Dam not been in existence during the 1952 high water period (Gut Dam was removed in January 1953). The results of these trial plans were the subject of detailed discussion and scrutiny during 1955 by the International Joint Commission and its advisers who also took into account written representations from riparians and navigation interests, and evidence presented at public hearings. Based upon the hearings held in Rochester, New York, and Toronto, Ontario in April 1955, the Commission, on 9 May 1955, recommended adoption by the two governments of the following:

"*(i) A range of mean monthly elevations for Lake Ontario of 244 feet (navigation season) to 248.0 feet as nearly as may be;*
(ii) Criteria for a method of regulation of outflows and levels of Lake Ontario applicable to the works in the International Rapids Section of the St. Lawrence River; and,
(iii) Plan of Regulation No. 12-A-9, subject to minor adjustments that may result from further detailed study and evaluation by the Commission."

The governments were also advised that the St. Lawrence Seaway and power entities could proceed with the determination of the critical water surface profiles and the final design of the channel excavations on the basis of this range of stage and plan of regulation.

The adopted criteria were as follows:

(a) The regulated outflow from Lake Ontario from 1 April to 15 December shall be such as to not reduce the minimum level of Montreal Harbour below that which would have occurred in the past with the supplies to Lake Ontario since 1860 adjusted to a condition assuming a continuous diversion out of the Great Lakes basin of 3,100 cfs at Chicago and a continuous diversion into the great Lakes basin of 5,000 cfs from the Albany River basin (hereinafter called the "supplies of the past as adjusted")
(b) The regulated winter outflows from lake Ontario from 15 December to 31 March shall be as large as feasible and shall be maintained so that the difficulties of winter power operation are minimized.
(c) The regulated outflow from Lake Ontario during the annual spring break-up in Montreal harbour and in the river downstream shall not be greater than would have occurred assuming the supplies of the past as adjusted.

(d) The regulated outflow from Lake Ontario during the annual flood discharge from the Ottawa River shall not be greater than would have occurred assuming supplies of the past as adjusted.
(e) Consistent with other requirements, the minimum regulated monthly outflow from Lake Ontario shall be such as to secure the maximum dependable flow for power.
(f) Consistent with other requirements, the maximum regulated outflow from Lake Ontario shall be maintained as low as possible, so as to reduce channel excavation to a minimum.
(g) Consistent with other requirements, the levels of Lake Ontario shall be regulated for the benefit of property owners on the shores of Lake Ontario in the United States and Canada so as to reduce the extremes of stage which have been experienced.
(h) The regulated monthly mean level of Lake Ontario shall not exceed elevation 246.77, 1985 International Great Lakes datum (IGLD) with the supplies of the past as adjusted.
(i) Under regulation, the frequency of occurrences of monthly mean elevations of approximately 245.77 and higher on Lake Ontario shall be less than would have occurred in the past with the supplies of the past as adjusted and with present channel conditions in the Galops Rapids Section of the St. Lawrence River ("present channel conditions" refers to conditions as of March 1955 with Gut Dam removed).
(j) The regulated level of Lake Ontario on 1 April shall not be lower than elevation 242.77 (IGLD). The regulated monthly mean level of the Lake from 1 April to 30 November shall be maintained at or above elevation 242.77 (IGLD).
(k) In the event of supplies in excess of the supplies of the past as adjusted, the works in the International Rapids Section shall be operated to provide all possible relief to riparian owners upstream and downstream. In the event of supplies less than supplies of the past as adjusted, the works in the International Rapids Section shall be operated to provide all possible relief to navigation and power interests.

The governments of Canada and the United States advised the Commission on 3 December 1955 that they approved the recommended range of elevations and criteria and the use of Plan 12-A-9 for the purpose of calculating critical profiles and design of channel excavations on the understanding that the Commission would continue its studies with a view to perfecting the plan of regulation so as best to meet the requirements of all interests, both upstream and down, within the approved range of elevations and criteria.

On 2 July 1956, the Commission issued a Supplementary Order to its Order of Approval of 29 October 1952 which deleted all reference to Method of Regulation No.5 and substituted the range of elevations and criteria approved by the governments. The Supplementary Order also provides that *"The Commission will indicate in an appropriate fashion, as the occasion may require, the inter-relationship of the criteria, the range of elevations and the other requirements."*

Plan 1958-A

From early 1958, when the Galops Rapids reach no longer provided the natural control for the outflows from Lake Ontario, until April 1960, the lake levels and outflows were regulated to

their "preproject" values, i.e. the objective was to maintain the "natural" regime (with Gut Dam removed). In early April of 1960, the International St. Lawrence River Board of Control was directed by the International Joint Commission to notify the power entities to discontinue, on 20 April 1960, operation of the St. Lawrence power project works to conform to preproject conditions and to commence operations on that date to the criteria and other requirements of the Commission's Orders of Approval of 29 October 1952 and 2 July 1956.

In consulting with the power entities on compliance with the Orders, the International St. Lawrence River Board of Control had developed a regulation method intended to comply with the Orders of the Commission and the Criteria listed above, which was labeled "Plan 1958-A". The International Joint Commission had approved Plan 1958-A as a workable plan on 24 October 1958 since it met, to a substantial degree, the objectives of its Orders. Regulation operations were commenced and the Board, in its letter dated 5 October 1960, outlined to the Commission the manner by which it would carry out its technical responsibilities so as to provide *". . . . in so far as possible optimum conditions for all interests concerned within the scope of the criteria and other requirements of the Orders of Approval"*. That letter, together with the acceptance by the Commission of "Operational Guides for Plan 1958-A" gave the Board latitude for prompt remedial action which might be necessary under winter operations and emergency situations. Nevertheless, on the basis of its brief experience operating under the approved plan during October and November 1960 when the regulated flows through Montreal Harbour were exceptionally low, the Board in the spring of 1961 sought and obtained from the Commission authority to make discretionary deviations from strict application of the regulation plan. In its joint letter of 5 April 1961, the Board of Control recommended to the Commission that it be granted "discretionary authority" to permit deviation from strict application of the regulation plan – in addition to the deviations necessary for winter operations or emergency situations – whenever, in the Board's opinion, such deviations would provide beneficial effects or relief from adverse effects to one interest without appreciable adverse effects to others and would not endanger meeting the criteria and other requirements of the Commission's Orders of Approval, subject to the following five principles:

1. That the approved range of stage for the regulation of Lake Ontario and the criteria and requirements of the Commission's Orders of Approval of 29 October 1952 and 2 July 1956 shall not be violated as a result of the deviation.
2. That the deviation shall have unanimous approval by the Board prior to the commencement of such deviation.
3. That, following such deviation in Lake Ontario and subject to the conditions of that deviation, the cumulative deviation from the corresponding procedural values shall be eliminated in accordance with the rules of Operational Guides for Plan 1958-A.
4. That any deviation agreed to by the Board shall be promptly reported to the Commission.
5. That, in the event of a disagreement among the members of the Board with respect to a proposed deviation which they are unable to resolve, regulation advice (to the power entities) shall be in accordance with the procedures then in effect and the matter shall be referred to the Commission for decision.

In informing the Board on 5 May 1961 of its approval, the Commission reiterated that the deviations were to be within the criteria and other requirements of the Commission's Order of Approval, *". . . which Order is paramount to any plan of regulation"*.

The use of operational discretion probably offers the best method of combining the advantages and minimizing the disadvantages of regulation by rigid rules and regulation by detailed forecast. By taking advantage of the generally satisfactory pattern of outflows and water levels established by testing rigid rules over a long period of record and by taking advantage of the valuable additional information that is available for a much shorter period of time, operational discretion should result in the optimum use of storage on Lake Ontario. Discretional deviations from a regulation plan with rigid rules would be advisable under the following circumstances:

(a) when a detailed examination of all available hydrological data indicates that the regulated outflows of the regulation plan are not responding to changes in supply conditions; and,
(b) when such deviations could alleviate adverse effects or provide benefits to one interest without detriment to other interests.

The discretionary authority which the Board has been given is a useful tool within its existing terms of reference.

