4.0 Resource Evaluations

In order to determine if alternative regulation plans meet contemporary and emerging needs, as well as interests and preferences for managing the system in a sustainable manner, evaluations need to be performed to assess the impacts of changes in levels and flows on various resource groups. The following sections list the studies that are recommended to provide the information necessary to make sound decisions on possible alternative regulation plans.

Resource evaluations will be conducted to address the entire study area, including Lakes Superior, Michigan, Huron and Erie, as well as the connecting channels (St. Marys River, St. Clair River, Lake St. Clair, Detroit River and Niagara River). The level of detail in the evaluation will depend on the degree of impacts of alternative water management options. Evaluations will be conducted to include all alternative regulation plans and St. Clair River investigations.

LESSON LEARNED: It is very important to define clearly the objective of the study and the questions to be answered. Studies should then be funded that will provide information to answer those questions, and not just interesting research projects. The subjects studied must clearly be impacted significantly by water levels and flows.

4.1 Ecosystem

The ecosystem resource area covers a broad spectrum of valuable individual resources on the upper Great Lakes from Lake Superior through Lake Erie that could potentially be affected by changes in regulation of Lake Superior outflows. Ecosystem is defined for purposes of this document as a community or assemblage of living things, together with their environment. The community of living things that will be addressed under the ecosystem evaluation area will include wildlife, fish, and supporting habitats and food web organisms. Ecosystems of particular interest are coastal habitats including wetlands, where water levels changes on the order of centimetres (inches) could shift or alter them significantly.

Variation in water levels over cycles of hours, days, seasons, years, decades, and beyond is a feature of the Great Lakes that sets them apart from other aquatic systems in North America. Existing ecosystems have evolved under conditions of water level variation since Holocene glaciation. Natural variation in annual levels of the Great Lakes is caused by climate-driven precipitation and evaporation patterns in the watershed and over the lakes. Glacial isostatic adjustment, causing some parts of the basin to slowly sink and others to slowly rise, also affects natural variation in lake levels over decades.

In the 20th Century, water levels of Lakes Superior and Ontario were affected by human structures that regulate outflows for purposes of hydroelectric power generation, flood control, and commercial navigation. The effect has been to reduce long-term variation especially in these lakes, but has also influenced lake levels for all of the Great Lakes.

Differences in shoreline topography, geomorphology, and geology among the upper lakes affect the manner in which the physical environment and biological communities respond to water level variations. For example, much of the Lake Superior Canadian shoreline is composed of a rugged bedrock shoreline, with beaches and wetlands occurring within some embayments, near river mouths, and in areas of lower topography. In other areas of the basin, the coastal zones may be comprised of active beaches or bluffs of less consolidated material. In these areas, erosional and depositional processes vary with storm events, water levels and flows.

Owing to the great variability of the upper Great Lakes shorelines, there is a complex array of response mechanisms of both the physical and biological environment to water levels changes. This response would be expected to differ in relation to the vertical range of variability (i.e., depth), the spatial extent of the area affected, and the duration of flooding or exposure (e.g., daily versus seasonal versus long term).

Shallow habitats of the nearshore and coast are disproportionately more influenced by lake levels than are deep waters. Small (centimetre) shifts in lake levels can alter the extent, structure, and functions of coastal habitats, and alter the extent of interaction between coastal and nearshore habitats. Most habitats and fish and wildlife populations occur in nearshore and coastal sites, and these zones are high in biodiversity. Human uses of natural habitats are highest in coastal and nearshore areas. Coastal habitats are maintained in states of arrested succession owing to annual and greater cycles of variation in Great Lakes water levels.

Daily flow variations due to hydropower peaking operations and releases from control structures have the potential for affecting local ecosystems. For example, in the St. Marys River, changes in flows may affect spawning fish, fish substrate, and other aquatic organisms. Monthly flow variations due to regulation plan gate changes can also impact fishery resources. Dispersing the effects of discharge changes in the Rapids over a longer period of time may be more beneficial. These resources should be evaluated. The Ecosystems Group will conduct any necessary studies to determine impact associated with hydropower peaking and ponding and participate with the Hydropower, Commercial Navigation and Lake Superior Outflow Regulation Groups to determine system-wide benefits and disbenefits.

Seasonal water-level variation is caused by watershed drainage of snowmelt and precipitation minus evaporation, which influences the growing season processes of habitats and fish and wildlife populations. Aquatic and wetland habitats, such as submerged vegetation, coastal marsh, beaches, mud bottoms and flats, and forested wetlands, form complexes and arrays supported by lake-level variation. Such ecosystem complexes serve many functions that are important to humans, such as reducing erosion; filtering nutrients, contaminants, and sediment; supporting populations of fish, wildlife and other aquatic biota, and commercial products such as wild rice and marsh hay; maintaining native biodiversity; and providing aesthetic and inspiring sites for tourism.

