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The International Lake Ontario - St. Lawrence River Study Board was formed in December 2000 by the International Joint Commission to manage a comprehensive five-year study that will assess and evaluate the Order of Approval used to regulate outflows from Lake Ontario through the St. Lawrence River.

INTERNATIONAL LAKE ONTARIO -
ST. LAWRENCE RIVER
STUDY BOARD

May 31, 2002

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Chairman, United States Section
International Joint Commission
1250 23rd Street, NW, Suite 100
Washington, DC, USA

Rt. Hon. Herb Gray
Chairman, Canadian Section
International Joint Commission
234 Laurier Avenue West, 22nd Floor
Ottawa, Ontario, Canada K1P 6K6

Dear Chairman Schornack and Chairman Gray:

The International Lake Ontario - St. Lawrence River Study Board is pleased to transmit herewith the Year 1 Report at the request of the International Joint Commission.

Respectfully submitted,

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United States

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International Lake Ontario - St. Lawrence River Study Board

Year 1 Report

To the International Joint Commission

December 12, 2000 to March 31, 2002

FOREWARD (PREFACE)

This report was developed by the International Lake Ontario - St. Lawrence River Study Board at the request of the International Joint Commission, to provide a comprehensive report on Study activities, accomplishments and findings from the inception of the Study in December 2000 to the end of Year 1 defined as March 31, 2002. This report is a summary of the data and information produced by the Study Team including, Study Board members, the Public Interest Advisory Group and the Technical Work Groups. Several supporting papers and documents are referenced in this report. All supporting documentation is available upon written request to the Study secretariats.

Over a hundred individuals have devoted considerable time and effort to the Study to date, many on a volunteer basis. The Study Board would like to thank all Study participants for their contributions.

Disclaimer

The statements, opinions and findings expressed in this report are those of the International Lake Ontario-St. Lawrence River Study Board and are not necessarily those of the International Joint Commission. Any mention of or reference to statements contained in this report should not be construed as their endorsement by the International Joint Commission.

Ce rapport est également disponible en français.

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1.0 INTRODUCTION

1.1 BOARD APPROACH

On December 12, 2000, the International Joint Commission created the International Lake Ontario-St. Lawrence River Study Board to evaluate the procedures and criteria used to regulate the outflows of Lake Ontario and the management of the levels of the Lake and St. Lawrence River to Trois-Rivières, Quebec. Prior to the Board's establishment, an international team developed a report entitled "Plan of Study for Criteria Review" for the International Joint Commission in September 1999, which outlined the procedures that should be undertaken to perform the required comprehensive evaluations. The report identified interests that should be considered including wetland/environment, recreational boating, coastal zone (including riparian/shore property erosion and flooding), commercial navigation, hydroelectric and domestic, industrial and municipal water uses. A common data needs group was suggested that would collect information that could be used by several interests. A hydrologic and hydraulic evaluation group was identified to evaluate regulation alternatives given historic water supplies, as well as, those resulting from climate change. The report stressed that public involvement was vital to the success of any evaluation and suggested that a Public Interest Advisory Group be established allowing individuals with diverse interests to be directly involved in the studies.

The Board adopted suggestions made within the Plan of Study report and established Technical Work Groups to perform the required evaluations. In addition to the six interests mentioned above and the common data needs and hydrologic evaluation groups, a ninth group, the Plan Formulation and Evaluation Group, was created. Members of each of the nine groups were chosen for their expertise in the interest to be evaluated. Resumes of potential members were reviewed by the Board and provided to the International Joint Commission for approval. The Board sought equal representation in both Canada and the U.S. wherever possible. The number of members in each Technical Work Group varied acccording to complexity of the interest and extent of evaluation required.

In order to provide comprehensive guidance and support to the Technical Work Groups, Board members liaise with those groups to which they have prior expertise and knowledge. Individual members of the Public Interest Advisory Group also liaise with the Technical Work Groups to ensure that necessary assessments consider public concerns and interests.

1.2 ACCOMPLISHMENTS

This report summarizes Year 1 activities, accomplishments and findings of the International Lake Ontario-St. Lawrence River Study, from December 12, 2000 to March 31, 2002. Throughout the report, "Study Findings" are identifed in *Italics* within the text. Highlights of these accomplishments are as follows:

- Establishment of an active communications program through the Public Interest Advisory Group with over two dozen stakeholder meetings, three workshops/public meetings, surveys to individuals throughout the basin, the first Study newsletter "Ripple Effects" and the creation of a Study web site;
- Establishment of nine Technical Work Groups consisting of experts in various scientific fields to perform detailed evaluations required of a comprehensive Study;
- Completion of an Institutional Structure report on Lake Ontario regulation;
- Development of a Shared Vision Model as a tool to incorporate public opinion and compare and evaluate alternative regulation plans;
- Delivery of a valuation workshop with Technical Work Group and Public Interest Advisory Group members to address performance indicators within a SVM framework;
- Completion of extensive topographic, bathymetric and ortho-imagery data collection along the shorelines of Lake Ontario and the St. Lawrence River;
- Initiation of extensive environmental impact and science studies particularly in the lower St. Lawrence River;
- Development of a framework for a flood and erosion prediction system;
- Completion of surveys of marina owners and operators regarding conditions affecting recreational boating in Canadian waters;
- Completion of several studies and updates of models and data related to hydrologic and hydraulic evaluations; and
- Initiation of an Information Management System that can capture, store and be used to retrieve and manipulate the vast amount of data for use by Study investigators and the public.

With the successful accomplishment of many critical activities during Year 1, the Board believes we have a good foundation on which to proceed in accomplishing the objectives specified by the Commission to improve the understanding of the system and the regulation of Lake Ontario.

1.3 FUNDING

In December 2000, $2.15 million (U.S. dollars) was made available to initiate activities outlined in the Plan of Study dated September 1999. In January 2002, Year 2 U.S. funding was made available in the amount of $3.0 million.

In Canada, $3.25 million (Canadian dollars) was spent for the Study activities, by the end of March 2002. Canadian funding in the amount of $4.0 million is budgeted for the year-2 Study activities.

Since the Study's inception, individuals and agencies supporting Study activities have provided significant in-kind services over and above the direct expenditures identified above. In addition, the Public Interest Advisory Group has contributed hundreds of hours of volunteer time in preparing for and giving presentations at stakeholder meetings throughout the Study area.

1.4 REPORT ON CURRENT REGULATION PROCESS

A report entitled "Lake Ontario and St. Lawrence River – Changes in the Institutional Structure and Their Impact on Water Levels, 1950 – 2001" was developed and provided in January 2002 to the Board by Clinton Edmonds and Associates, Ltd. and the University of Ottawa, Institute of the Environment. The focus was an assessment of institutional structures and arrangements with a view to suggesting changes in the water levels regulation decision-making process. In order to arrive at recommendations, the investigators examined:

- Significant responses of decision-makers to lake levels;
- The decision-making process; and
- The decision support infrastructure pertaining to:
  - climate and hydrology inputs,
  - knowledge of ecosystem sustainability and levels control,
  - accessibility of stakeholders, and
  - current initiatives, which could, or should, influence the levels decision-making process.

Article VIII of the Boundary Waters Treaty lists sanitary and domestic, navigation and power as three uses recognized as important in 1909, leaving the accommodation of other uses not addressed. Since the Treaty was prepared, the entire ecosystem, human and natural has evolved. There has been:

- Significant population growth in the Great Lakes Basin;
- Exponential increase in understanding the value of the ecosystem; a recognition of the need to treat it holistically; how it works; and, concerns for what we do not know;
- Changing uses and intensities of use of the waters; and
- Changing governance - participation, recognition of rights of minority groups.

The report concluded that the International Lake Ontario – St. Lawrence River *Study Board's initiatives are a much-needed institutional response*. The overall observation is that *the institutional structure is effective, as have been the members and officials who have populated it over the years. The control system has been operated to satisfy many interests, within the envelope of hydrologic knowledge available to decision-makers. Since 1958, when the control structures were commissioned, demands on the boundary waters and scientific and cultural understanding of ecosystem have changed dramatically. In tandem, needs and opportunities have also changed*, providing in part the basis for observations and recommendations included in the report that the Board is reviewing. The Board will provide an assessment of report findings in Year 2.

2. PUBLIC INTEREST ADVISORY GROUP

To ensure that the public is fully engaged in the Study, the International Joint Commission appointed concerned citizens with a knowledge of the Lake Ontario – St. Lawrence River system to participate in a Public Interest Advisory Group (PIAG).

The Public Interest Advisory Group comprises an equal representation of American and Canadian volunteers from many regions throughout the basin. This 22 member group of individuals participates in all aspects of the study, working to ensure effective two-way communication between the Study Team and the general public and by liaising with the Technical Work Groups and the Study Board directly. Members are appointed for a term of 18 months and each has the opportunity for reappointment throughout the Study. Individual members volunteer to liaise with the various Technical Work Groups. The Public Interest Advisory Group also has two co-chairs from the United States and Canada who are members of the Study Board. The framework for communication is shown in Figure 1.