Plan 1958-C

Plan 1958-A was adopted in the knowledge that certain revisions might be necessary in the light of further studies and operating experience. The regulated low flows in October and November 1960 resulted in a re-examination of the manner in which the plan met the requirements of downstream navigation interests, particularly Montreal harbour, and led to the development of a second operating plan, Plan 1958-C. The St. Lawrence Board recommended that this plan be substituted for Plan 1958-A, still having in mind that certain revisions could be necessary in the light of further studies and operating experience. The Commission directed that Plan 1958-C be implemented on 3 January 1962.

Plan 1958-D

Due to deviations from the rule curves of Plan 1958-C because of ice conditions and the below normal supplies which began to be received in the spring of that year (1962), the Board was obliged to use its "operational discretion" in advising the power entities on the regulation of the outflows from Lake Ontario during the period January 1962 through September 1963. In the meantime, a third plan had been developed, Plan 1958-D which was a revision of Plan 1958-C and also provided for an improvement of low water levels in Montreal harbour without reduction of the minimum winter flows of that plan when tested over the available long period of level and flow record (1860-1954). Plan 1958-D was approved for implementation on 4 October 1963.

Since October 1963, Plan 1958-D, with the application of operational discretion as required, has been used by the Board in consulting the power entities and other interests concerned on compliance with the criteria and other requirements of the Commission's Order of Approval of 29 October 1952, as amended 2 July 1956.

Further Regulation Studies

On October 7, 1964, the two governments submitted a Reference to the Commission concerning further regulation of Great Lakes water levels as a result of wide-spread public concern over the extremely low water levels experienced in the mid-1960's. The Commission established the International Great Lakes Levels Board on December 2, 1964. The Board's final report was submitted under date of December 7, 1973.

With regard to coastal development, the Board stated: *"Without question, the benefits to shore property interests are subject to great change if the development of the shoreline becomes more intense. In fact, all the benefits attributable to shoreline property could diminish if proper land use practices are not followed. The demand for waterfront property has resulted in development of low-lying shorelines during the low-water period of the 1960's even though such areas were flooded by high water in 1951-52. Some beach and bluff areas which were relatively stable during the low water period have also been developed even though they were subjected to erosion in 1951-52. All these areas are again experiencing damage from high water levels.....Continuation of such practice will increase future losses despite improved lake regulation."* The Levels Board also pointed out that the *"Great Lakes are a dynamic natural system. Their water levels will fluctuate even with regulation. In periods of high water, storm-driven waves will flood and erode vulnerable shorelands. To live in harmony with his environment and avoid continual losses, man must keep development out of the danger zone."* and the Board recommended that *"Appropriate authorities should act to institute land use zoning and structural setback requirements to reduce future shoreline damage."* In addition, the Great Lakes Levels Board provided estimates of the reduction in the supply to the Great Lakes basin, all of which would be felt by Lake Ontario, through consumptive uses from 2,300 cfs in 1965 to 4,000 cfs in 1985, 6,000 cfs by 2000 and 13,000 cfs by 2030.

In 1973, the St. Lawrence Board requested its Working Committee to review actual operation since regulation began, with the objective of possible incorporation of some of the operational experience and techniques employed over the years into the regulation plan. The Working Committee developed four plans during its investigation and the Board, after reviewing the results of these plans completed in 1975, concluded that none of the plans provided significant improvement over the present regulation plan, i.e. Plan 1958-D with discretionary authority. Subsequently, the Commission, by letter of October 18, 1978, requested the Board to update the 1975 report to include *". . . examination of the period from 1900 to the present for the alternative plans and for Plan 1958-D and a comparison of how each alternative plan meets the range of stage and criteria compared with Plan 1958-D. The Board's report should include as well, the relative costs and benefits of the alternatives. . ."* The Board's

report to the Commission, dated January 1980, concluded that none of the plans investigated, including Plan 1958-D with discretionary authority, met all of the criteria. The Board also pointed out that *". . . waiving specific limits, at the discretion of the Board, when the consequences of such action are more clearly known or understood, provides for more flexible operation and more reasonable results than permanently waived limits based on rigid rules."* As a result of that study, the Board recommended that Plan 1958-D with operational discretion be continued as the plan of regulation for Lake Ontario at that time. The Board also recommended that *"Should the Commission desire further study of all possible changes in regulation beyond the scope of responsibilities assigned the Board in the Commission's letter of 5 October 1960, including physical capacity of the St. Lawrence River, improved forecasting techniques, shoreline management, and the redistribution of benefits which may result, it is believed that such a study should not be conducted by this Control Board, but rather by a Study Board operating under an appropriate reference and fully resourced."*

Under date of October 2, 1979, the St. Lawrence Board of Control requested the International Lake Erie Regulation Study Board to conduct an economic evaluation of its four alternative regulation plans for Lake Ontario. The Lake Erie Regulation Study Board was set up by the Commission on May 3, 1977 to undertake the necessary studies to enable the Commission to reply to the Reference from the two governments on 21 February 1977. A description of the methodologies employed by the Lake Erie Board together with the necessary rationale and software to implement these procedures are found in the final report of the Lake Erie Board which was submitted under date of July 1981. It is noted that, because of funding constraints, an economic analysis of impacts on recreational beaches and boating was not undertaken in Canada. Some of the alternative plans to Plan 1958-D provided relatively minor benefits to coastal zones and recreational interests but all the plans produced losses to navigation and power. In summary, the comparison of the total net economic benefits/losses for each plan clearly showed that all of the alternative regulation plans are inferior to the present operating procedure, i.e. Plan 1958-D with discretionary authority. The economic evaluation reinforced the St. Lawrence Board's conclusion and recommendation as already noted.

From a study of the current regulation criteria, it is obvious that the requirements of regulation pertaining to the needs of power interests are very general. The present interpretation of the term "consistent with other requirements" in Criterion (e) is that benefits to power are limited by the requirements of all other interests. Therefore, as more interests realize that they are being affected adversely by regulation, and as more demands are made on the water resources of the St. Lawrence River system, it is to be expected that the benefits to power due to the plan of regulation will decrease unless the plan can be improved appreciably.

In March 1993, the Levels Reference Study Board submitted its report on methods to alleviate the adverse consequences of fluctuating water levels in the Great Lakes-St. Lawrence River System in response to the Commission's directive of 8 February 1990, as revised 20 April 1990. With particular regard to regulation of Lake Ontario water levels, the Board recommended, among other measures: closer coordination of Lake Superior and Lake Ontario

regulation; revision of criterion (d) for Lake Ontario regulation and the addition of two new criteria to better reflect current needs and interests, and action to improve the data base for water supply forecasting.

Under date of June 2, 1997, the International St. Lawrence River Board of Control submitted a report on its recent regulation studies to the Commission. The Board recommended its updated Plan 1998 replace existing regulation Plan 1958-D. It was pointed out that Plan 1998 retained much of the structure of Plan1958-D so that its improvements over the latter plan were the results of updates to parameters and structure of 1958-D based upon operational experience. The Board noted that, since there is no change in the physical aspects of the system, such as channel capacity and installed generating capacity, improvement in water level and flow conditions is limited. The Board also concluded that implementing Plan 1998 would result in marginal improvements for some of the interests but should be pursued.

On January 15, 1998, after studying the proposed Regulation Plan 1998, the Commission announced in a Press Release that it had decided not to adopt Plan 1998, noting that *"After full consideration of issues raised during public comment, the IJC determined that it does not have sufficient information on the environmental impacts associated with the proposed plan and that the plan would not constitute sufficient improvement over the existing situation."* The Commission also noted that it would *"---continue to pursue support and funding for the development and execution of the more comprehensive studies outlined in a Scope of Work prepared by the ISLRBC in 1996."* The Commission then proceeded with the appointing of this bi-national working group to translate the Scope of Work into a Plan of Study.

ANNEX 4
BACKGROUND DOCUMENTATION AND CORRESPONDENCE

(a) Scope of Work, Criteria Review- Orders of Approval for Regulation of Lake Ontario-St. Lawrence River Levels and Flows by the International St. Lawrence River Board of Control, March 25, 1996.