Ongoing studies of the wetlands in Georgian Bay will provide valuable information on the identification and assessment of these wetlands. Specifically, determinations are being made as to which wetlands will be able to migrate towards or away from the shore in response to persistently high or low water levels.

A large scale study was recently completed by The Nature Conservancy and Nature Conservancy of Canada to identify lands and waters critical to the biodiversity in the Great Lakes region. The "Binational Conservation Blueprint for the Great Lakes" scientifically and systematically identifies native species, natural communities and ecological system characteristics and determines where they need to be protected to ensure their long-term survival. These studies will be valuable to the Upper Lakes Study.

Part of an assessment for the ecosystem needs to include the examination of issues related to future basin land use changes. Demographic and land use changes and shifts will likely continue to occur in the basin, along with corresponding water needs. Increased population can result in construction of new highways near the lakeshore or across floodplains. Where these highways cross riverine wetlands adjacent to the lake, flow restrictions under bridges or though culverts also disrupt sediment transport processes and can result in excessive siltation in wetlands or alter hydrological processes. Encroachment can result in direct loss of nearshore environment and chemical contamination of that environment.

The Ecosystem Group should address the issues of climate change/variability and how the ecosystem may need to adapt in the future to respond to more extreme conditions than have been experienced in the past. While water levels and flows will be generated by the Lake Superior Outflow Regulation Group, the impact on ecosystems will be assessed here.

Fundamental to understanding the relationship between management of Lake Superior outflows and the coastal ecosystems of Lakes Superior, Michigan, Huron, St. Clair, and Erie is development of various shoreline mapping and modelling tools. Decision-support tools allow us to synthesize information about relationships and to simulate conditions based on alternative regulation scenarios. In the International Lake Ontario – St. Lawrence River Study an "Integrated Ecological Response Model" (Limno-Tech, 2005) was developed to simulate the interactions of various ecosystem performance indicators and their response to various water level regimes.

Resource-specific analyses are needed to relate the landscape-scale patterns to ecosystem functions and biological populations and communities. Endpoints for analysis include resources such as species at risk, key fisheries, wildlife, wetlands, and other shoreline habitats important to ecosystem sustainability. Resource-specific analyses can fill important gaps in decision-support tools to aid us in understanding and predicting responses of ecosystems to changes in Lake Superior outflow regulation vs.

natural variation and climate. Ecosystem study aspects would include the following tasks:

- Assess impacts of water level variations, such as from peaking and ponding, on the St. Marys River ecosystem, in particular, habitat for fish species, and provide input on guidelines governing flow variations in the St. Marys River at Sault Ste. Marie
- Should a structural solution having dynamic capability be proposed as an option to remediate conditions resulting from modifications to the St. Clair River, a similar analysis needs to be undertaken.
- Acquire and synthesize, for purposes of analysis of lake level scenarios, existing data and expert opinion on the following ecosystem functions of coastal and nearshore habitats: wetlands and other coastal habitats for fish and wildlife, species at risk, fisheries, colonial nesting birds, amphibians and reptiles, submerged aquatic vegetation, exotic/invasive species, wild rice, toxic contaminants, and eutrophying nutrients.
- Develop decision-support models to link water levels and flows with ecosystem information to have predictive capabilities to assess effects of various alternative regulation plans on ecosystems. Methods for model validation should be included. Incorporate existing bathymetry and topography for coastal ecosystems where data are available, and make decision-support tools available to stakeholders.
- Enhance platforms for status and trend reporting and ways to incorporate status and trend information into decision support tools.
- Evaluate effects of alternative regulation scenarios on the ecosystem.
- Develop a risk assessment framework for use in evaluation of lake level responses by key features of ecosystems, as the scope of effects emerges.

While water quantity does have an impact on water quality, it is not within the mandate of this study to investigate water quality in detail. Qualitative discussions will be included where appropriate. It is noted that water quality is being addressed by other avenues such as the Great Lakes Water Quality Agreement and portions of the Great Lakes Regional Collaboration.

LESSON LEARNED: The International Lake Ontario – St. Lawrence River Study started with many environmental performance indicators. Of 400 performance indicators initially simulated, 32 were deemed to have sufficient sensitivity, significance and confidence in their relationship to water levels to be used in evaluations. The same exercise may be needed for the Upper Lakes Study, but the Lake Ontario experience should expedite the process.