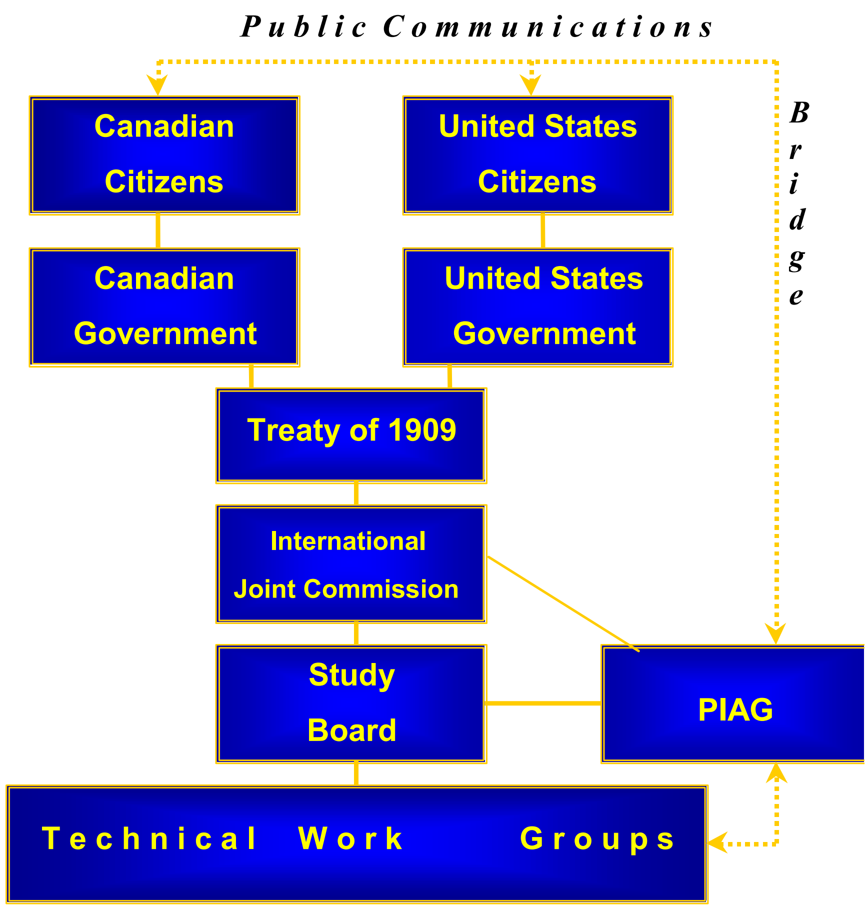

Figure 1: Framework of the Communications Process

The Public Interest Advisory Group held their initial meeting in January 2001 in Burlington, Ontario to outline the actions that they would like to complete during their first year. Their second meeting was held in March 2001 in Rochester, New York to edit a survey designed to gather information from the public, and to develop a slide show to be used during meetings with local groups around the Lake Ontario-St. Lawrence River System. The group's multi-year work plan was presented to the Study Board in July 2001 and approved.

During Year 1, the Public Interest Advisory Group served as a speaker's bureau by giving 30 presentations to various stakeholder groups, organizations and associations in the U.S. and Canada. In addition to these outreach activities, the group hosted three public meetings in Year 1 throughout the Lake Ontario basin. The public meetings were preceded by an afternoon roundtable discussion with selected invitees.The combined attendance for all public meetings in Year 1 is approximately 1,115. Surveys were distributed at every available opportunity. Over 230 surveys were returned to the group and have been used to help gauge public awareness of water levels and regulation in the system.

The survey was designed to provide input on public concerns regarding coastal/shoreline erosion, recreational boating, and environmental and wetland concerns. Responses were analyzed by the members and are presented in detail in the group’s Year 1 report **published separately and available on the Study’s website**. These results were also provided to the Technical Work Groups and the Study Board to integrate on-going public input in Study activities. The Public Interest Advisory Group's objective is to ensure that the results of the study reflect the interests and the "natural knowledge" of the public.

Based on analysis from the survey, the Public Interest Advisory Group is led to conclude that *there are clearly defined "information gaps" and "trust gaps" between the public and the regulating bodies. The public seems to be well aware that there are differing concerns and desires thoughout the system and that everyone cannot be happy all the time. However, few understand* <u>*why*</u> *this is so. There exists both a lack of understandable information and an abundance of misinformation. Until the public has a clearer understanding of pre-project and post-project conditions, they will be unable to grasp just what can and cannot be accomplished with regulation plan changes***.**

Many other findings are contained in the group’s Year 1 Report. A sampling of concerns and comments are summarized below:

- *Among* (survey) *respondents sharing common levels (Lake Ontario and uppermost reaches of the St. Lawrence River), most want less than a four-foot range* (in long term water level fluctuations). *Lake Ontario south shore residents favor an upper limit somewhat lower than that preferred by upper St. Lawrence River respondents.*

- *Respondents from Lake Ontario largely favor lower water levels rather than higher levels.*
- *There is a widely held public belief that water levels on Lake Ontario have been held artificially higher since regulation began. Since the public generally associates higher water levels with increased shoreline damage, it is believed that shoreline damages have been increased by regulation.*
- *Respondents from the St. Lawrence River-Lake St. Lawrence region cite soil and shoreline erosion problems associated with high water levels, high flow rates and ship wakes.*
- *Boaters experience problems with both high and low water levels.*
- *Is it possible to maintain water at levels fully usable for boaters from May to September and then begin to drop levels immediately thereafter for the winter and spring rather than dropping levels significantly in July and August?*
- *Environmental interests want greater water level fluctuations to regenerate wetland species that have been negatively affected by regulation.*
- *Water level fluctuations in Lac Saint-Francois are currently maintained within a 30 cm (1 foot) variation compared to natural variation of about 1.5 metres (5 feet) prior to construction of the first Hydro-Quebec powerplant in 1928. Pleasure boaters find this an ideal arrangement, while environmental interests are concerned with the loss of wetland vegetation variety due to more constant levels.*
- *On Lac Saint-Louis water levels in the order of 21.5 metres are preferable from recreational boating and shoreline flooding perspectives.*
- *In the Montreal Harbour reach, levels below datum (5.5 metres) cause significant problems for both commercial shipping and recreational boaters. Ideal summer levels are between elevation 6.5 and 7.5 metres, above which flood damage begins.*
- *On Lac Saint-Pierre low water levels down to elevation 3.7 metres in 1999, 2000 and 2001 caused severe difficulties for recreational boaters. Preferred water levels are above 4.3 m at low tide. Flooding in this area is not a major concern unless due to occasional ice jams at the lake's outlet which can raise water levels by several metres. However, reduced water level fluctuations and the occurrence of ice jams has reduced wetland biodiversity.*

During Year 1, a newsletter and a website were developed to facilitate the group's public outreach activities. The Study also has a mailing list containing the addresses of over 3,000 people who have indicated that they have an interest in the Study.

3.0 TECHNICAL WORK GROUP ACTIVITIES AND ACCOMPLISHMENTS

The end result of this Study will be a recommended policy for managing the flows and water levels in Lake Ontario and the St. Lawrence River. To identify, assess, and compare alternative water management policies, the public and the Study Board needs to identify the multiple impacts resulting from each alternative water management policy or practice. The Study Board has developed a framework in which the public in general and the Technical Working Groups representing each interest or user group help us identify performance measures for each water related interest and activity in the Lake and River. The values of these performance measures will vary depending on how the lake levels and flows are managed. Simulating various water management alternatives to obtain their resulting performance measure values (i.e., impacts on each use, activity, or interest) will provide the information needed in any public debate about which management alternative is the best compromise among all interests, users and activities in the Lake and River.

Each step of the plan formulation and evaluation approach involves working with the various stakeholders and publics in the Basin. These individuals provide important inputs to the evaluation process. In addition, stakeholders who will be involved in influencing or making water management decisions need to understand just how this multi-objective plan formulation and evaluation process works if they are to accept and benefit from its results. Stakeholder involvement in this process can help lead to a common understanding (or 'shared vision') of how the system works and the trade-offs that exist among conflicting objectives.

The sections that follow contain summaries of activities performed by the nine Technical Work Groups. More detailed activity descriptions are provided as supporting documents and are published seperately. These are available through written request to the Study secretariats. Each group is developing a list of performance indicators which help define how their interest is affected either positively or negatively to changing water levels or flows. These will be used collectively by the Plan Formulation and Evaluation Group when alternative regulation plans are compared as the Study progresses.

4.0 COMMON DATA NEEDS

In the Plan of Study report (International Joint Commission, September 1999), it was recognized that a considerable amount of information and data would be required to evaluate the Lake Ontario-St. Lawrence River System and alternative regulation criteria and plans. It was also realized that the collection of some data might be of benefit to several groups; for instance, the collection of bathymetric data could be used to assess coastal processes as well as environmental factors. It was therefore determined that the establishment of a Common Data Group was necessary. The group was envisioned to exist during the initial years of the Study when the most intense data collection would take place. However, now that the Study is underway, *a new need and activity has been identified, that of data management, archival and retrieval by study team members and others including the public*. This new activity for the Common Data Needs Group will be the focus of the group's efforts in subsequent years of the Study.