(b) Letter to Governments from the International Joint Commission regarding the establishment of a Binational Study Team and development of a Plan of Study for Criteria Review, April 15, 1999.

(c) Directive to the St. Lawrence River-Lake Ontario "Plan of Studies" Team from the International Joint Commission.

(d) Article VIII of the "Treaty between the United States and Great Britain relating to the Boundary Waters, and Questions arising between the United States and Canada" (Boundary Waters Treaty of 1909), May 5, 1910 and Appendix G, "Orders of Approval for Regulation of Lake Ontario", July 2, 1956.

ANNEX 4 (a)

International St. Lawrence River
Board of Control

SCOPE OF WORK
CRITERIA REVIEW
in the
Orders of Approval for
Regulation of Lake Ontario-St. Lawrence River Levels and Flows

1.0 INTRODUCTION

By letter dated February 10, 1995, the International Joint Commission (IJC) requested that the International St. Lawrence River Board of Control (Board) submit a scope of work outlining the investigations needed to examine the criteria contained in its Order of Approval for regulation of water levels and flows in the Lake Ontario-St. Lawrence River system. In addition, the IJC requested that the Board address investigations needed to respond to the potential climate change/variability impacts in the Lake Ontario - St. Lawrence River system outlined in the Levels Reference Study Board report.

This document outlines the work necessary to address the issues raised above.

2.0 BACKGROUND

In 1952, following the requests from the Governments of Canada and the United States, the IJC issued an order of approval for the hydropower projects in the international section of the St. Lawrence River. In 1956, the IJC issued a supplementary order and specified a number of criteria which would govern the regulation of Lake Ontario outflows made possible by the hydropower project. The IJC's criteria, contained in Annex 1, explicitly recognized three major interests - riparians, hydropower and commercial navigation. The regulation plans used since 1960 have been developed to meet these IJC's criteria. Currently, the plan in effect is called Plan 1958-D.

The March 1993 final report of the IJC's Levels Reference Study Board (Study Board) contained recommendations calling on the IJC to review and consider amending the criteria "to better reflect the current needs of the users and interests of the system". These Study Board recommendations are as follows:

> *"In particular, the Board recommends that Criterion (d) of these orders be amended as follows: The regulated outflow from Lake Ontario during the annual flood discharge from the Ottawa River shall not be greater than would have*

occurred assuming supplies from the past as adjusted. When Lake Ontario levels and supplies allow, consideration should be given to reducing outflows from Lake Ontario during the annual flood discharge from the Ottawa River."

"The Board recommends that the Orders of Approval for the Regulation of Lake Ontario be modified by adding the following Criteria: Consistent with other requirements, the outflows of Lake Ontario shall be regulated to minimize the occurrence of low water levels on Lake Ontario and the St. Lawrence River downstream as far as Trois Rivières during the recreational boating season."

"Criteria should be added that consider the environmental interest in Lake Ontario and the St. Lawrence River downstream as far as Trois Rivières."

In response to the above, the St. Lawrence River Board in April 1994 appointed a working group charged with determining how the regulation criteria might be modified to be more responsive to current interests.

3.0 CONCURRENT WORK

Concurrent with the development of the scope of work to conduct a review of the regulation criteria, the Board has initiated a study to evaluate two new regulation plans. One plan, called 35P, is a product of the IJC Reference Study while the other independently developed plan is called IS4, a new approach based upon interest satisfaction. These plans are being assessed in terms of the existing IJC criteria. The Board is tracking the performance of these plans as compared to Plan 1958-D and will present its findings at the end of the three-year test period, sometime in 1997.

4.0 PUBLIC CONSULTATION ON THE DRAFT SCOPE OF WORK

During the period April 1994 to May 1995, the Working Group drafted an initial Scope of Work (SOW) for the Criteria Review. To ensure that the views and comments of citizens, interest groups and government agencies are taken into consideration, the Board held a series of public consultation meetings throughout the Lake Ontario - St. Lawrence system.

The Board first introduced the Criteria Review at its annual public meeting of May 15, 1995 in Dorval, Quebec. The draft scope of work was presented in subsequent public consultation meetings, as follows:

August 9,1995 in Alexandria Bay, N.Y.
September 18, 1995 in Rochester, N.Y.
September 19, 1995 in Kingston, Ontario
September 20, 1995 in Cornwall, Ontario, and
November 7, 1995 in Montreal, Quebec

In all, more than 800 people attended these meetings. Presentations made to the Board included those of private citizens and government agencies.

The SOW was finalized, incorporating items and investigations considered by the Board to be required to respond to issues raised during and as a result of the public consultations.

5.0 MEASURING THE NEEDS OF THE INTERESTS

5.1 Emphasis

During the Levels Reference Study, as well as in the current Board's study of new regulation plans, a number of interests or user groups have been identified as being directly affected by fluctuations of water levels and flows in the Lake Ontario - St. Lawrence River system. The potential impacts of the level and flow fluctuations on the majority of these interests are understood and documented in previous reports.

The work envisaged in the study will include an assessment of how water level fluctuations affect the various interests. This will consist primarily of a review of findings and reports of the Reference Study to be followed up with field investigations as needed. Emphasis will be placed on identifying the needs of the environmental, recreational boating and shoreline property interests. Information gathered will be suitable to evaluating the effects of criteria modifications on all affected interests.

The study will bear in mind Article VIII of the Boundary Waters Treaty (attached) and the existing conditions of the Order (attached).

5.2 Geographic Scope

Regulation of the outflows of Lake Ontario affect water level conditions on Lake Ontario and the St. Lawrence River as far as Lac St. Pierre near Trois Rivières. It should be noted that water level fluctuations downstream of Cornwall, Ontario and Massena, New York are also affected by other actions taken at other control works as well as natural factors. For example, the outflows of Lake St. Francis are regulated by control works at Coteau operated by Hydro Quebec. The levels and flows of the St. Lawrence River in the vicinity of Montreal can be significantly affected by discharges from the Ottawa River, particularly during the spring freshet. The Ottawa River discharges are coordinated by the Ottawa River Regulation Planning Board. These Ottawa River discharges can be at times as significant as those of Lake Ontario. However, the Ottawa River and Coteau operations are not under the jurisdiction of the IJC, and therefore no regulation changes will be proposed, but they will be considered in the study.

5.3 The Necessity of Appropriate Data

Recent work, including that of the Levels Reference Study, has generated extensive information on the perceived needs of various interests in relation to Great Lakes water level fluctuations. However, data in a form required to quantitatively analyze the effects of different outflow regulation criteria and plans on the interests are still not available. Useful, representative information pertaining to the environment, wetland habitats, and shore property are key examples.

The Study Board recognized these shortfalls and recommended, among others, that efforts be made to:

- collect data on long-term shoreline erosion and recession rates,
- conduct surveys of flood damage to improve estimates of stage-damage relations, with priority placed on Lake Ontario and the St. Lawrence River, and
- compile a comprehensive wetlands inventory for use in assessing long-term relations between wetlands and water level fluctuations.

The St. Lawrence Board also recognizes these information shortfalls and has concluded that a criteria review will be confronted with these information deficiencies. In order to achieve an evaluation of possible criteria modifications and to make progress towards the resolution of the disparate viewpoints, the collection of appropriate data must form the foundation of this study.

5.4 Relationships between Interests and Level Fluctuations

5.4.1 Wetlands/environment

Significant concern was expressed at the recent public consultation meetings about the effects fluctuating levels and outflow regulation on the natural environment. The lack of specific criteria recognizing the importance and sustainability of the natural environment was a concern

Lake Ontario and St. Lawrence River wetlands are essential habitats for a wide range of flora a fauna. Water level fluctuations affect the extent and composition of wetlands. This relationship can be considered to represent the impact of outflow regulation on the natural environment, but the study will also consider other environmental effects.

Wetland characteristics vary and their resident species have differing needs in terms of levels and flows. The work will include developing a suitable methodology building upon the Levels Reference wetland study findings, and apply those findings to the Lake Ontario - St. Lawrence wetland system. This will involve literature review, consultation with experts in this field, as well as selected but detailed field investigations. Identifying and quantifying the needs of wetlands and translating these needs into useful criteria for outflow regulation is expected to be far more complex than for most of the other interests. The challenge is to provide sufficient data and knowledge such that representative and useful criteria can be found.