The costs for the ecosystem evaluation, including salaries and travel, are estimated as follows:

	Year 1	Year 2	Year 3	Year 4	Year 5
Total Cost (U.S. dollars)	$200K	$550K	$550K	$350K	$100K

or

Total Cost (Canadian dollars)	$240K	$660K	$660K	$420K	$120K

The total cost for Ecosystems would be about $1,750K (U.S. dollars). This is equivalent to about $2,100K in Canadian dollars.

4.2 Recreational Boating and Tourism

Recreational boating and tourism are important economic industries in the Great Lakes states and in Ontario. The Great Lake Commission estimates that there are over a million recreational boats registered in U.S. counties that border the Great Lakes and nearly 800,000 in Ontario that are used on the Great Lakes (GLC, 2000). The recreational boating industry is greatly affected by water levels. Low water may adversely affect recreational boating in several ways. Direct effects include damages to boats, docks, and seawalls, and reduced accessibility as water levels drop. Accessibility is particularly a problem to properties that have water-only access, such as on eastern and northern Georgian Bay. Damage to boats may occur when boats run aground or hit submerged objects. Docks and seawalls exposed to air as water levels drop may start to decay, leading to accelerated deterioration and failure. Even high water levels can cause occasional problems, preventing passage under bridges, for example.

Although effects due to high and low water would both be addressed, most of the effects to recreational boating occur due to low water, so those would be a primary focus of the recreational boating effort. Indirect effects of low water on recreational boating include the loss of boat use and the resulting reduction in related spending. Marinas, boat launches, and related boater support services suffer when boating days are reduced either due to low or high water. Costs for dredging increase during low water periods as many marinas are forced to dredge to stay in business. Facilities often have to be renovated or upgraded. Boat sales also suffer during periods of low water, as the perception of low water affects overall user interest in the industry.

Outdoor recreation and water-related tourism is likewise greatly affected by variations in water levels. Extreme high and low water levels can reduce business at marinas, waterfront restaurants, and other commercial establishments and increase costs of doing business. Beaches are a very popular tourist destination in the Great Lakes, and the vacation dollars they bring to the local economies are significant. The commercial and sport fishing industry is also a growing economic force. When extreme high or low water levels occur, tourism in the coastal communities throughout the upper Great Lakes suffers.

In order to assess the effects of alternative regulation plans on recreational boating and tourism in the upper Great Lakes, a detailed description of current recreational boating use and tourism would be developed. A detailed recreational boating study was recently completed for Lake Michigan (PZ&C et. al., 2001). The recreational boating study on Lake Michigan assessed the economic effects of extreme low and high water levels on the recreational boating, sports fishery, marinas, and boat launching facilities.

A similar study could be performed on Lakes Superior, Huron, St. Clair, and Erie. In addition, the implications of changes to the Lake Superior regulation plan on tourism throughout the upper Great Lakes would be assessed.

The study approach may entail the use of site visits, mail and phone surveys, focus groups, interviews, and mapping to collect and analyze data. A crucial element of any survey task is to develop and test the surveys that would be given to the recreational boaters, marinas, dealerships, charter fishing boats and other related tourism sectors. The end result would include a wealth of never-before-gathered information about how Great Lakes water levels affect the tourism and recreation economic sectors and how the Lake Superior regulation plan can be modified to help the recreation and tourism industry on the upper Great Lakes. It would provide a tremendous amount of information that would also be useful to natural resource and recreation administrators at all levels.

The study would assess the current state of recreational boating and tourism on the upper Great Lakes and then project potential impacts due to alternative operating plans and climate conditions. The study would be designed similar to the study recently completed on Lake Michigan so that the Lake Michigan results can be used directly in this study. The low water level period that began in the late 1990s provides a useful basis of comparison when conducting the surveys.

Once an assessment of the recreational boating on the lakes is complete, the results of the survey can be used to develop a relationship between water levels and boater days. The economic information collected through the surveys would also be used to develop an average cost expended per day. Using these relationships, the relative impacts of alternative regulation scenarios on recreational boating can be evaluated. Although this approach does not develop a computerized “model” to predict economic impacts of different water levels, it is appropriate for determining relative impacts between alternative regulation scenarios and has been used successfully for the same purpose on Lake Michigan.

Many areas in the upper Great Lakes are prime fishing locations. Extreme high and low water levels impact the quality and availability of fishing resources, including such issues as the ability to launch boats as well as to wade in the rivers, lakes and rapids areas.

Impacts on tourism would also be addressed in this study. Impacts would be limited to those directly related to fluctuating water levels, such as effects on waterfront commercial districts that are inaccessible during high water levels. Conversely, effects could also include impacts on businesses in small waterfront communities during low water periods that make their marinas inaccessible or reduce the attractiveness of waterfront facilities, such as beaches, for visitors and customers. Sport and commercial fishing will also be addressed.