4.1 Topography and Bathymetry

Detailed mapping of the near-shore zone, both on the land side (topographic mapping) and the underwater portion (bathymetric mapping), is critical to providing the information for technical groups evaluating flooding, erosion and low water level impacts, for assessing the impacts of water levels on wetland and environmental health and sustainability, and for assessing water level impacts on private and public shore properties, municipal water intakes and outflows, and recreational boating facilities.

Recent technological advances in airborne laser mapping systems now provide unprecedented potential for the mapping of coastal topography and bathymetry using an airborne Light Detection and Ranging (LIDAR) system. This system uses pulses of light to illuminate the terrain and by accurately measuring the round trip travel time of the laser pulse from the aircraft to the ground, a highly accurate spot elevation can be calculated.

While there are a number of companies offering topographic data collection using a light detection and ranging system, there are relatively few such systems in the world that collect bathymetric data. In North America the only system is the SHOALS (Scanning Hydrographic Operational Airborne LIDAR System) operated by the U.S. Army Corps of Engineers, Mobile, Alabama. SHOALS uses a green laser to penetrate water and an infra-red laser, which does not penetrate water to detect the water surface location. (Figure 2).

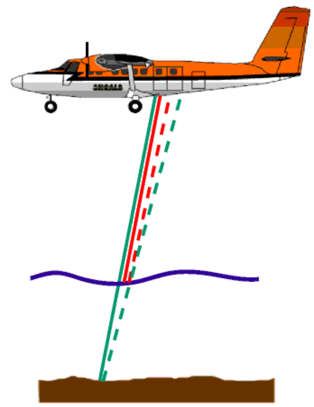

Figure 2: SHOALS (Scanning Hydrographic Operational Airborne LIDAR System) Green and Red Lasers.

Initially it was hoped that the entire shoreline could be flown, however, the costs were prohibitive and so a prioritization of the shoreline was undertaken. Based on input from the Study's Technical Work Groups regarding the areas most sensitive to water level impacts and identification of existing topographic, bathymetric and imagery data for near-shore areas, priority locations were identified.

From the assessment and prioritization exercise it was concluded that *the highest priority for detailed topographic and bathymetric data collection in the U.S. was for the Lake Ontario shoreline within Orleans, Monroe, Cayuga and Oswego Counties of New York* (*US2, US4 and US7 in Figure 3*). The topographic LIDAR collection and the bathymetric LIDAR using SHOALS is complete for these U.S. shore units.

In Canada, the highest priorities for detailed bathymetric data on Lake Ontario were along the shore from Niagara to Hamilton, Toronto, Durham and Northumberland and the Bay of Quinte in the Province of Ontario (*CDN1, CDN7 and CDN11 in Figure 3*). SHOALS bathymetric LIDAR collection was completed in conjunction with the U.S. collection.

On the St. Lawrence River, both bathymetric and topographic priorities were identified from the Lakes of the Montreal Archipelago downstream to Trois-Rivières. *Due to the turbidity of the St. Lawrence River, it was decided that the SHOALS system would not be used in the River. As an alternative, traditional acoustic soundings from a small boat were used where possible and economically feasible*. Topographic LIDAR collection was completed for the entire area from Cornwall, Ontario to Trois-Rivières, Quebec (*Riv 7 through Riv 10 in Figure 3*).

Figure 3 illustrates the topographic and bathymetric data collection in Year 1 shown in blue (bathymetric LIDAR), yellow (topographic LIDAR) and green (existing flood mapping).

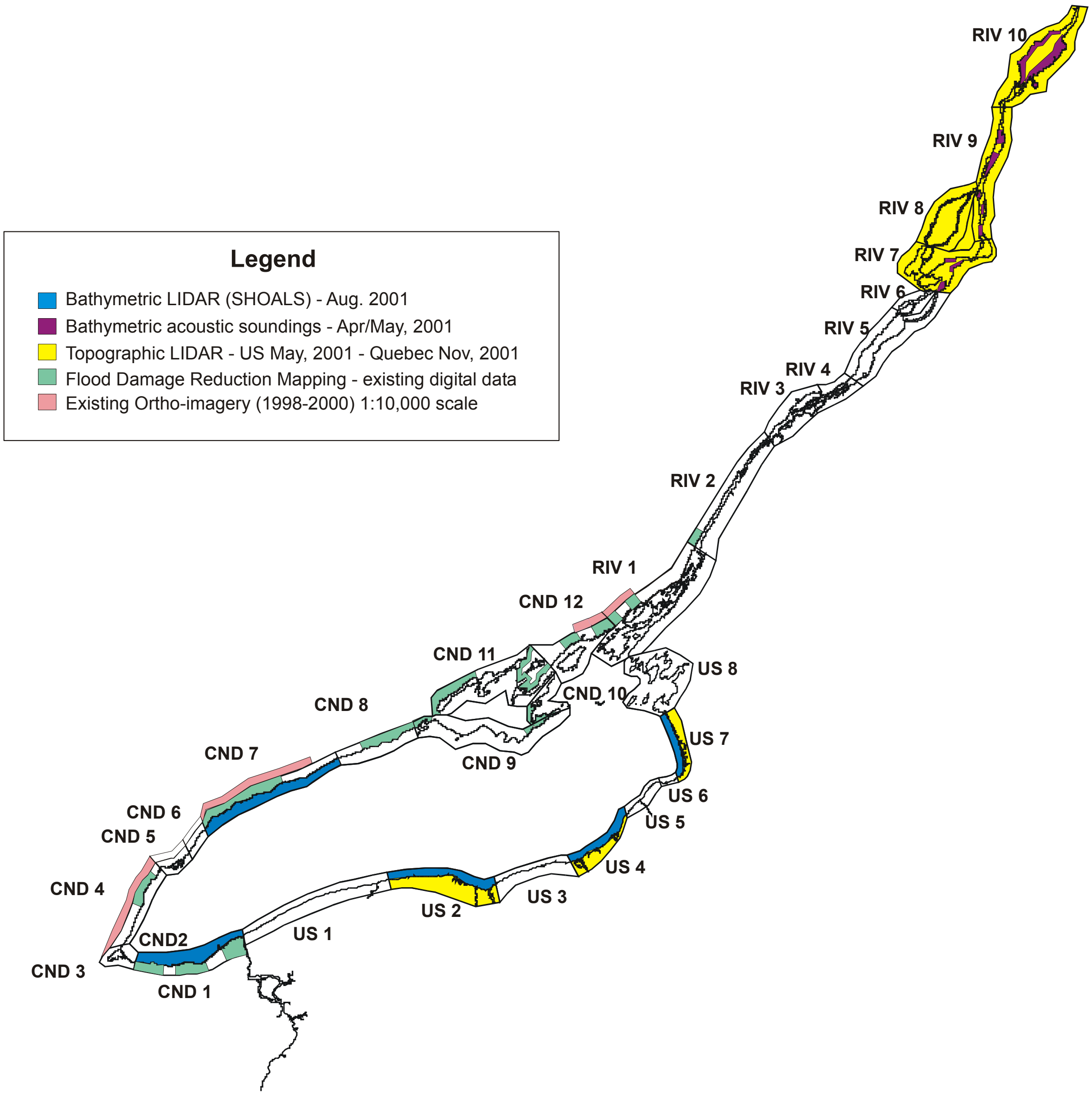

Figure 3: Topographic & Bathymetric Data Collection Areas Completed in Year 1

4.2 Imagery

Remotely sensed imagery data have also been identified as important in the evaluation process. *Imagery data can often fill in gaps, assist in the quality control of topographic data and are valuable in determining the location of buildings, presence of shore protection, docks, boat houses, and marinas. The data are also valuable for vegetation classification* by the Environmental Technical Work Group.

Colour Infra-Red aerial photography is complete for all 16 U.S. wetland sites and 5 Canadian sites where existing data were not available. *Colour Infra-Red is particularly useful for vegetation classification.* Site locations and an example is shown in Figure 4.