Potential sites representative of Lake Ontario and the St. Lawrence River wetlands that may be chosen for detailed study of the inter-relationship between water level fluctuations and wetland include: Braddock Bay (Rochester), Bay of Quinte (Trenton/Belleville), Lakeview Marsh (an east shore location in Jefferson Country), Chippawa Bay (upper St. Lawrence River), and lower St. Lawrence River sites in the Lac St. Francis, Lac St. Louis, and Lac St. Pierre areas.

5.4.2 Recreational Boating

Recreational boating has been a growing use of Lake Ontario-St. Lawrence River waters. In

recent years, boaters from many areas in the system have expressed their concerns to the Board about water levels too low to meet their needs. The general relationship between water levels and recreational boating is well understood. Boaters require adequate water levels or depths to allow them access to their docks, launch sites and other facilities, as well as the recreational waters. Quantitative information on the magnitude of the affects on boating of various water levels in different months and in the different areas of the Lake Ontario St. Lawrence system is generally lacking. The recreational boating site study at Alexandria Bay, New York, developed by the Levels Reference Study, will be examined to determine if its methodology of calculating benefits and losses is appropriate for other locations. Additional work will include gathering additional recreational boating data and developing a suitable method to evaluate the effects of criteria revisions on recreational boating. Based on public consultations, areas to investigate are the eastern shore of Lake Ontario, the upper St. Lawrence River between Kingston and Ogdensburg and downstream in Lac St. Louis and Lac St. Pierre.

5.4.3 Shoreline Property Flood and Erosion Damage

The shoreline property damage concerns expressed by riparians were recognized as important factors in the development of the existing regulation criteria by the IJC in the 1950s. Since regulation began, there have been several periods of high water supplies, storm events and levels that have caused damage to properties on Lake Ontario and in the St. Lawrence River. Although some historic stage-damage information is available, up to date information that quantifies the effects of high and low water levels on shoreline properties is not available. The work in the study will include a review of the existing historic stage-damage information followed by the development and conduct of an appropriate method to provide representative information on the relationship between still water levels and property damage on Lake Ontario and the St. Lawrence River system. The form and extent of the information will be suitable to evaluating the effects of criteria revisions on shoreline property. Potential sites for detailed study could include Greece, N.Y., and Grimsby, Ontario on Lake Ontario and municipalities along Lac St. Louis near Montreal. The erosion evaluation methodology developed by the Levels Reference Study will be examined to see if it can be used to calculate changes in erosion damages.

5.5 Other Interests

Other major interests affected by water level fluctuations include hydropower, agriculture, commercial navigation and domestic-industrial water supply. Based on the experience of the Levels Reference Study, information exists in the literature about these interests. The work will include a review, evaluation and compilation of existing information.

6.0 PUBLIC CONSULTATION

While the May-November 1995 public consultation meetings helped assess the range and intensity of interest views and opinion, they also underscored the need for clearly conveyed messages on Board activities, and the potential impacts of criteria revision. The continuous involvement of all interests throughout the criteria review process is critical to the success of the

endeavor and will be included.

7.0 ASSESSMENT OF CRITERIA

All existing criteria will be reviewed and potential modifications or changes identified, based on operational experiences and the information compiled on the relationships between water levels/flows and the needs of the interests. Emphasis will be placed on possible new criteria.

Regulation plan modelling will be used to test and evaluate various proposed revisions or additions to the criteria. Models will be tested with historic water supply time series, and possibly other supply sequences, to determine the hydrologic effects and feasibility of the revised criteria.

8.0 IDENTIFY ADDITIONAL MEASURES FOR THE OFFSETTING OF CONCERNS

Additional measures available to interests that can or may address concerns and problems will be identified. For example, shoreline property protection and land use management measures have the potential to resolve some shoreline flood and erosion problems. The feasibility of independent regulation of water levels in wetland areas and modifications to recreational boating and navigation practices (e.g., dock siting guidelines, including floating docks, dredging) to resolve some concerns will be addressed. The siting of municipal water intakes will also be addressed.

9.0 IMPACTS OF CLIMATE CHANGE/VARIABILITY

Existing information from the Levels Reference Study Board and other sources will be used to define the possible impacts that climate change/variability might have on Lake Ontario-St. Lawrence River water supplies. Possible modifications to the regulation plan and regulation criteria that would appear to be needed to respond to climate change and variability will be identified.

The result of this work will be a set of recommendations on how the Board and 1JC should respond both in the short term and long term to potential climate change impacts on Lake Ontario-St. Lawrence River water level and flow regulation activities. It is expected that this task will utilize information developed by, and coordinated with, the Canada/U.S. Great Lakes-St. Lawrence Climate Change Project.

10.0 STUDY SCHEDLUE/COSTS

This study will require work that cannot be deliverable through current Board resources, which are sufficient only for overseeing the operations related to the regulation of Lake Ontario. A criteria review will require additional dedicated resources and personnel. The Board expects that this study may take about 3 years at a cost of about $3 million. These resources are not

currently identified in any of the supporting agency budgets.

ANNEX 4 (b)

International Joint Commission

April 15, 1999

Honourable Lloyd Axworthv
Minister of Foreign Affairs
Department of Foreign Affairs and International Trade
125 Sussex Drive
Ottawa, ON KIA OG2

Honorable Madeleine Albright
Secretary of State
Department of State
2201 C Street, NW
Washington, D.C. 20520

Dear Minister Axworthy and Secretary Albright:

It is becoming increasingly urgent to review the regulation of Lake Ontario in view of dissatisfaction, on the part of some interests, with the working of that system and in the light of environmental concerns and climate change issues. We would like to take this opportunity to provide some background information on this subject, inform you of recent decisions by the Commission, and request assistance in pursuing further progress.

Background

In its 1993 report to governments on methods of alleviating the adverse consequences of fluctuating water levels in the Great Lakes – St. Lawrence River Basin, the Commission stated that it would review its study board's recommendations that the criteria of the Commission's Orders of Approval for the regulation of Lake Ontario be revised to better reflect the current needs of the users and interests of the system, and in particular, that the criteria should be amended to address the annual flood discharge from the Ottawa River, concerns of recreational boating, and environmental interests. The Commission informed governments that, in carrying out this review, the Commission would be bound by the "rules or principles" set forth in Article VIII of the Boundary Waters Treaty of 1909.

Two years later, on December 12, 1995, the Commission informed the governments that in accordance with recommendations provided by the study board, and because of continuing concerns about whether its Order of Approval made appropriate provision for all interests, the Commission's International St. Lawrence River Board of Control was undertaking two tasks:

- development of a definition of the work (Scope of Work) that would need to be undertaken to determine whether the study board's recommended amendments, or other amendments or additions, to the criteria listed in the Commission's Order of Approval are appropriate, and
- a review of alternative regulation plans for Lake Ontario outflows intended to meet the requirements of the current Order of Approval.

Scope of Work

Subsequently, in its letter of July 2, 1996, the Commission requested the views of the governments on whether to proceed with the studies described in an attached Scope of Work. The Commission said that, if a decision was made to undertake these studies, a detailed plan of studies would be developed to specify how they would be conducted. Moreover, it recognized that. while the studies described in the Scope of Work were meant to examine the criteria contained in the Commission's Order and determine whether additional regulation criteria were feasible and desirable, such a review could lead to changes in the entire Order.

Having not received a substantive reply from either government to its letter of July 2, 1996, the Commission informed the governments' representatives in Vancouver on October 9, 1997, that it had decided to direct its International St. Lawrence River Board of Control to proceed with the studies described in the Scope of Work as soon as funding permitted. Since that time, the Commission has explored ways of proceeding with the Scope of Work in small, separable segments as funding became available, but funding has not been available. The Commission has now concluded that the Scope of Work cannot be executed incrementally.