The Recreational Boating and Tourism Group should address the issues of climate change/variability and how these resources may need to adapt in the future to respond to more extreme conditions then have been experienced in the past. While water levels and flows will be generated by the Lake Superior Outflow Regulation Group, the impact on recreational boating and tourism will be addressed here.

The study on recreational boating and tourism would include tasks as follows:

- Refine study method in consultation with U.S. and Canadian agency representatives, industry organizations, First Nations/Native Americans leaders.
- Analyze tourism, boating, and commercial fishing businesses and the relationship of their infrastructure to water levels on Lakes Superior, Huron, Michigan, St. Clair, and Erie.
- Integrate all data to report on the size and economic importance of coastal tourism, commercial and charter fishing, and recreational boating and the relationship of these resources to water level fluctuations.
- Conduct mail and telephone surveys of marinas, charter boats, boat dealers, boat repair and reconditioning facilities, boaters, and Great Lakes-dependent tourism businesses in Ontario and the states bordering the upper Great Lakes. Representative samples of registered boat owners would be developed to ensure the survey sample represents all sizes and types of boats and marinas.
- Integrate economic analysis on industries and Great Lakes economy to estimate the economic impacts of fluctuating water levels on recreational boating and tourism industry.
- Assess relative impacts of alternative regulation plans and make recommendations for any improvements to regulation plans specifically for the recreational boating and tourism industry.

LESSON LEARNED: The magnitude of water level changes due to Lake Superior outflow regulation is relatively small and the upper lakes recreational boaters might not be as sensitive to these small changes. If recreational boating has problems, they may not be as a result of Lake Superior regulation, but other factors.

The costs for the recreational boating and tourism evaluation, including salaries and travel, are estimated as follows:

	Year 1	Year 2	Year 3	Year 4	Year 5
Total Cost (U.S. dollars)	$50K	$125K	$125K	$100K	$50K
or					
Total Cost (Canadian dollars)	$60K	$150K	$150K	$120K	$60K

The total cost would be about $450K (U.S. dollars). This is equivalent to about $540K in Canadian dollars.

4.3 Hydropower

There are two hydroelectric power plants located on the United States side of the St. Marys River. The U.S. Government Hydropower Plant consists of a plant completed in 1951 together with a smaller unit that is the remnant of a larger plant originally built in 1888. The other U.S. plant, which was built in 1902, is operated by Edison Sault Electric Company. In Canada, Great Lakes Power Limited retired its older station and constructed a new plant in 1982. In accordance with IJC Orders, after the requirements for domestic use, navigation, and St. Marys Rapids including the fishery remedial works are met, the remaining outflow from Lake Superior is shared equally between Canada and the United States for hydropower purposes. Any remaining flow allotment that exceeds the discharge capacity of the hydropower plants is normally released through the compensating works.

Since the redevelopment of the Canadian facilities in 1982, the total installed hydropower capacity on the St. Marys River has been increased. It is doubtful that there will be any significant hydropower expansion in the future. However, given the age of the Edison Sault facilities, their eventual redevelopment should be considered in the review of the regulation criteria. Equipment upgrades in the future are expected to marginally improve the efficiencies of these plants.

There are no hydropower facilities on the St. Clair and Detroit Rivers. Several hydropower plants are located at Niagara Falls, New York and Ontario. These plants divert water from the Chippawa-Grass Island Pool above Niagara Falls, and return the water to the Niagara River below Niagara Falls. The amount of water available for hydropower purposes at these plants depends on the Niagara River flow which, in turn, depends on the water level of Lake Erie. The initial work efforts of the study would be focused more on the hydropower generation on the St. Marys River, where changes to Lake Superior regulation would have the greatest impact on hydropower operations. If, however, potential changes to Lake Superior criteria and regulation plan were expected to have measurable impacts on Lake Erie and its outflows, study tasks to include impacts on hydropower facilities at Niagara would be initiated.

The amount of hydropower generation on the St. Marys River depends on several factors, the key ones being head, flow, efficiency, tailwater level, river ice and aquatic growth, and meteorological disturbances. Apart from these physical factors, there are other elements that affect hydropower operations. The first element is timing. In some years, the water available for hydropower production in June may not generate as much monetary return as the same water in January when electrical demand is typically higher. On the other hand, hydropower would be a premium during a heat wave in June. When the flows are too low, the electricity generated may not meet the demands of the customers and the utilities may have to purchase power from other sources at relatively higher prices. The purchased power may be generated by coal, oil, or nuclear. Therefore, the purchasing power would involve transfer of monetary benefits and may have environmental implications. The move to an open market system means that reliability of water is essential for both long- and short-term planning purposes.