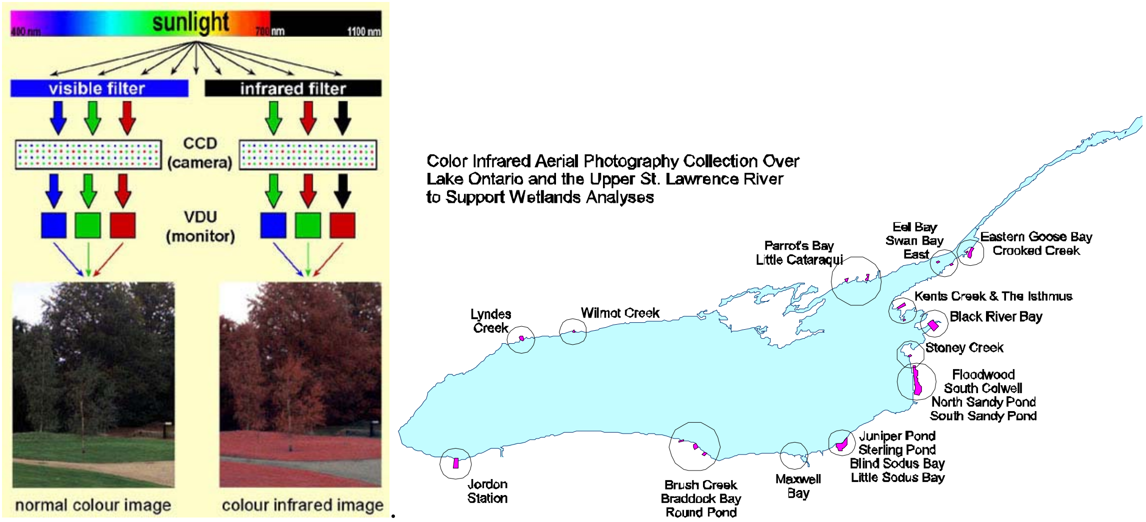

Figure 4: Example of Colour Infra-Red Imagery and Locations of Imagery Collection

Existing ortho-imagery required by the Coastal Processes Technical Work Group for their priority zones for assessing top and toe of bluff and building footprints has been acquired where available in Canada. This includes most of the north shore of Lake Ontario and the Kingston area. Existing ortho-imagery purchased in Year 1 is identified in Figure 3 (pink zones).

4.3 Geographic Information Systems Development

Many of the Technical Work Groups will be using geospatial data. Geospatial data have latitude and longitude coordinates and can be mapped, analyzed and modeled using geographic information systems. This type of system allows viewing of how shoreline features and environmental conditions change over time. During Year 1, guidelines were provided to each technical work group so that shoreline digital elevation models including all topographic and bathymetric data collected in Year 1 could be developed for inclusion in a geographic information system.

Figure 5: Example of Ortho-Imagery for Kingston *(Courtesy Of The City Of Kingston)*

4.4 Information Management Strategy

Many of the Technical Work Groups will generate and/or access, manage, and provide considerable information resources. The types of data and information both required and generated will vary among groups. While the Hydrology and Hydraulic group has a focus on input and output data on levels and flows, most of the other groups will be developing performance indicators for evaluating the impacts of changes to the regulation plan. They will be focusing on the data and information needed to support these indicators. The Public Interest Advisory Group will likely focus on information products for public distribution and the Study Board on results of investigations.

To address all the information management needs and issues of the Study, and to enable archival and future retrieval of information developed over the course of the investigation, it was determined that a well thought through and crafted Information Management Strategy should be incorporated into the Study. As a result, a contractor was hired to develop with a team of information strategy experts, a set of options, all under the supervision of the Common Data Needs Technical Work Group.

5.0 COASTAL PROCESSES

Year 1 activities of the Coastal Processes Technical Work Group focused on establishing clear and effective strategic direction for the group. Initial planning objectives and performance indicators were developed and decisions were made on approaches to be undertaken for modeling impacts. Data review and collection were undertaken, along with refinement of the models to be used.

5.1 Planning Objectives and Performance Indicators

Given all the possible riparian impacts that can occur for both high and low water levels, the key "problem" identified for the group was the need to develop a methodology and a set of tools that can effectively take all possible impacts into consideration for each (or a range of) water level scenarios. This methodology and its tools would be used to suggest a regulation plan that provides an acceptable balance of benefits and drawbacks for the riparian interest group and to allow an evaluation of impacts related to erosion and flooding.

A series of broad "planning objectives" was drafted to help the group identify what they would prefer to see in a regulation plan for Lake Ontario and the St. Lawrence River. These planning objectives include:

- Reduce real/potential flood events and associated damages along the shores of Lake Ontario and the St. Lawrence River;
- Reduce real/potential erosion and associated damages along the shores of Lake Ontario and the St. Lawrence River; and
- Reduce real/potential extreme low water events and associated damages along the shores of Lake Ontario and the St. Lawrence River.

To achieve these broad objectives however, the group must first address a number of what might be considered more specific objectives. These include:

- Determine the possible response of both Lake Ontario and St. Lawrence River shoreline types to changes in water levels and flows that may occur as a result of changes to the regulation plan;
- Based on the above responses, determine the various impacts (both positive and negative) that may result to the riparian interest group along these shorelines;
- Determine as well, the impacts (both positive and negative) of possible flooding or low water level scenarios that may occur as a result of changes to the regulation plan; and
- Using the above evaluations, provide recommendations of new regulation criteria that best considers the needs of the riparian interest group.

There are many possible performance indicators being discussed by the group. An initial set of indicators has been developed and it is the group's plan to revisit these every six months based on additional knowledge gained from studies.

5.2 Modeling Workshop

A workshop was held to review and evaluate coastal processes, shoreline response and other hydraulic modeling techniques that are available for assessing shoreline response to water level and flow changes in Lake Ontario and the St. Lawrence River, both upstream and downstream of the regulation structure. Modeling will be used to characterize and understand the response of various open-coast and riverine shoreline types and profiles to changes in the way the regulation of the levels and flows of the Lake and River are carried out.

Two models were selected to simulate and predict shoreline response to water level and flow change. On the open Lake and Upper River, a model known as the Flood and Erosion Prediction System, will be used. For the Lower St. Lawrence River, a derivation of a model called SedSim is being developed.

5.3 Data Mining Report

The TWG conducted a data inventory of various government agencies (federal, provincial, state, regional and local), consultants, academics, non-government organizations and public interest groups to determine what physical and "landside" data is available. This also included an inventory of any mapping, GIS and aerial photography that exists for the Lake Ontario shoreline, as well as the U.S. and Ontario sections of the St. Lawrence River. All data sources discovered were summarized in a data mining report.

5.4 Shoreline Classification - Lake Ontario and Upper St. Lawrence River

The development, collection and organization of data sets needed for these models were initiated. One of the key data sets required for the flood and erosion prediction system model was a comprehensive classification of the different shoreline types, shore protection types and nearshore geology that exist along both the Lake and the River shorelines. These data sets are important because they all directly relate to the overall erosion sensitivity of the shoreline. They also allow the identification and determination of the extent of these different shoreline types so that lake-wide and river-wide analysis can be made from representative sites. This classification was undertaken on a kilometre-by-kilometre basis around Lake Ontario and the St. Lawrence River upstream of the control structure. Data developed from this classification were entered into a geographic information system for use with the model. An example of this mapping is shown in Figure 6.

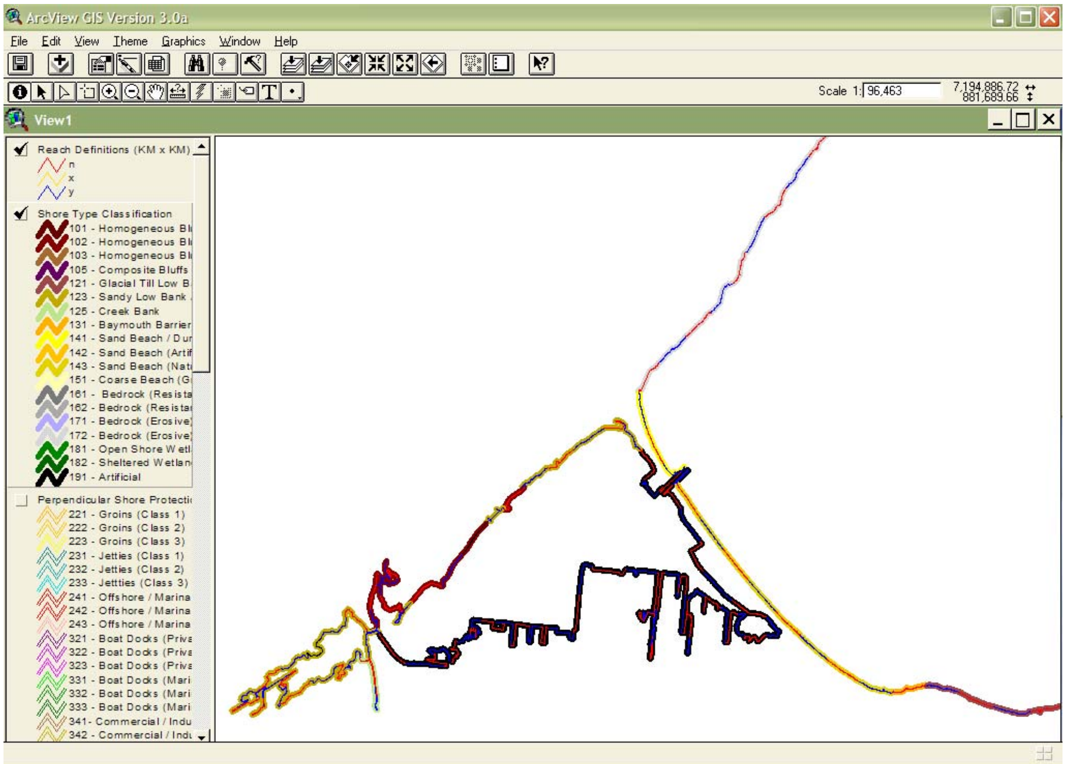

Figure 6: Example of Shore Type Classification Mapping for Western End of Lake Ontario and Hamilton Harbour (Thick Colour Lines = Shore Type Class, Thin Red and Blue Alternating Lines = Reach Breaks).