Review of Alternative Regulation Plans

In 1997, the International St. Lawrence River Board of Control completed its review of alternative regulation plans, referred to in the Commission's above-mentioned letter of December 12, 1995, and recommended that the Commission implement a new regulation plan, Plan 1998, which the Board had developed in the course of its review. The Commission, however, decided on January 12, 1999, not to adopt Plan 1998 for the regulation of Lake Ontario outflows at this time. After full consideration of issues raised during public comment, the Commission determined that it does not have sufficient information on the environmental impacts associated with the proposed plan and that the Plan would not constitute sufficient improvement over the existing situation. The International St. Lawrence River -Board of Control will continue to manage the waters of the Lake Ontario - St. Lawrence River system according to Plan 1958-D with deviations, as is now the case.

Commission's Plans for Progress

The Commission is continuing to pursue support and funding for the development and execution of the more comprehensive studies outlined in the Scope of Work prepared by the International St. Lawrence River Board of Control in 1996. These studies are intended to address concerns with regulation of the Lake Ontario - St. Lawrence River system mentioned

earlier and including consideration of:

- environmental factors, which were poorly understood when the current regulation plan was developed in the 1950s,
- recreational boating and related interests that have developed in the region,
- the combined effect of St. Lawrence River and Ottawa River flows during the Ottawa freshet,
- the full range of water supplies actually received, instead of the narrower range of anticipated supplies on which the current regulation plan was designed, and
- effects of climate change and climate variability.

As a first step, the Commission will constitute a binational work group to translate the Scope of Work into a Plan of Studies. Afterwards, subject to available funds, the Commission will carry out the studies described.

Requested Government Support

While no additional funding will be required to prepare the Plan of Studies, the Commission, as in the past, will require the services of personnel from appropriate departments to carry out this work. We would appreciate governments support in seeking appropriate agency assistance for this effort. Once the Plan of Studies has been developed, significant funding will be required to carry out the studies described. We request that the governments, working within usual funding mechanisms, identify funding sources for the timely execution of the defined studies.

Upon completion of the study process, the Commission will consult with governments regarding its findings. The Commission recognizes the unique role that the governments played in developing and proposing the conditions that the Commission adopted in its 1952 Order of Approval and that they also played in approving, in advance, criteria that the Commission proposed for addition to that Order in 1956. Accordingly, upon completion of the study effort, if the Commission concludes that a broader or adjusted set of goals and objectives, conditions and criteria for regulation is both feasible and desirable, then, consistent with established practice under this application, it will seek the concurrence of governments before incorporating such changes into the Orders of Approval. In this context, the Commission notes that the "no less protection" clause was added to the Order by the Commission on its own initiative.

We look forward to your response on this increasingly urgent matter, and thank you for your consideration of our request.

Sincerely,

Gerald E. Galloway
Secretary
U.S. Section

Murray Clamen
Secretary
Canadian Section

Attachment: July 2, 1996 Letter to Governments with Scope of Work

cc: Hon. Frank Loy, Under Secretary for Global Affairs, U.S. Department of State
Hon. Peter Romero, Acting Assistant Secretary, Western Hemispheric Affairs, U.S. Department Of State
Mr. Victor Comras, Director, Office of Canadian Affairs, U.S. Department of State
Mr. David Preston, Canadian Ministry of Foreign Affairs and International Trade
General Hans Van Winkle, U.S. Co-Chair, St. Lawrence River Board of Control
Ms. Jean Murray, Canadian Co-Chair, St. Lawrence River Board of Control

ANNEX 4 (c)

DIRECTIVE
to the
ST. LAWRENCE RIVER - LAKE ONTARIO "PLAN OF STUDIES" TEAM

The purpose of this directive is to establish and direct the St. Lawrence - Lake Ontario "Plan of Studies" Team (Team) to transform the existing Scope of Work (SOW) into a Plan of Studies (POS) to review the operation of the structures controlling the flows and levels of the Lake Ontario - St. Lawrence River system.

This POS shall include:

a. the definition of the studies to be performed and the level of detail anticipated for each study,
b. recommendations as to the agencies or organizations capable of carrying out each study,
c. sources of, or means of obtaining, needed information, and
d. estimates of the time, dollar and personnel resources required for the conduct of each study.

At a minimum, the following studies or activities will be required:

a. Climate change impacts on levels and flows
b. Topographic and bathymetric data acquisition
c. Environmental impacts of levels and flow regimes and ecosystem needs
d. Shoreline impacts of levels and flows, including assessment of zoning and other land use management issues
e. Determination of the needs of recreational boaters, confirmation/updating of the needs of other interest groups (such as riparians, hydropower, commercial navigation, and municipal water supply), in the light of the 1909 Boundary Waters Treaty.
f. Qualitative assessment of how demographic and other possible future changes may affect user needs, water supplies, and regulation impacts
g. System flow modeling using compiled historical flow records
h. Alternative control approaches that as nearly as possible meet the needs of all interests (including the integrity of the ecosystem) while always respecting the requirements of the Boundary Waters Treaty and in particular Article VIII
i. Development and implementation of decision-support algorithm to choose among alternative approaches developed
j. Public involvement in the study process, building upon the substantial public involvement already undertaken in developing the Scope of Work

The Commission shall appoint members to the Team. Members act in their personal and professional capacities and not as representatives of their countries, agencies, organizations, or other affiliations. Members of the Team shall be responsible for their own expenses unless otherwise arranged by the Commission.

The Team may consult with others as necessary, and especially the International St. Lawrence River Board of Control, to complete its work. It shall take note of work of all other agencies and organizations in both countries in order to make the most effective use of resources and efforts in both countries.

The Team shall keep the Commission informed of its progress and direction. The Team shall submit a POS to the Commission by 31 July 1999.

Documents, letters, memoranda, and communications of every kind in the official records of the Commission are privileged and become available for public information only after release by the Commission. The Commission considers all documents in any official files that the team may establish to be similarly privileged. Accordingly, all such documents shall be so identified and maintained as separate files.

To assist in carrying out this assignment, attached are copies of the following:

a. 1909 Boundary Waters Treaty
b. IJC Orders of Approval
c. IJC 1993 IJC Report to governments on Adverse Consequences of Fluctuating Water Levels
d. March 26, 1996, Scope of Work, developed by the International St. Lawrence River Board of Control
e. July 2, 1996 letter to governments
f. December 10, 1998 memorandum summarizing the efforts of an ad-hoc work group formed to investigate the pursuit of an "incremental" approach to the Scope of Work (undertaking small, separable segments of the Scope of Work as funding became available.) This memorandum provides a scoping level analysis of study requirements.
g. January 15, 1999 Press Release on Plan 1998 and Scope of Work
h. April 15, 1999 letter to governments
i. Membership of the St. Lawrence River Board of Control
j. Membership of the Ad-hoc work group
k. List of draft study reports regarding the St. Lawrence-FDR Power Project Relicensing

ANNEX 4 (d)

ARTICLE VIII

This International Joint Commission shall have jurisdiction over and shall pass upon all cases involving the use or obstruction or diversion of the water with respect to which under Articles III and IV of this treaty the approval of this Commission is required, and in passing upon such cases the Commission shall be governed by the following rules or principles which are adopted by the High Contracting Parties for this purpose.

The High Contracting Parties shall have, each on its own side of the boundary, equal and similar rights in the use of the waters herein before defined as boundary waters.

The following order of precedence shall be observed among the various uses enumerated hereinafter for these waters, and no use shall be permitted which tends materially to conflict with or restrain any other use which is given preference over it in this order of precedence:

(1) Uses for domestic and sanitary purposes;

(2) Uses for navigation, including the service of canals for the purpose of navigation;

(3) Uses for power and for irrigation purposes.

The foregoing provisions shall not apply to or disturb any existing uses of boundary waters on either side of the boundary.

The requirement for an equal division may in the discretion of the Commission be suspended in cases of temporary diversions along boundary waters at points where such equal division cannot be made advantageously on account of local conditions, and where such diversion does not diminish elsewhere the amount available for use on the other side.

The Commission in its discretion may make its approval in any case conditional upon the construction of remedial or protective works to compensate so far as possible for the particular use of diversion proposed, and in such cases may require that suitable and adequate provision, approved by the Commission, be made for the protection and indemnity against injury of any interests on either side of the boundary.