Relatively high water levels on Lake Superior means relatively higher flows, as directed by the regulation plan. This translates into more electricity generated. Relatively low water levels on Lake Superior would bring about the opposite condition. When the amount of water available for hydropower purposes exceeds the capacities of the plants, the excess is typically discharged into the St. Marys Rapids via the compensating works. This represents a potential loss to hydropower generation. Extended periods of equipment shutdown at the plant could also lead to additional water released at the compensating works.

To meet energy demand, which varies within the day and within the week, the hydropower plants in the St. Marys River carry out peaking and ponding operations. In peaking and ponding operations, the plants pass high flows during the daylight hours when energy demand is high, which they offset by using less water during the night and on weekends. Such adjustments are made, while ensuring plan flows are met on a monthly basis. These operations take place when the water allocated for hydropower purposes is less than the flow capacity of the hydropower plants, and thus typically take place when Lake Superior's water levels and outflows are below average. While beneficial to the hydropower interests, these flow variations have given rise to concerns by navigation, fisheries, and other interests in the St. Marys River. The concerns become more pronounced during low water level and flow conditions in the river. It is recommended that priority be given to address this issue. The impacts of peaking and ponding operations would be assessed early in the study, which would provide input to development of guidelines governing these operations, subject to confirmation at the completion of the study. The issue of peaking and ponding affects other resources as well. It is recommended that the Hydropower Group lead the effort to examine peaking and ponding impacts. A small subgroup may be required which would include participation from the Ecosystems and Commercial Navigation Groups as well as the Lake Superior Outflow Regulation Group.

The Hydropower Group should address the issues of climate change/variability and how hydropower may need to adapt in the future to respond to more extreme conditions than have been experienced in the past. While water levels and flows will be generated by the Lake Superior Outflow Regulation Group, the impact on hydropower will be addressed here.

Tasks would include the following:

- Evaluate in energy and monetary terms the impacts of peaking and ponding operations; provide inputs in developing guidelines governing peaking and ponding operations.
- Project hydropower facilities for the study period; determine their flow capacities and generating efficiencies.
- Update, and develop as required, evaluation methods that determine the relationships between energy production and flows.
- Investigate, and adapt wherever suitable, other evaluation techniques including those used in the International Lake Ontario - St. Lawrence River Study.
- Assist in identifying changes to regulation plans to improve operation.

- Evaluate the impacts of Lake Superior outflow regulation under a range of alternative regulation and supply scenarios, including those generated by climate variability and change.

Fairly sufficient information is available to evaluate the hydropower effects due to alternative regulation plans. Therefore, no extensive data collection efforts are required. The costs for the hydropower evaluation of the study, including salaries and travel, are estimated as follows:

	Year 1	Year 2	Year 3	Year 4	Year 5
Total Cost (U.S. dollars)	$20K	$100K	$100K	$20K	$20K
or					
Total Cost (Canadian dollars)	$24K	$120K	$120K	$24K	$24K

The total cost for the study would be about $260K (U.S. dollars). This is equivalent to about $312K in Canadian dollars.

4.4 Commercial Navigation

Using the Great Lakes – St. Lawrence River navigation system, waterborne freight is transported both within the Great Lakes and between much of North America and overseas. The present system of locks and channel deepening was completed by the early 1960s. At that time, channels provided an available depth of 8.2 metres (27 feet) over the entire route from Montreal in the St. Lawrence River to Lake Superior. A series of locks enables vessels to bypass rapids and other barriers in the St. Lawrence River between Montreal and Lake Ontario. Likewise, locks in the Welland Canal enable vessels to transit between Lake Ontario and Lake Erie, bypassing Niagara Falls. In the St. Marys River, there are four navigation locks in the United States, and one lock in Canada enabling vessels to transit between Lake Superior and Lakes Michigan and Huron.

The focus of this study would be on the water levels and flows of the upper Great Lakes from Lake Superior through Lake Erie. However, it should be recognized that vessels affected by water levels on the upper lakes (for example vessels carrying lighter loads to compensate for low levels in connecting channels) could be affected on their trans-Atlantic and other global trade routes. In addition, there are other factors that could have impacts on water levels and flows, and Lake Superior regulation, and vice versa. A recent study prepared for the St. Lawrence Seaway Development Corporation titled *Economic Impact Study of the Great Lakes St. Lawrence Seaway System* would provide useful information on economics related to the commercial navigation industry.