5.5 Shoreline Classification - Lower St. Lawrence River Activities

Several projects were initiated for the lower St. Lawrence River to contribute to shoreline classification and development of a recession rate model.

A review of existing data sources and availability was undertaken, as well as data needs for planned modeling. The architecture of a geographic information system to support the modeling was developed.

A review of the physical processes affecting erosion and flooding on the St.-Lawrence River and a review of available erosion models and preliminary recession modeling was undertaken. An analysis of wind climatology was undertaken and used to generate wave data for use in modeling.

Enhancement of an existing coastal zone geographic information system database was undertaken through quality control of existing datasets, addition of new measured information concerning recession rates at specific locations, and a literature review of existing studies on recession rates. High-resolution recession rates along the river were calculated for 1964 to 2000 through the use of aerial photography.

6. ENVIRONMENTAL

The Environmental Technical Work Group was given the task of answering the difficult questions concerning the effect of water levels and flows on different environmental indicators. The overall objectives for the group are to:

- Ensure that all types of native habitats and shoreline features are represented in an abundance that allows for the maintenance of ecosystem resilience and integrity over all seasons; and
- Maintain hydraulic and spatial connectivity of habitats to ensure that fauna have access, temporally and spatially, to a sufficient surface of all the types of habitats they need to complete their life cycles.

In addition, effects of different water regulation plans on environmental indicators must be determined. In other words, these effects must be determined quantitatively or qualitatively to the extent possible so that they may be effectively compared with effects on other aspects of water regulation, as investigated in other working groups of the Study.

During Year 1, the Environmental Technical Work Group focused their work on:

- Wetland vegetation studies and mapping to provide recommendations on the regulation scenarios to maintain dynamic cycles and processes;
- Faunal studies to protect significant habitat in coastal waters for fish species and communities; and
- Modeling and integration of data to estimate outcomes of water level scenarios on all environmental attributes.

One of the more difficult challenges for the group has been to determine the best way in which "environment" should be defined. *The group has defined "environment" primarily in terms of habitat assessments and biological performance indicators. That is, the main effect of different water levels and fluctuations is considered to be related to habitat quantity and quality, particularly wetlands. In turn, biological parameters are strongly related to habitat characteristics. An additional environmental indicator is water quality, particularly for portions of the St. Lawrence River.* Specifically, flows in the St. Lawrence River are mixed with other tributaries, resulting in different dilution effects and concentrations of chemical species of interest. Water quality also is affected by varying water levels in the river, as sediments in shallow regions may be eroded more readily or may become exposed to air.

Another main challenge for the group is to determine the best way to assign a value to a particular change in an environmental parameter, once "environment" is defined. Ideally, an economic value would be assigned to various changes in the environmental parameters, or used to quantify the change in a given environmental parameter to a change in water level and/or flow. It may be possible to do this in some cases, such as evaluating loss of tourism income due to loss of desirable fish stock. However, in most cases this is a difficult task. For example, how much is it worth to preserve a certain wetland, or how much of a loss might it be if half the area of a wetland is lost due to changes in water levels? Evaluation in terms of economic parameters would facilitate comparison of different regulation plans and these kinds of questions will require further evaluation by the group as the Study proceeds. Public input is considered to be an important element in these deliberations.

6.1 Specific Activities

Specific activities in Year 1 are summarized as follows:

A. Wetlands

- Identification and selection of 32 wetland sites of 4 geomorphic types (Lake Ontario/Upper St. Lawrence Region) (*see Figures 7 and 8*);
- Identification and selection of 14 wetland sites in the Lower St. Lawrence River;
- Development of detailed bathymetric and topographic data;
- Photo-interpretation and mapping of wetland vegetation communities (historic and recent); and
- Development of mathematical and geographic information system model capable of predicting relative proportions of wetland vegetation communities under proposed new regulation plans.

B. Fish

- Data collection and modeling to lead into future work;
- Identification of missing information (e.g., topography, bathymetry, and temperature information); and
- Development of consistent performance indicators.

C. Birds

- Review of bird use of Lake Ontario and St. Lawrence River nearshore habitats;
- Literature review to identify habitat variables that influence waterbird communities and the occurrence of species of concern; and
- Development of a model for predicting wetland bird community diversity and abundance.

D. Priority species

- Effects of water levels on the St. Lawrence River, between Boucherville – Sorel spawning grounds of large pike and their recruitment;
- Impacts of water levels and flows on the colonization, abundance, and distribution of zebra mussels and other exotic species.

Figure 7: Braddock Bay (photo courtesy of Douglas Wilcox).

Figure 8: South Colwell Pond (photo courtesy of Douglas Wilcox).

E. Integration and assessment criteria development

- Experts workshop to select environmental regulation criteria;
- Development of interim environmental criteria for the regulation of the Lake Ontario-St. Lawrence River System; and
- Modeling hydroecology relationships for assessing impacts of water regulation plans on the Lake Ontario and St. Lawrence River System.

In addition to the studies listed above, *an important element of Year 1 activities was to identify a reasonable set of performance indicators that might best represent environmental effects of different water regulation plans*. These performance indicators include some of the categories listed above and have been developed to form a framework for work to be conducted in future years of the Study. The performance indicators were chosen on the basis of the following criteria:

- Relevance to water levels and flow regulation;
- Applicability to formulate regulation criteria and test scenarios;
- Quantitative relationship with manageable hydrological factors;
- Information/expertise readily available;
- Potential for integration with other studies;
- Geographic area of applicability;
- Usefulness of interim products or results; and
- Usefulness in addressing Public Interest Advisory Group and decision maker concerns.

From an original list of approximately three dozen candidates, the following indicators were chosen:

- Wetland birds;
- Wildfowl and colonial birds;
- Amphibians and reptiles;
- Fish;
- Habitat quantity;
- Habitat quality;
- Water quality; and
- Mammals.

In addition, *data and model integration* also *were identified as significant needs for the group*. Several directions and possible modeling frameworks were debated, and development of a modeling framework as an integrating factor for the various activities of the group will be continued in Year 2.

7. RECREATIONAL BOATING AND TOURISM

Work performed or currently in progress includes:

- Marina inventory on Lake Ontario and the St. Lawrence River (U.S. and Canada), including physical data collection (water depths, etc.);
- Developing a marina physical impact survey;
- Using preliminary data from surveys on socio-economic valuation; and
- Working on a regional impact model and related topics.

7.1 Marina Surveys and Impact Studies

Site characterization and operators surveys were performed for this first year. Site characterization was done before the survey in order to have an independent view on marina and club characteristics and situations. Also, it was necessary to obtain physical data in order to relate them with operator perception and with International Great Lakes Datum station reference points (hydrologic attributes).

The purpose of the physical marina survey was to obtain site characterization data (capacity, type of boats and water-depth needs, goods and services provided, etc.) in the study area. This will be key in relating water levels to boating activity impacts, especially with performance indicators chosen by the Recreational Boating Technical Work Group. Figure 9 shows a marina on Lake St. Pierre (Club nautique de la batture, Nicolet).

Figure 9: Lower St. Lawrence River Marina

Physical data measurement was completed for Lake Ontario, Upper and Lower St. Lawrence River. All boat access sites were visited to ensure a complete picture of all sites along the Lake and the River (downstream to Lake St. Pierre). The following information was gathered:

Lake Ontario:
- *85 marinas, yacht clubs or other clubs, 37 boat launching ramps (municipal)*

    - *55 (65%) are marinas with predominance of floating docks*
    - *54 (64) are marinas with protective measures for boats (e.g. wall)*

Upper River:
- *35 marinas, yacht clubs or other clubs, 27 boat launching ramps (municipal)*

    - *26 (74%) are marinas with predominance of floating docks*
    - *29 (66%) are marinas with protective measures for boats*

Lower River:
- *43 marinas, yacht clubs or other clubs, 35 boat launching ramps (municipal)*

    - *40 (93%) are marinas with predominance of floating docks*
    - *26 (60%) are marinas with protective measures for boats*

Almost all facilities inventoried were in good shape (fully usable), but many facilities experienced moderate to high constraints due to aquatic plants (on-site examination). Mean water depth estimates according to selective reference measures were as follows for what could be considered unfavorable depths related to low water level conditions:

- *Lake: 2.48 metres (8.14 feet) (August-September 2001)*
- *Upper River: 2.18 metres (7.15 feet) (August-September 2001)*
- *Lower River: 1.9 metres (6.23 feet) (July-August 1999 and August 2000)*

This information must be carefully interpreted in order to measure selectivity and a huge standard variation between sites. In order to have a better estimate on a site basis, a sensitive site (inventoried in 1999) was chosen and water level fluctuation was analyzed according to water depth variability and water level scenarios. Three classes of draft constraints were also used in estimating potential impacts for this site. *With different water level scenarios (e.g., one metre above and below chart datum), accessibility to the representative marina was drastically changing.* This is the first step toward a more comprehensive analysis of site variability in estimating impacts and water level preferences.