In cases involving the elevation of the natural level of waters on either side of the line as a result of the construction or maintenance on the other side of remedial or protective works or dams or other obstructions in boundary waters or in waters flowing therefrom or in waters below the boundary in rivers flowing across the boundary, the Commission shall require, as a condition of its approval thereof, that suitable and adequate provisions, approved by it, be made for the protection and indemnity of all interests on the other side of the line which may be injured thereby.

The majority of the Commissioners shall have power to render a decision. In case the Commission is evenly divided upon any question or matter presented to it for decision, separate reports shall be made by the Commissioners on each side of their own Government. The High Contracting Parties shall thereupon endeavor to agree upon an adjustment of the question or matter of difference, and if an agreement is reached between them it shall be reduced to writing in the form of a protocol, and shall be communicated to the Commissioners, who shall take such further proceedings as may be necessary to carry out such agreement.

ANNEX 4 (d)

Appendix G

ORDER OF APPROVAL FOR REGULATION OF LAKE ONTARIO

Office Consolidation

IN THE MATTER OF THE APPLICATIONS OF THE (GOVERNMENT OF CANADA AND THE GOVERNMENT OF THE UNITED STATES OF AMERICA FOR AN ORDER OF APPROVAL OF THE CONSTRUCTION OF CERTAIN WORKS FOR DEVELOPMENT OF POWER IN THE INTERNATIONAL RAPIDS SECTION OF THE ST. LAWRENCE RIVER.

NOTE:

1. *The amendments of July 2.1956 are in Light Italic type.*
2. All elevations have been converted to International Great Lakes Datum (1955).

ORDERS OF APPROVAL
October 29, 1952, as amended by a supplementary
Order dated July 2, 1956

WHEREAS the Government of Canada and the Government of the United States of America under date of 30 June, 1952, have submitted Applications to the International Joint Commission (hereinafter referred to as the "Commission") for its approval of the construction, jointly by entities to be designated by the respective Governments, of certain works for the development of power in the International Rapids Section of the St. Lawrence River, these being boundary waters within the meaning of the Preliminary Article of the Boundary Waters Treaty of 11 January, 1909 (hereinafter referred to as the "Treaty"), and of the construction, maintenance and operation of such works subject to and under conditions specified in the Applications, and have requested that the Applications be considered by the Commission as in the nature of a joint application; and

WHEREAS pursuant to the aforementioned request of the two Governments, the Commission is considering the two Applications as in the nature of a joint application; and

WHEREAS notices that the Applications had been filed were published in accordance with the Rules of Procedure of the Commission; and

WHEREAS Statements in Response to the Applications and Statements in Reply thereto by both Applicants were filed in accordance with the Rules of the Commission; and

WHEREAS pursuant to published notices, hearings were held by the Commission at Toronto, Ontario, on 23 July, 1952; at Ogdensburg, New York, on 24 July, 1952; at Cornwall, Ontario, on 25 July, 1952; at Albany, New York, on 3 September, 1952; at Montreal, Quebec, on 8 September, 1952; and at Washington, D.C. on 20 October, 1952; and

WHEREAS by reason of the said notices of the said applications and hearings, all persons interested were afforded convenient opportunities of presenting evidence to and being heard before the Commission; and

WHEREAS pursuant to the said Applications, the hearings before, the evidence given, and material filed with the Commission, the Commission is satisfied that the proposed works and uses of the waters of the International Rapids Section comply with the principles by which the Commission is governed as adopted by the High Contracting Patties in Article VIII of the Treaty; and

WHEREAS the Commission has been informed that the Government of Canada has designated The Hydro-Electric Power Commission of Ontario as the entity to construct, maintain and operate the proposed works in Canada; and

WHEREAS the commission has been informed that the President of the United States of America by Executive Order No. 10,500, dated 4 November 1953. designated the Power Authority of the State of New York as the United States entity to construct, maintain and operate the proposed works in the United States; and

WHEREAS the program of construction of the works, as proposed by the Applicant's, includes the removal of Gut Dam from the International Rapids Section and the Government of Canada has informed the Commission that it is its intention to take steps for the early removal of Gut Dam as soon as the construction of the proposed works is approved and as soon as river conditions and the protection of down river and other interests that will be affected during its removal will permit, thereby advancing the time of removal of Gut Dam; and

WHEREAS the Commission finds that suitable and adequate provision is made by the laws in Canada and by the Constitution and laws in the United States for the protection and indemnity of all interests on either side of the International Boundary which may be injured by reason of the construction, maintenance and operation of the works; and

WHEREAS the Commission finds that it has jurisdiction to hear and dispose of the Applications by approval thereof in the manner and subject to the conditions hereinafter set out; and

WHEREAS the Commission, by Order dated 29 October 1952 (Docket 68), approved the construction, maintenance and operation of the works; and Appendix A to the said Order describes the features of the works so approved and provides that channel enlargements will be undertaken in specified areas; and

WHEREAS condition (i) of said Order provides that, upon completion of the works, the discharge of water from Lake Ontario and the flow of water through the International

Rapids Section shall be regulated to meet the requirements of conditions (b), (c) and (d) thereof, and subject to possible modifications and changes to be recommended subsequently by the International St. Lawrence River Board of Control, in accordance with Method of Regulation No. 5, as prepared by the General Engineering Branch, Department of Transport, Canada, dated Ottawa, September 1940; and

WHEREAS, by the said Order of 29 October 1952, the Commission specifically retained jurisdiction to make such further Order or Orders relating to the subject matter of the Applications of the United States of America and Canada (Docket 68) as may be necessary in the judgment of the Commission; and

WHEREAS the Commission, as a result of its investigations under the Reference from the Governments of Canada and the United States of America, dated 25 June 1952, regarding the levels of Lake Ontario (Docket 67), has determined that it would not be practicable to base the regulation of flows from Lake Ontario on the said Method of Regulation No. 5, and

WHEREAS, pursuant to published notices, hearings were held by the Commission at Detroit, Michigan, on 4 June 1953, Rochester, New York, on 17 November 1953 and 12 April 1955, Hamilton. Ontario, on 18 November 1953, and Toronto, Ontario on 14 April 1955, at which all persons interested were afforded convenient opportunity of presenting evidence to and being heard before the Commission; and at the said hearings held at Toronto and Rochester in April 1955 all interested persons were given convenient opportunity to express their views upon the criteria and range of stage which had been tentatively proposed by the commission: and

WHEREAS the Commission, on 9 May 1955, by letters addressed to the Secretary of State for External Affairs of Canada and the Secretary of State of the United States of America, respectively, recommended adoption by the two Governments of the following:

(i) A range of mean monthly elevations for Lake Ontario of 242.8 feet (navigation season) to 246.8 feet as nearly as may be; and

(ii) Criteria for a method of regulation of outflows and levels of Lake Ontario applicable to the works in the International Rapids Section of the St. Lawrence River; and

(iii) Plan of Regulation No. 12-A-9, subject to minor adjustments that may result from further detailed study and evaluation by the Commission: and

WHEREAS, by letters dated 3 December 1955, the Secretary of State for External Affairs of Canada and the Under Secretary of State of the United States of America advised the Commission that the Government of Canada and the Government of the United States of America, respectively, approved the range of mean monthly elevations for Lake Ontario and the criteria recommended in the Commission's said letters of 9 May, 1955; and also approved Plan of Regulation No. 12-A-9 for the purpose of calculating critical profiles and the design of channel excavations in the International Rapids Section of the St. Lawrence River; and

WHEREAS, in the said letters dated 3 December 1955, the two Governments urged the Commission to continue its studies with a view to perfecting a plan of regulation so as best to meet the requirements of all interests both upstream and downstream, within the range of elevations and criteria therein approved; and

WHEREBY, by letter dated 3 December 1955, the Secretary of State for External Affairs, on behalf of the Government of Canada, has informed the Commission of the arrangements that have been made for the redesign of a portion of the St. Lawrence Seaway Canal in the vicinity of Montreal, between Lake St. Louis and the Laprairie Basin; and

WHEREBY condition (i) of the said Order of Approval dated 29 October 1952 makes provision for adjustments and progressive improvements in the plan of regulation, subject to requirements and procedures specified therein;

NOW, THEREFORE, IT IS ORDERED that the construction, maintenance and operation jointly by The Hydro-Electric Power Commission of Ontario and the *Power Authority of the State of New York* of certain works (hereinafter called "the works") in accordance with the "Controlled Single Stage Project (238-242)", which was part of the joint report dated 3 January, 1941, of the Canadian Temporary Great Lakes-St. Lawrence Basin Committee and the United States St. Lawrence Advisory Committee, containing the features described in Appendix "A" to this Order and shown in Appendix "B" to this Order, be and the same are hereby approved subject to the conditions enumerated below, namely,

(a) All interests on either side of the International Boundary which are injured by reason of the construction, maintenance and operation of the works shall be given suitable and adequate protection and indemnity in accordance with the laws in Canada or the Constitution and laws in the United States respectively, and in accordance with the requirements of Article VIII of the Treaty.