Generally, higher water levels allow for deeper draft vessels carrying heavier loads. At lower water levels, shallower drafts, and consequently, lighter loads, are necessary. More trips are needed to carry the same tonnage of cargo, and some per ton operating expenses rise accordingly, to the disadvantage of the shipping industry. Excessively high water levels would not bring additional benefits since vessel sizes are limited by

existing lock dimensions. Very high water levels could flood some dock facilities, and generate undesirable and hazardous water currents in the connecting channels.

Ice on the Great Lakes and in the connecting channels can severely hamper navigation transits. It is not uncommon to see severe ice jams in the St. Clair and Detroit Rivers that last for days or even weeks. The ice problem is much less frequent or pronounced on the St. Marys River, due to the use of an ice boom. A severe and prolonged winter can cause significant problems at times of opening or closing of the navigation season.

One factor that affects navigation interests is flow variations at the hydropower plants at Sault Ste. Marie. The high flows during daytime and weekdays at the hydropower facilities cause higher levels in the vicinity of the Soo locks and channels immediately downstream of Sault Ste. Marie, which could be beneficial. However, the offsetting lower flows at night and on weekends cause lower levels and could delay ship transit and affect cargo capacity. This problem is more pronounced during low water level periods. Shippers also need to know in advance accurate forecast of water levels to plan their short-term and long-term routes. Accurate advance water level information helps planning and increases operating efficiency. The Commercial Navigation Group will conduct any necessary studies to determine impact associated with hydropower peaking and ponding and participate with the Hydropower, Ecosystems and Lake Superior Outflow Regulation Groups to determine system-wide benefits and detriments.

Much of the study can take advantage of the data, forecasts and evaluation methods currently generated in the International Lake Ontario - St. Lawrence River Study. These would be reviewed to determine whether they are applicable to this study. Because of the many inherent economic assumptions made in the forecast and evaluation calculations, particularly regarding monetary values which are subject to change, the evaluation of impacts of water level fluctuations should not be conducted in terms of purely economic values.

The Commercial Navigation Group should address the issues of climate change/variability and how commercial navigation may need to adapt in the future to respond to more extreme conditions than have been experienced in the past. While water levels and flows will be generated by the Lake Superior Outflow Regulation Group, the impact on commercial navigation will be addressed here.

Tasks would include the following. The POS team assumes that some of this information may already be available from commercial navigation resources and agencies:

- Project Great Lakes–St. Lawrence navigation facilities for the study period, including planned dredging projects and capital investments that have a high likelihood of occurring.
- Project cargoes and routes and make an assessment of the relationship between navigation service and other means of transportation (air, rail, pipeline, and truck).
- Determine applicability of existing transportation and evaluation models.

- Formulate assumptions concerning fuel costs and other operating costs.
- Update, and develop as required, the relationships between transportation costs and water levels and flows.
- Investigate, and adapt wherever suitable, other evaluation techniques.
- Identify changes to regulation plans or criteria to improve operations for navigation and navigation interests.
- Identify the impacts on navigation due to level and flow variations in the St. Marys River, identify critical water level locations in the St. Marys River, provide input in developing guidelines governing hydropower operations; identify remedial measures including improvements in communication and scheduling of ship transits.
- Evaluate the effects of alternative regulation and supply scenarios on navigation and navigation interests, including flooding under high level conditions and deterioration of timber crib/pile under low level conditions.

LESSONS LEARNED: Future traffic projections may be obtainable from current studies for a new navigation lock at Sault Ste. Marie. Be careful with issues related to commodity growth – that gets tricky. The model used in the Lake Ontario Study may be useable for the Upper Lakes Study.

The costs for the commercial navigation evaluation of the study, including salaries and travel, are estimated as follows:

	Year 1	Year 2	Year 3	Year 4	Year 5
Total Cost (U.S. dollars)	$20K	$100K	$100K	$20K	$20K
or					
Total Cost (Canadian dollars)	$24K	$120K	$120K	$24K	$24K

The total cost of the study would be about $260K (U.S. dollars). This is equivalent to about $312K in Canadian dollars.

4.5 Municipal, Industrial, and Domestic Water Use

In general, municipal and industrial water intakes are not greatly affected by fluctuating water levels on the upper Great Lakes system. Most, if not all, intakes are located at depths well below the historical range of water levels recorded in the previous century. Record low water levels occurred in the mid-1920s on Lake Superior and in the mid-1960s on Lakes Michigan-Huron. All major municipal and industrial water intakes built subsequent to these low water levels are most likely designed to accommodate at least these record lows; further investigations would verify whether this is the case.