The New York State Sea Grant recently updated an inventory of marinas. The Lake Ontario and St. Lawrence River portion of the data is being placed into a geographic information system. All subsequent data collected at marina sites will then automatically have a geographic component.

Physical data collection at a sample of marinas in three representative areas was conducted in late August/early September 2001. Select bottom elevations at slips in marinas along Lake Ontario and the St. Lawrence River (U.S.) were collected to compare them to those taken in 1990 at marinas. The three areas were: Alexandria Bay to Clayton, NY; Great Sodus Bay; and North Sandy Pond. The comparison in bathymetry at the marinas was used as a basis to determine the necessity of a new data collection effort for all marinas to replace the bathymetry established in 1990. The sample data was also used to establish a comparison in size and boat type distributions in these marinas as compared to those obtained in 1990. The draft marina inventory survey developed for the inventory of Canadian marinas was pre-tested at the marinas at these sites and was used in the process to modify and finalize that survey instrument.

Going further in the analysis of marinas and club impact, a survey was designed to review basic information about supply of services and access, identify impacts and problems, review water level preferences, and identify adaptation measures to cope with uncertainty of water level fluctuations, especially low water situations. A preliminary survey was performed in 2000 to test some question types and variability of response according to water level impact, economic situation and climatic factors and adaptation measures. Literature review and further pre-testing of a new close-ended survey completed this pre-survey step.

The same survey form was used for the 2001 survey of the Lake, Upper and Lower River (with a French translated version). Marina and club operators were surveyed in autumn 2001, after a problematic low water level summer for boaters. This context should be kept in mind.

Response rates were quite good (74% - Upper River, 79% - Lower River, and 87% - Lake). The Collaboration of the Ontario Marine Operators Association helped to ensure this high response rate. *The first performance indicator has to do with boat capacity (number of slips and moorings) and according to responses received, an estimate of the 2001 capacity for Canadian marinas is:*

- *14,620 places for the Lake;*
- *3,465 places for the Upper River; and*
- *5,289 places for the Lower River.*

This will serve as the basis for estimating water level impacts on marinas' and clubs' capacities.

7.2 Developing a Regional Model

The first task in developing a model was to identify a performance indicator matrix that will be used to estimate impact according to different water level scenarios and regulation plans. This was done as an on-going process with input from, the technical work groups and the Study Board. Another task will have to do with identifying boaters' impacts, tourism related impacts and more extensive boating services such as charters and cruises. The definition of the relationship between water level and dock usability will be incorporated as a spatial analysis function.

7.3 Evaluation of Tourism

A preliminary study was also done for the Lower River and more precisely on Old-Port of Montreal boat services in order to identify possible variability of impacts of water level variations. Some clarification of issues and definitions had been made in collaboration with the University of Quebec in Montréal, Urban ecosystems Chair (Chaire sur les écosystèmes urbains).

Preliminary results show differences of impact and possible ways of adaptation (changing service, itinerary, modifying docks, boat design, etc.). *Results of this study show the need for a more extensive examination of the tourism sector according to sensitive areas along the Lake, Upper and Lower River, and for specific tourism areas such as Toronto waterfront, Thousand Islands, and the Lake St. Pierre Reserve of the Biosphere.*

8. COMMERCIAL NAVIGATION

The Commercial Navigation Technical Work Group Year 1 efforts concentrated on:

identifying key geographical areas within the study area (Lake Ontario to the St. Lawrence River through Becancour, Quebec), developing planning objectives, developing performance metrics and indicators, and coordinating a contract with the Center For Research And Training In Maritime and Intermodal Transportation, now “Maritime Innovation”, to develop commercial navigation data.

8.1 Key Geographical Areas

Five key geographical areas were identified: Port Weller to Kingston (Lake Ontario); Kingston to Cornwall; Cornwall to Beauharnois; Beauharnois to Montréal; and Montréal to Bécancour. The navigation season for the first four areas is approximately nine months, from the fourth week of March through the end of December. The navigation season for the Port of Montréal and downstream is year around. *Each of these five geographical areas have their own concerns about water level changes resulting from regulation of Lake Ontario, including impacts from high and low lake outflows and impacts from timing of discharges.* Also addressed were impacts from ice management, mainly between Montréal and Bécancour.

8.2 Developing Planning Objectives

In general, high water levels do not cause a problem for commercial navigation. Higher lake levels allow vessels to take full advantage of their loading capability. However, negative impacts to commercial navigation from high water levels include the inundation of commercial docks and difficulties due to high water velocities and high cross current flows making navigation unsafe.

The timing and frequency of water level fluctuations, as well as the time of year they occur, play a role in the ultimate impact on commercial navigation. Water level fluctuations also affect ice control operations at Montreal and downstream.

Given the above, planning objectives were identified, four of which are:

- Optimize water levels and currents to maximize benefits (predictability, reliability, revenues, safety) and maintain safety of commercial navigation, without exceeding flood thresholds;
- Minimize extremes in term of amplitudes and frequencies to provide stability and predictability of water levels and currents, in order to optimize long-term cargo load planning and effectiveness of navigation;
- Maintain currents in a safe range for commercial navigation; and
- Maximize ice cover stability and integrity from Montreal down to Becancour in wintertime to prevent ice jams and resulting flooding, and maintain safety of navigation.

8.3 Performance Indicators

The hydraulic attributes that caused commercial navigation impacts in each geographical area were identified. Performance indicators were developed for each of the areas to identify when these impacts would begin. A total of 42 initial indicators were developed which looked at identifying when impacts to navigation are encountered (speed reductions, loading reductions, cessation of vessel movement due to unsafe cross current conditions, etc.). The indicators were developed for high flow conditions, low flow conditions, timing of discharges and target gradients for each area. Indicators were also developed that would enhance the development of a stable ice cover important to winter navigation at the Port of Montreal.

8.4 Commercial Navigation Data

A major work item performed during Year 1 involved a contract to define commercial navigation data between Saint Lambert and Sept Isles, Quebec. Data collection focused on commercial vessels, voyages, cargo carried and ports.

Data on commercial vessels included: name; registration number; type (bulker, tanker, self unloader); flag of registry; length; width; draft; carrying capacity by commodity and tons per inch immersion factor at the mid-summer load line.

Data on voyages included: vessel arrival and departure dates; vessel time of arrival and departure; port of origin; port of destination and vessel draft when fully loaded at mid-summer, by commodity.

Cargo data included: transit port in Canada; type of cargo; amount of cargo; port of origin/destination; type of traffic (international or domestic) and direction of the flow (import or export).

Port data included: name of port; municipality the port was located in; commercial address; berth locations (latitude and longitude); information on berths (number, length, depth of water alongside); identification of terminal operators and presence of railroad connections.

Data was collected for 1995 to 1999 and placed into a database allowing queries to be performed. A series of typical queries were identified.

9. HYDROPOWER

The Hydropower Technical Work Group is preparing a methodology to evaluate performance of the new Plan proposals. Two options are possible:

- The Power entities could make their own evaluation of each plan proposal and provide the results to the Plan Formulation and Evaluation Group, as was proposed in the Plan of Study dated September 1999; or
- Simplified models could be provided to the Plan Formulation and Evaluation Group for preliminary plan evaluation. The hydropower entities would provide input to the models for specific concerns or scenarios.

The evaluation methodology will be determined in Year 2.

The New York Power Authority, Ontario Power Generation and Hydro Quebec, are generally well prepared in terms of technical knowledge of their systems, including equipment characteristics, and maintenance and operation concerns. They own models or software programs for their power planning.

9.1 Performance Indicators

The Hydropower performance indicators to be evaluated for new plans are:

- *Efficiency* : *Maximize Generation Efficiency*

  - *Generate the maximum amount of power with the water available.*
  - *Power vs flow curves can be provided for different periods of the year.*

- *Economic value* : *Maximize the economic value of the power during the year and on a daily basis.*

  - *A weighting curve can be provided for the individual hydropower complexes to take into account variation of the value of power with time (seasonal changes and peak demand periods).*
  - *Evaluate the impact of proposed plans on Greenhouse Gas Emissions if the power is replaced by fossil fuel plants.*

- *Mid-Term Predictability* : *The outflow of Lake Ontario should be mid-term predictable with a good level of accuracy.*

  - *Essential for production and maintenance planning.*

- *Flow stability* : *The flow should be stable from week to week.*

  - *This condition is important for production and maintenance planning. Frequent up and down variations from week to week should be avoided except for special conditions like ice cover formation or emergencies.*

- *Ice management* : *It is essential to form a stable ice cover, without which river outflows cannot be guaranteed and significant ice jam problems can occur.*

9.2 Peaking and Ponding

The power entities provided the results of two studies related to Peaking and Ponding to the Study Board in March 2002. Several studies including environmental impact studies have been carried out by the Power Entities over the past 20 years. This information was also provided to the Study Board and its working groups.

9.3 White Paper

The group was asked to produce a "White paper" describing in particular the state of the industry in terms of present and future trends, market factors and effects of climate change. Much of the work was completed during Year 1, with the paper to be completed in Year 2.