(b) The works shall be so planned, located, constructed, maintained and operated as not to conflict with or restrain uses of the waters of the St. Lawrence River for purposes given preference over uses of water for power purposes by the Treaty, namely, uses for domestic and sanitary purposes and uses for navigation, including the service of canals for the purpose of navigation, and shall be so planned, located, constructed, maintained and operated as to give effect to the provisions of this Order.

(c) The works shall be constructed, maintained and operated in such manner as to safeguard the rights and lawful interests of others engaged or to be engaged in the development of power in the St. Lawrence River below the International Rapids Section.

(d) The works shall be so designed, constructed, maintained and operated as to safeguard so far as possible the rights of all interests affected by the levels of the St. Lawrence River upstream from the Iroquois regulatory structure and by the levels of Lake Ontario and the lower Niagara River; and any change in levels resulting from the works which injuriously affects such rights shall be subject to the requirements of paragraph (a) relating to protection and indemnification.

(e) The hydro-electric plants approved by this Order shall not be subjected to operating rules and procedures more rigorous than are necessary to comply with the provisions of the foregoing paragraphs (b), (c) and (d).

(f) Before the Hydro-Electric Power Commission of Ontario commences the construction of any part of the works, it shall submit to the Government of Canada, and before the *Power Authority of the State of New York* commences the construction of any part of the works, it shall submit to the Government of the United States, for approval in writing, detailed plans and specifications of that part of the works located in their respective countries and details of the program of construction thereof or such details of such plans and specifications or programs of construction relating thereto as the respective Governments may require. If after any plan, specification or program has been so approved, The Hydro-Electric Power Commission of Ontario or the *Power Authority of the State of New York* wishes to make any charge therein, it shall, before adopting such change, submit the changed plan, specification or program for approval in a like manner.

(g) In accordance with the Applications, the establishment by the Governments of Canada and the United States of a Joint Board of Engineers to be known as the St. Lawrence River Joint Board of Engineers (hereinafter referred to as the "Joint Board of Engineers") consisting of an equal number of representatives of Canada and the United States to be designated by the respective Governments, is approved. The duties of the Joint Board of Engineers shall be to review and coordinate, and, if both Governments so authorize, approve the plans and specifications of the works and the programs of construction thereof submitted for the approval of the respective Governments as specified above, and to assure the construction of the works in accordance therewith as approved. The Joint Board of Engineers shall consult with and keep the Board of Control, hereinafter referred to, currently informed on all matters pertaining to the water levels of Lake Ontario and the International Rapids Section and the regulation of the discharge of water from Lake Ontario and the flow of water through the International Rapids Section, and shall give full consideration to any advice or recommendations received from the Board of Control with respect thereto.

(h) A Board of Control to be known as the International St. Lawrence River Board of Control (herein referred to as the "Board of Control") consisting of an equal number of representatives of Canada and of the United States, shall be established by this Commission. The duties of the Board of Control shall be to give effect to the instructions of the Commission as issued from time to time with respect to this Order. During construction of the works the duties of the Board of Control shall be to keep itself currently informed of the plans of the Joint Board of Engineers insofar as these plans relate to water levels and the regulation of the discharge of water from Lake Ontario and the flow of water through the International Rapids Section, and to consult with and advise the Joint Board of Engineers thereon. Upon completion of the works, the duties of the Board of Control shall be to ensure that the provisions of this Order relating to water levels and the regulation of the discharge of water from Lake Ontario and the flow of water through the International Rapids Section as herein set out are complied with, and the Hydro-Electric Power Commission of Ontario and the *Power Authority of the State of New York* shall duly observe any direction given them by the Board of Control for the purpose of ensuring such compliance. The Board of Control shall report to the Commission at such times as the Commission may determine. In the event of any

disagreement amongst the members of the Board of Control which they are unable to resolve, the matter shall be referred by them to the Commission for decision. The Board of Control may, at any time, make representations to the Commission in regard to any matter affecting or arising out of the terms of this Order with respect to water levels and the regulation of the said discharge and flow.

(i) Upon the completion of the works, the discharge of water from Lake Ontario and the flow of water through the International Rapids Section shall be regulated to meet the requirements of *conditions (b), (c) and (d) hereof; shall be regulated within a range of stage from elevation 242.8 fret (navigation season) to elevation 246.8 feet, as nearly as may be; and shall be regulated in accordance with the criteria set forth in the Commission's letters of 17 March 1955 to the Governments of Canada and the United States of America and approved by the said governments in their letters of 3 December 1955 and qualified, by the terms of separate letters from the Government of Canada and the Government of the United States of America dated 11 Apr11 1956 and 1 May 1956, respectively, to the extent that these letters agree that the criteria are intended to establish standards which would be maintained with the minimum variation. The project works shall be operated in such a manner as to provide no less protection for navigation and riparian interests downstream than would have occurred under pre-project conditions and with supplies of the past as adjusted, as defined in criterion (a) herein. The Commission will indicate in an appropriate fashion, as the occasion may require, the inter-relationship of the criteria, the range of elevations and the other requirements.*

The criteria are as follows:

(a) The regulated outflow from Lake Ontario from 1 April to 15 December shall be such as not to reduce the minimum level of Montreal Harbour below that which would have occurred in the past with the supplies to Lake Ontario since 1860 adjusted to a condition assuming a continuous diversion out of the Great Lakes Basin of 3,100 cubic feet per second at Chicago and a continuous diversion into the Great Lakes Basin of 5,000 cubic feet per second from the Albany River Basin (hereinafter called the "supplies of the past as adjusted").

(b) The regulated winter outflows from Lake Ontario from 15 December to 31 March shall be as large as feasible and shall be maintained so that the difficulties of winter power operation are minimized.

(c) The regulated outflow from Lake Ontario during the annual spring break-up in Montreal Harbour and in the river downstream shall not be greater than would have occurred assuming supplies of the past as adjusted.

(d) The regulated outflow from Lake Ontario during the annual flood discharge from the Ottawa River shall not be greater than would have occurred assuming supplies of the past as adjusted.

(e) Consistent with other requirements, the minimum regulated monthly outflow from Lake Ontario shall be such as to secure the maximum depend-

able flow for power.

(f) Consistent with other requirements, the maximum regulated outflow from Lake Ontario shall be maintained as low as possible to reduce channel excavations to a minimum.

(g) Consistent with other requirements, the levels of Lake Ontario shall be regulated for the benefit of property owners on the shores of Lake Ontario in the United States and Canada so as to reduce the extremes of stage which have been experienced.

(h) The regulated monthly mean level of Lake Ontario shall not exceed elevation 246.8 with the supplies of the past as adjusted.

(i) Under regulation, the frequency of occurrences of monthly mean elevations of approximately 245.8 and higher on Lake Ontario shall be less than would have occurred in the past with the supplies of the past as adjusted and with present channel conditions in the Galops Rapids Section of the St. Lawrence River. ("present channel conditions" refers to conditions as of March 1955.)

(j) The regulated level of Lake Ontario on 1 April shall not be lower than elevation 242.8. The regulated monthly mean level of the lake from 1 April to 30 November shall be maintained at or above elevation 242.8.