Low water levels, however, could lead to problems including increased pumping costs, poor water quality in some areas, increased turbidity which can be worsened by passing boats and commercial vessels, algae growth and decay, and higher water treatment costs. Very low water levels predicted by some of the global climate models may render some of these intakes ineffective or completely inoperable. High water levels, on

the other hand, may flood water treatment facilities that are located on flood prone coastlines.

Outside the urban centres, shore-wells are the source of water for many cottages, campers, and permanent homes along the shores of the upper Great Lakes. Shore-wells are generally not built to accommodate the total historical range of water level fluctuations due to lack of regulatory oversight and excessive costs. Again, if the low water levels predicted by some of the global climate models actually occur, many shore-wells would be affected to the point of complete shutdown.

This study can make use of the data and evaluation methods being generated in the International Lake Ontario - St. Lawrence River Study. A fairly comprehensive inventory of the major urban and industrial intakes, especially those relatively more vulnerable to water level fluctuations, should be made. Much of this inventory data is already available from state or provincial agencies. For example, the U.S. Environmental Protection Agency is conducting a source water assessment in all Great Lake states. All major water intakes have been documented. Invert elevations for many of these intakes are also available through this effort. Any additional information that is needed can be obtained by letter and telephone communications and if needed, followed by visits to the critical sites. During this data collection effort, information on future basin needs for municipal and industrial water supply can also be obtained, if available. This information would be closely related to future land use changes in the basin. As population continues to grow and shift, water demand will also. Analyses should include identification of areas where additional water use may occur in the future as well as relative magnitude of these potential increases.

The Municipal, Industrial and Domestic Water Use Group should address the issues of climate change/variability and how the water use as a whole may need to adapt in the future to respond to more extreme conditions than have been experienced in the past. While water levels and flows will be generated by the Lake Superior Outflow Regulation Group, the impact on all water uses will be addressed here.

Tasks would include the following:

- Use existing state and provincial agency inventories to identify major municipal and industrial intakes, including those vulnerable to extreme water level fluctuations.
- Compile current municipal and domestic uses; estimate future expected water demands, in terms of quantity and quality.
- Assess the effects of the current regulation plan on these water uses, assuming present and future use projections.
- Conduct pilot studies designed to provide more detailed assessment, if necessary, using selected urban and rural areas.
- Visit selected sites to collect data, if necessary.
- Investigate, and adapt wherever suitable, evaluation techniques.
- Assist in identifying any changes to regulation plans to improve operations to benefit municipal, industrial, and domestic water uses.

- Evaluate the effects of alternative regulation and supply scenarios on municipal, industrial, and domestic water interests.

While water quantity does have an impact on water quality, it is not within the mandate of this study to investigate water quality in detail. Qualitative discussions will be included where appropriate. It is noted that water quality is being addressed by other avenues such as the Great Lakes Water Quality Agreement and portions of the Great Lakes Regional Collaboration.

The costs for the municipal, industrial, and domestic water use evaluation of the study, including salaries and travel, are estimated as follows:

	Year 1	Year 2	Year 3	Year 4	Year 5
Total Cost (U.S. dollars)	$50K	$150K	$150K	$100K	$50K
or					
Total Cost (Canadian dollars)	$60K	$180K	$180K	$120K	$60K

The total cost for the municipal, industrial, and domestic water use evaluation of the study would be about $500K (U.S. dollars). This is equivalent to about $600K in Canadian dollars.

4.6 Coastal Zone

Coastal Zone in this plan of study includes the shore zone and lands adjacent to the water that are either under private or public ownership. Fluctuating water levels affect the coastal zone in all of the lakes under consideration in this study. Coastal impacts include erosion and flooding along the coast and impacts due to low water levels. Near shore littoral sand movement can also be impacted by fluctuating water levels. These impacts affect shore property values and thus result in economic gains or losses. The occurrence of long-term maximum and minimum water levels, when combined with short-term seiche or surge/drawdown impacts, can cause substantial damage to coastal resources.

Fluctuating water levels affect most coastal zone interests either directly or indirectly. High water levels can combine with storm waves or ship wakes to cause serious flood and erosion damage. Low levels increase the shore area, but can also affect water intakes, ramp and docking facilities, and water quality, and can lead to the undercutting of shore protective works.

Due to its geological setting and the relatively sparse urban development, flood and erosion damage on the Canadian shores of Lake Superior is relatively minor compared to that on the U.S shores or on the other Great Lakes. On the Canadian shores, the major urban centres affected by both high and low water levels are Thunder Bay and Sault Ste. Marie, Ontario. Numerous campsites, marinas and boat docks, cottages (some year-round) are located along the shores of Lake Superior, Lake Huron including Georgian Bay, and the St. Clair – Detroit River system. The Canadian shores of Lake Erie consist of mainly low-lying farmland in the western portion, and a combination of

farms, cottages and small urban and industrial centres further to the east. Studies during the Levels Reference Study found that, in Canada, the highest incidence of erosion has occurred on Lake Erie.