10. DOMESTIC, INDUSTRIAL AND MUNICIPAL WATER USES

The Domestic, Industrial and Municipal Water Uses Technical Work Group is tasked with identifying potential problems with water supply infrastructure related to water level fluctuations. One specific area of concern is the potential for impacts on municipal and industrial intakes along Lake Ontario and St. Lawrence River shorelines. *Very low water levels and/or flows can impair the functioning of water intakes thereby reducing their capacity and also may impact on water quality. High water levels and/or flows may also* *impact on municipal and industrial structures. In addition to municipal and industrial impacts, there are concerns about the impacts of fluctuating water levels on private domestic intakes and shore wells.*

A contract was issued to examine potential problems for the municipal and industrial infrastructure associated with lake level fluctuations. The contractor has undertaken the following tasks:

Task 1: Identify existing secondary data sources containing information regarding municipal, industrial, and domestic water supply intakes in Lake Ontario and the St. Lawrence River.

Task 2: Based upon an assessment of secondary data sources on water supply intakes, targeted data will be collected. Information will be incorporated into an electronic database and a draft interview guide developed for use in Task 3 of the study.

Task 3: Based on data developed in Task 2, municipal suppliers will be identified that withdraw substantive quantities of water and may be likely to have problems associated with fluctuations in lake levels and/or water flows. Those municipal suppliers will be interviewed by telephone and on-site.

The following summarizes Task 1 and Task 2 activities completed during Year 1.

10.1 Survey of Water Intakes

Collection of readily available secondary data sources has involved contacts with the following agencies and organizations:

- New York State Department of Environmental Conservation;
- New York State Department of Health;
- New York Rural Water Association;
- Great Lakes Commission;
- U.S. Geologic Survey, New York District;
- U.S. Army Corps of Engineers Buffalo District;
- Fisheries and Oceans Canada;
- Ministry of the Environment and Energy, Ontario;
- Quebec Environment Ministry; and
- Local municipal jurisdictions of New York, Ontario, and Quebec.

In the U.S., the New York State Department of Environmental Conservation and the New York State Department of Health maintain the two primary sources of publicly available data on water intakes along Lake Ontario and the St. Lawrence River.

The New York State Department of Environmental Conservation provided available data from the Public Water Supply Permit Program. This program complies with the Great Lakes Water Withdrawal Registration Program that requires entities withdrawing 100,000 gallons per day or more from Lake Ontario to apply to the department for a permit. The program data contain records of large industrial intakes (e.g., Kodak Eastman, ALCAN) and a number of public systems including the largest identified – Monroe County Water Authority, Onondaga County Water Authority and Wayne County Water Authority.

The New York State Department of Health provided data compiled as part of New York's Safe Drinking Water Information System. New York State regulations require a permit for systems with at least five service connections that are used year-round for potable water. The U.S. contractor contacted the department to determine if the information system contains additional information regarding the physical characteristics of intakes such as elevation, longitude, latitude and capacity.

Given that Lake Ontario and the St. Lawrence River are navigable waterways, the Corps of Engineers has regulatory authority with respect to projects in or on the Lake or River. The U.S. contractor contacted the Buffalo District's Regulatory Branch. Buffalo has historic records on some intakes, but their database is incomplete and the Corps is not always informed about intake or discharge construction projects on or in Lake Ontario.

The Ontario Ministry of Environment has been identified as the centralized source of data regarding intakes in Ontario. The Ontario Water Resources Act is the primary means by which the ministry regulates water withdrawals, known as "water takings" in Canada, from surface or groundwater supplies. The act requires that water takings in excess of 50,000 liters per day obtain a permit from the ministry via the Permit to Take Water Program.

In Quebec, contacts have included the central Ministry of Quebec Environment office in Quebec City and the local district office in Montreal. Documents regarding pollution that are more industry specific were obtained from the St. Lawrence Centre, a branch of Environment Canada, in Montreal, but these records contain limited information regarding municipal supplies.

11. HYDROLOGY AND HYDRAULICS

The responsibilities of the Hydrology and Hydraulics Technical Work Group are summarized as:

- Develop appropriate hydrologic scenarios for use in the formulation and evaluation of regulation plans, and
- Construction of hydrologic and hydraulic models of the Lake Ontario - St. Lawrence River System to enable the simulation of levels, flows and other hydraulic conditions

that would result from the application of various regulation plans given different hydrologic scenarios.

11.1 Hydrologic Scenarios

Three hydrologic scenarios are being assembled and developed to evaluate the plans.

- Recorded historic set of hydrologic conditions;
- "Stochastically" generated water supply sequences to account for natural variability; and
- Water supply sequences generated from Global Climate Models that simulate climate change for a number of transient atmospheric change scenarios.

11.2 Hydrologic and Hydraulic Model Development

Numerical models are required to determine the levels, flows and other hydraulic conditions in the system that will result from different regulation plans given various hydrologic scenarios. In addition, precipitation-runoff and lake evaporation models are needed to simulate the net basin water supplies for the Great Lakes and the Ottawa River Basins for the climate change scenarios.

Two types of numerical hydraulic models are of use in the study:

- Those based on principles of water balance; and
- Those related to two-dimensional hydrodynamics.

An existing water balance type model, the Coordinated Great Lakes Regulation and Routing Model, is available to simulate time series of Lake Erie outflows given time series of net basin water supplies to each of the upper lakes. The Lake Ontario mean level and flow for the period are used in existing discharge relationships to calculate water levels at key sites along the international section of the St. Lawrence River. Similar empirical models are needed to relate flows and levels at key St. Lawrence River locations downstream of the Cornwall-Massena control structures.

11.3 Year 1 Progress

The Year 1 projects of the group included work towards the development of the hydrologic scenarios and model development. The following is a list of these projects:

<u>Development of Empirical Relationships to Estimate Water Levels of the St. Lawrence River from Montréal to Batiscan, Quebec</u>. The development of these relationships is complete.

<u>Great Lakes Net Basin Supply and Ottawa River Inflows Stochastic Generation</u>.

In Year 1, work was carried out on two related activities. An analysis of the historical net basin supplies for each of the Great Lakes and the precipitation and temperature series was completed. An update was made of an existing stochastic model known as the “multivariate shifting level model”, previously used in Great Lakes flood assessments, and its extension for use in the Great Lakes and Ottawa River Systems under the entire range from flood to drought conditions.

Climate Change Scenario Development. Three climate change scenario tasks were completed in Year 1. The first task was the extension of the existing Great Lakes climate change scenario dataset to the Ottawa River basin. In the second project, a comparison of available global climate model climate scenarios within the Great Lakes–St. Lawrence River area was made. The third task described current methods for constructing regional climate scenarios and recent advances in regional downscaling techniques for global climate model outputs.

Ottawa River Regulation and Routing Model Upgrade. Work was done jointly by specialists at Hydro Quebec and the Quebec Ministry of Environment to upgrade the MENVIQ model, developed in the 1980s by the Quebec Ministry of Environment, for the simulation of the Ottawa River outflows resulting from the various hydrologic scenarios.

Hydrodynamic Modeling of the St. Lawrence River. Work was done to do the initial development and make operational 2-dimensional hydrodynamic models of two separate sections of the St. Lawrence River for which models did not previously exist. The first project developed a set of models for the upper St. Lawrence River from the outlet of Lake Ontario near Kingston/Cape Vincent to the control structure at Cornwall/Massena.

Lake Ontario Pre-project Outlet Hydraulic Relationship. To identify changes in Lake Ontario levels and flows that have taken place due to outflow regulation compared to pre-project or unregulated conditions, a review of the hydraulic relationship for the Lake Ontario pre-project outlet control section was conducted.

Review of Methods to Regulate Reservoir Outflows. As a first step to determine if there are alternative methods to regulate reservoir outflows that may have good potential for application for the regulation of Lake Ontario, a review of the published water resources engineering literature and an internet search were conducted in Year 1. This review found that *a host of optimization methods are available for consideration as multi-objective reservoir regulation techniques*. Future work on this subject is being considered by the Plan Formulation and Evaluation Group.

Variation of Hourly Water Levels on the St. Lawrence River Downstream of Montreal. Accurate hourly simulations must take into consideration many “higher frequency” processes (e.g. variations in winds, atmospheric pressure, hourly variations in flow at the Hydro Quebec power plants, etc.) that affect short-term water levels. An analysis of the differences between hourly water levels and the quarter-monthly mean water levels in the Study area from Montreal downstream to Batiscan was conducted.

12. PLAN FORMULATION AND EVALUATION

In Year 1 the Study Board spent considerable time discussing how to formulate and then evaluate alternative regulation criteria and regulation plans in order to provide strategic direction for data collection, a framework for the study and an orderly and well-understood decision-making process throughout the Study. This process has been termed Plan Formulation and Evaluation and is expected to take considerably more attention and Study resources than had been identified in the Plan of Study.