(k) In the event of supplies in excess of the supplies of the past as adjusted, the works in the International Rapids Section shall be operated to provide all possible relief to the riparian owners upstream and downstream. In the event of supplies less than the supplies of the past as adjusted, the works in the International Rapids Section shall be operated to provide all possible relief to navigation and power interests.

The flow of water through the International Rapids Section in any period shall equal the discharge of water from Lake Ontario as determined for that period in accordance with *a plan of regulation which, in the judgment of the Commission, satisfies the aforementioned requirements, range of stage and criteria and when applied to the channels as determined in accordance with Appendix A hereto produces no more critical governing velocities than those specified in that appendix, nor more critical governing water surface profiles than those established by Plan of Regulation 12-A-9, when applied to the channels as determined in accordance with Appendix A hereto,* and shall be maintained as uniformly as possible throughout that period.

Subject to the requirements of conditions (b), (c) and (d.) hereof, *and of the range of stage, and criteria, above written,* the Board of Control, after obtaining the approval of the Commission, may temporarily modify or change the restrictions as to discharge of water from Lake Ontario and the flow of water through the International Rapids Section for the purpose of determining what modifications or changes *in the plan of regulation* may be advisable. The Board of Control shall report to the Commission the results of such experiments, together with its recommendations as to any changes or modifications *in the plan of regulation. When the plan of regulation has been perfected so as*

best to meet the requirements of all interests, within the range of stage and criteria above defined, the Commission will recommend to the two Governments that it be made permanent and, if the two Governments thereafter agree, *such plan of regulation* shall be given effect as if contained in this order.

(j) Subject as hereinafter provided, upon completion of the works shall be operated initially for the test period of ten years, or such shorter period as may be approved by the Commission with the forebay water level at the power houses held at a maximum elevation of 236.8 feet. Subject to the requirements of paragraphs (b), (c) and (d) hereof, the Board of Control, after obtaining the approval of the Commission, may temporarily modify or change the said forebay level in order to carry out experiments for the of determining whether it is advisable to increase the forebay water level at the power houses to a maximum elevation exceeding 236.8 feet.

If the Board of Control, as a result of these experiments considers that operation during this test period at a maximum elevation exceeding 236.8 feet would be advisable, and so recommends, the Commission will consider authorizing operation during this test period at a maximum elevation exceeding 236.8 feet. At the end of this test period, the Commission will make such recommendations to the two Governments with respect to a permanent forebay water level as it deems advisable or it may recommend an extension of the test period. Such of these recommendations as the two Governments thereafter agree to adopt shall be given effect as if contained in this Order.

(k) The Hydro-Electric Power Commission of Ontario and the *Power Authority of the State of New York* shall maintain and supply for the information of the Board of Control accurate records relating to water levels and the discharge of water through the works and the regulation of the flow of water through the International Rapids Section, as the Board of Control may determine to be suitable and necessary, and shall install such gauges, carry out such measurements, and perform such other services as the Board may deem necessary for these purposes.

(l) The Board of Control shall report to the Commission as of 31 December each year on the effect, if any, of the operation of the down-stream hydro-electric power plants and related structures on the tail-water elevations at the hydro-electric power plants approved by this Order.

(m) The Government of Canada shall proceed forthwith to carry out its expressed intention to remove Gut Dam.

AND IT IS FURTHER ORDERED that the allocation set out in Appendix "C" of the costs of constructing, maintaining and operating the works approved by this Order between The Hydro-Electric Power Commission of Ontario and the *Power Authority of the State of New York* be and the same is hereby approved but such approval shall not preclude the Applicants from submitting to the Commission for approval any variation in the said allocation that may be agreed upon between them as being appropriate or advisable.

AND IT IS FURTHER ORDERED that the Commission retains jurisdiction over the subject matter of these Applications, and may, after giving such notice and opportunity to all interested parties to make representations as the Commission deems appropriate, make such further Order or Orders relating thereto as may be necessary in the judgment of the Commission.

APPENDIX A

FEATURES OF THE WORKS APPROVED BY THIS ORDER:

(a) Channel Enlargements

Channel enlargements will be undertaken from above Chimney Point to below Lotus Island, designed to give a maximum mean velocity in any cross-section of the channel which will be used for navigation not exceeding four feet per second at any time, also between Lotus Island and Iroquois Point and from above Point Three Points to below Ogden Island designed to give a maximum mean velocity in any cross-section not exceeding two and one-quarter feet per second with the flow and at the stage to be permitted on the first of January of any year, under regulation of outflow and levels of Lake Ontario in accordance with *Plan of Regulation No 12-A-9, as prepared by the International Lake Ontario Board of Engineers, dated 5 May 1955*. Downstream from the power houses channel enlargements will be carried out for the purpose of reducing the tail water level at the power houses.

Final locations and cross-sections of these channel enlargements will be determined from further studies.

As approved by the Government of Canada and the Government of the United States of America in similar letters dated 3 December 1955, the said Plan of Regulation No 12-A-9 shall be the basis for calculating critical profiles and designing channel excavations.

(b) Control Facilities

Adequate control facilities will be constructed for the regulation of the outflow from Lake Ontario.

(c) Power House Structures

The power house structures will be constructed in the north channel extending from the lower end of Barnhart Island to the Canadian shore, and so located that one structure will be on each side of the International Boundary. Each power house structure will include the main generating units to utilize economically the river flows available to it, with provision for ice handling and discharge sluices.

(d) Dams and Associated Structures

A control dam will be constructed extending from Iroquois Point on the Canadian side of the river in an easterly direction to the United States mainland above Point Rockway.

A dam will be constructed in the Long Sault Rapids at the head of Barnhart Island.

Dykes and associated works will be provided as may be necessary in both the Province of Ontario and the State of New York.

All the works in the pool below the control dam will be designed to provide for full Lake Ontario level.

(e) Highway Modifications

In both the Province of Ontario and the State of New York provincial and state highways, and other roads, will be relocated in those portions subject to flooding, and reconstructed to standards at least equal to those now in existence.

(I) Railway Modifications

Such railway relocations as may be required as a result of the works herein described will be made in the Province of Ontario and the State of New York to standards at least equal to those now in existence.

(g) Navigation Facilities

Provision will be made for the continuance of 14-foot navigation throughout the International Rapids Section during the construction period.

(h) Flooded Areas

Lands and buildings in both the Province of Ontario and the State of New York will be acquired or rehabilitated as required. Inundated wooded areas will be cleared.

APPENDIX B

General Plan showing major works of the Great Lakes-St. Lawrence Basin Power Project are not included in the consolidation.

APPENDIX C

1. The power development works under this Application are those specified in Section 8 of the Application.

2. Total costs of the works described in Section 8 shall be based on Canadian costs and United States costs and the total shall be equally divided between the two constructing entities.

3. The costs to be divided should be based on actually experienced and audited expenses.

4. In relation to the three principles above, the three following provisions apply:

   (a) The amount to be paid to Canada, as specified in the Agreement of December 3, 1951, between Canada and Ontario, in lieu of the construction by the power--developing entities of facilities required for the continuance of 14-foot navigation, shall be excluded from the total cost of the power project to be divided between the Canadian and United States power-developing entities, in consideration of the fact that actual replacement of 14-foot navigational facilities will be rendered unnecessary by reason of the concurrent construction of the deep waterway in Canada.

   (b) The Authority to be established pursuant to the provisions of the St. Lawrence Seaway Authority Act, Chapter 24 of the Status of Canada, 1951 (Second Session), shall contribute an agreed sum of money towards the cost of the channel enlargement which the power-developing entities must undertake in the St. Lawrence River, as set out in paragraph 4 of the Annex to the Canada-Ontario Agreement of December 3, 1951, and in section 8 of the Application to the International Joint Commission, in consideration of the benefits which will accrue to navigation from such channel enlargement.

   (c) All costs for construction, maintenance and operation of the project except machinery and equipment in the respective power houses shall be borne equally by the two entities. All costs for construction, maintenance and operation of machinery and equipment in their respective power houses shall be paid by the respective entities and shall be deemed to satisfy the principle of an equal division between the two entities.

ANNEX 5
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ANNEX 6
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