The eastern coast of Georgian Bay is unique in its features. By size alone, it could be considered a lake in itself. However, unlike other bays on the Great Lakes, it is geologically, hydrologically, geomorphologically, and limnologically unique. Because of the shallow waters around the 30,000 islands, Georgian Bay is greatly affected by changes in water levels. There are extensive wetlands among the shallow waters in the steep granite shoreline island areas. When water levels change, these wetlands have difficulty migrating due to the steep nearshore environment.

The U.S. side of the upper Great Lakes differs from the Canadian coastal zone in several key areas. Population on the U.S. side is much greater than on the Canadian side. The potential for coastal damages is much higher. The U.S. portion of the upper Great Lakes coastal zone also contains more shoreline area and more areas that are subject to active erosion and flooding. Coastal erosion and flooding are a particular concern in the high bluff environment of Lake Michigan, the far western shores of Lake Superior, and select areas on Lake Erie. Previous studies have identified shore type and recession rates along all the Great Lakes.

Investigations on Lake Michigan should take advantage of the detailed analyses conducted during the Lake Michigan Potential Damages Study (LMPDS). The coastal processes model established for five coastal counties on Lake Michigan under the LMPDS could be used for this study. The models were developed using detailed bathymetric and topographic data, historical bluff line analysis, and coastal feature collection. The coastal processes model for these five counties could be run with water level scenarios from alternative regulation plans to assess the relative effects of the alternative plans on coastal erosion in these representative regions on Lake Michigan. If there is little relative difference in coastal erosion predicted under various alternative regulation plans for these five counties, or if the predicted differences in erosion rates is within the margin of error of the models, further intensive data collection to support detailed coastal modelling would not be recommended.

Coastal zone analyses must include investigations into the potential impacts of future basin land use changes. Demographic and land use changes and shifts will likely continue to occur in the basin. Demographic changes may result in increased shoreline development that may affect the nearshore environment. When shoreline protection is constructed, natural sediment transport processes are altered, and erosion of barrier beaches and coastal wetlands increases. A review should be made of the existing land use management practices, including zoning, designed to minimize flood and erosion damage. What can not be “managed” through water level regulation, may be able to be mitigated by appropriate land use management practices. An inventory of current practices may help to educate the users of the system as to what can be done to make developments along the coasts more sustainable.

The Coastal Zone Group should address the issues of climate change/variability and how the coastal zone may need to adapt in the future to respond to more extreme conditions than have been experienced in the past. While water levels and flows will be generated by the Lake Superior Outflow Regulation Group, the impact on the coastal zone will be addressed here.

Tasks would include the following:

- Conduct a literature review of past flood and erosion concerns, as well as riparian risk land use trends.
- Conduct site-specific visits to gather additional information.
- Gather master plans and zoning ordinances of upper Great Lakes waterfront communities, including existing land use maps, air photos, and other sources of information on land use.
- Consult riparian representatives, experts, and land-use planners on desirable ranges of water levels.
- Assess the impacts on coastal zone of the lower St. Marys River due to flow variations at Sault Ste. Marie, provide input to developing guidelines governing hydropower operations.
- Develop water level – impact relationships or other alternatives such as stage-damage curves, erosion sensitivity versus water level or flooded buildings versus water level curves to compare regulation plans.
- Review and assess effectiveness of existing land use regulations at protecting coastal zone interests from water level related damages, now and into the future.
- Conduct pilot studies for detailed assessment of impacts of water levels [note—pilot study could consist of using the detailed modelling results developed on Lakes Michigan and Ontario and develop a strategy to apply the results to similar shore environments, thus maximizing use of previous work and reducing amount of detailed modelling necessary; consider modelling five Lake Michigan counties under alternative regulations plans].
- Develop new stage-damage curves and other evaluation techniques.
- Identify any changes to regulation plans that could minimize coastal resource impacts.

The costs for the coastal zone evaluation of the study, including salaries and travel, are estimated as follows:

	Year 1	Year 2	Year 3	Year 4	Year 5
Total Cost (U.S. dollars)	$200K	$300K	$300K	$200K	$100K
or					
Total Cost (Canadian dollars)	$240K	$360K	$360K	$240K	$120K

The total cost for the coastal zone evaluation would be about $1,100K (U.S. dollars). This is equivalent to about $1,320K in Canadian dollars.