The Plan Formulation and Evaluation Group's, task is to provide an integrated system to formulate, evaluate and rank alternative Lake Ontario regulation plans. The group was created in July 2001. The Study Board agreed to adopt a multi-objective framework for evaluation of alternatives as proposed and previously used by Board member Dr. Peter Loucks. In this framework, plans are quantitatively evaluated by measuring their success in meeting stated goals and objectives. Key components for measuring success includes the use of performance indicators and the relationship of those indicators to hydrologic attributes (e.g. levels and flows) of any proposed regulation plan. For example, one of the planning objectives identified by the Study may be to maintain the reliability of navigation conditions in Lake Ontario and the St. Lawrence River through to Becancour. A way of measuring success in meeting this objective can be through a performance indicator which measures the economic impacts of the number of vessels/tons that were either light loaded or incurred transit delays relative to levels and flows under any given regulation plan. Each technical work group was given the task of identifying performance indicators and relating them to hydrologic attributes of the System.

The basic steps of the framework, which is still being developed by all Study participants, are outlined in Figure 10. To facilitate the use of this framework, the group developed a tool to track and compute all necessary relationships identified throughout the evaluation framework in a single computer simulation called the shared vision model. The model contains all the necessary objectives, performance indicators, hydrologic attributes and methods for combining indicators, weighting and ranking interests and evaluating and ranking plans. A shared vision model is built with the help of stakeholders, experts and decision makers. This is an innovative and progressive model building approach. The norm is for "black box" models of particular parts of the managed system, such as coastal damages or river stages, to be developed in relative isolation by specialists. *The shared vision approach improves the chances that the model will simulate the things that people care about, and it makes it more likely that the model will be trusted and used in making study decisions*.

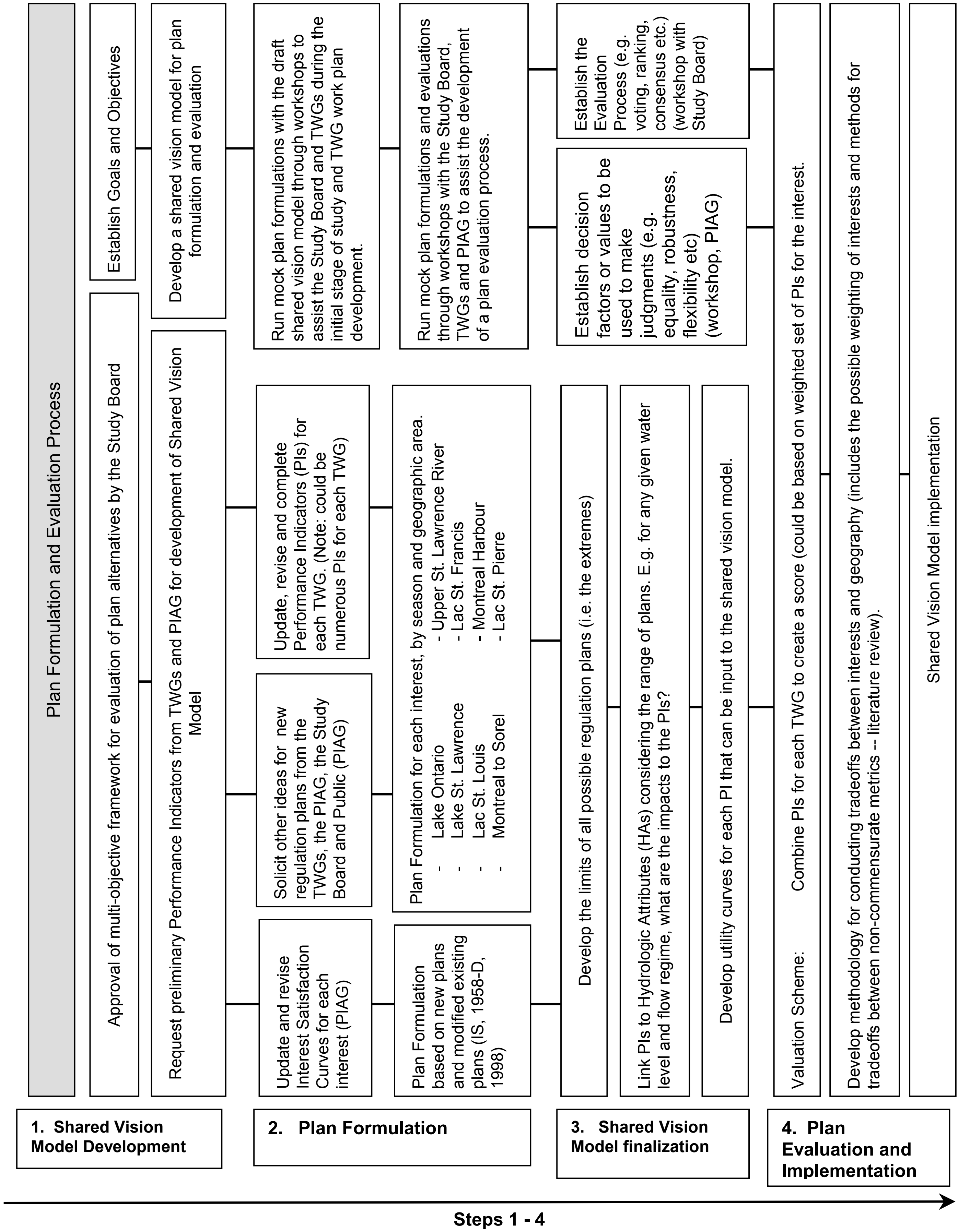

Figure 10: Plan Formulation and Evaluation Group Basic Framework

12.1 The Mock Model

A mock shared vision model was developed using Microsoft Office software and the help of the Hydrologic and Hydraulic Technical Work Group, to show the Study team what such a model could look like. The model allows users to either select from one of five regulation plans or to build a new plan by modifying Plan 1958-D or Plan 1998. The model simulates Plan 1958-D or Plan 1998 by systematically applying decision rules to the input data for each quarter-month of the simulation period. The model does not simulate Plan 1958-D with deviations, Pre-Project or Interest Satisfaction. Instead, it inserts water releases calculated for those plans and then calculates the resulting lake levels, river stages, hydrologic attributes and performance indicators.

12.2 February 2002 Workshop

The Plan Formulation and Evaluation Group developed and executed a planning workshop in February 2002 to guide the Study Team through the whole planning process - from problem identification to plan selection. The goal was to make sure the Study Team would have the information and the framework needed later in the Study to select desirable criteria and regulation plans.

Technical work group co-chairs were asked to present their problems, opportunities, planning objectives, hydrologic attributes, and performance indicators. They then were asked to tell the Board how and when each group would deliver the information needed to support their performance indicators. The group co-chairs were asked to articulate significant issues the Study Team needed to understand or make a decision on.

In subsequent years of the Study workshops with the Public Interest Advisory Group, Technical Work Groups , Board members and the public will be held to refine performance indicators and the shared vision model.

13.0 Supporting Documents

Detailed Descriptions of Year 1 Activities for all Technical Work Groups

Approved Year 1 Work Plans for all Technical Work Groups

Board, Public Interest Advisory Group and Technical Work Group Membership

Glossary of Terms

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

Public Interest Advisory Group, 2002. *Year 1 Report*. Submitted to the International Lake Ontario-St. Lawrence River Study Board, April 2002.

St. Lawrence River–Lake Ontario Plan of Study Team, 1999. *Plan of Study for Criteria Review in the Orders of Approval for Regulation of Lake Ontario-St. Lawrence River Levels and Flows.* Submitted to the International Joint Commission, September 1999.

University of Ottawa, Institute of the Environment & Clinton Edmonds and Associates Limited, 2002. *Lake Ontario and St. Lawrence River – Changes in the Institutional Structure and Their Impact on Water Levels, 1950-2001*, January 2002.

<u>Documents Generated by Technical Work Groups:</u>

a. <u>Coastal Processes</u>

Christian J. Stewart Consulting, 2002. *A Review of Potential Data Sources for Use in Evaluating Coastal Process and Riparian Impacts Associated With Changing Water Levels on Lake Ontario and the St. Lawrence River*.

<u>b. Hydrology and Hydraulic Modeling</u>

Barrow, E., 2002. *Climate Change in the Great Lakes-St. Lawrence Region: A Comparison of Climate Change Scenarios.*

Barrow, E., 2002. *Obtaining Finer Resolution Scenarios of Climate Change: A review of Downscaling Methodologies.*

Caldwell, R. and D. Fay, 2002. *Lake Ontario Pre-project Outlet Hydraulic Relationship.*

Fan, Y. and D. Fay, 2001. *Variation of St. Lawrence River Hourly Water Levels about the Quarter-Monthly Mean.*

Fan, Y. and D. Fay, 2002. *Development of Empirical Relationships to Estimate Water*

Levels of the St. Lawrence River from Montreal to Batiscan, Quebec. March 2002.

Lyttle, A., 2002. *Review of Methods to Regulate Reservoir Outflows.*

Morin, J., 2002. *Two-dimensional Hydrodynamic Model for Lac St. Louis.*

Thompson, A., 2002. *Two-dimensional Hydrodynamic Models for the upper St. Lawrence River from the Outlet of the Lake near Kingston/Cape Vincent to the Control Structure at Cornwall/Massena.*