Report to the International Joint Commission On Peaking and Ponding Operations On the St. Marys River by the International Lake Superior Board of Control

Edward L. Ryerson in the Rock Cut. John Belliveau/www.boatnerd.com

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Executive Summary

By letter dated December 10, 2001, the International Joint Commission (IJC) asked the International Lake Superior Board of Control (Board) to conduct a review of peaking and ponding operations by hydropower plants in the St. Marys River. This report summarizes the results of the Board's review, and contains the Board's findings and recommendations.

The amount of water available for hydropower purposes in the St. Marys River is determined each month in accordance with the regulation plan for the outflows of Lake Superior, and the IJC's Orders of Approval and supplementary orders. At times, the monthly average amounts of water available for hydropower purposes are less than the capacities of the plants in the river. During such periods, the hydropower plants may choose to operate at higher flows during the day and evening hours when demand for electricity is high, and lesser flows at night and on weekends to make more efficient use of their allocated water. Peaking is the variation of the flow about the daily mean flow. Ponding is the variation of the daily mean flow about the weekly mean flow.

In 2000, some navigation interests first expressed concerns about the low water level in the St. Marys River, and that these problems they experienced were exacerbated by fluctuations due to peaking and, in particular, ponding operations. They also expressed a similar concern at the annual public meeting hosted by the Lake Superior Board on June 27, 2001 in Port Severn, Ontario. Subsequently, discussions took place between the shipping interests representatives and the Lake Superior Board staff. An outcome of the discussions was the issuing, at the beginning of each month to the shipping interests, the scheduled hourly flows in the St. Marys River for each day of the month.

As the water level of Lake Superior declined during the autumn of 2001, so did the Lake Superior outflow specified by the regulation plan. In November 2001, the Shipping Federation of Canada once again expressed concern about the lower weekend flows due to ponding operations and their impacts on the already low water level conditions. With the cooperation of Great Lakes Power Limited, the Board arranged short-term increases in the Lake Superior outflow on three successive weekends starting on December 1, 2001. These short-term flow increases, lasting about six hours each time, were reported to have reduced the delay time for the ships exiting the lower St. Marys River. The over-discharges were offset by under-discharges the remaining part of the month. Concurrently, the IJC considered it necessary to examine the issue of peaking and ponding for the longer-term, and their effects on not just the navigation interests, but also other interests in the river including the environment.

Given the time constraint imposed on the study, the Board focused its investigation in public consultation and analysis of readily available data. In late December 2001, the Board sent letters to the various interest groups in the St. Marys River asking for their views and comments by February 8, 2002. On January 28, 2002, the Board assisted the IJC in conducting its public hearings in Sault Ste. Marie, Ontario, and Sault Ste. Marie, Michigan. All comments collected from this consultation process have been taken into consideration in preparing this report.

On the basis of its review, the Board has the following conclusions and recommendations in response to the issues raised in the Commission's December 10, 2001 letter:

A review of past peaking and ponding operations

The technical study included analysis of the hourly flows through the various structures and hydropower plants in the St. Marys River for the period 1998-2001 when levels on the upper Great Lakes were on the decline. During this period, peaking and ponding operations took place at various times and by varying degree, and became more prominent beginning in the late autumn of 2000.

The higher flows during the day raise the water levels below the hydropower plants and in the St. Marys River downstream of Sault Ste. Marie. These higher flows extend as late as 11:00 p.m. The offsetting overnight flows and the reduced flows during the weekends lower the water levels in the lower river.

Peaking and ponding operations have their maximum water level impacts immediately downstream of the power plants. Based on a statistical analysis of data over the past four years, the Board found a significant correlation between increasing flow changes and increasing water level fluctuations in the lower St Marys River. It was found that the level at U.S. Slip changes by about 16 centimetres (6.4 inches) for a 1,000 cubic metres (35,000 cubic feet) per second change in the flow. The impacts dissipate as one proceeds further downstream and at Rock Cut, near the mouth of the St. Marys River, they become negligible. The water level effect also diminishes towards Garden River in the North Channel. Although there are other factors affecting water levels in the river, such as winds, barometric pressure changes, and Lake Huron levels, the separate effects due to each of these possible sources were not addressed in this study. In examining the data, however, it is noted that, on average, these other effects cause a fluctuation of $\pm$ 6 cm (2.4 inches) during the day at U.S. Slip. Peaking and ponding operations are found to have a negligible impact on the water levels upstream of Sault Ste. Marie.

Impacts of these operations on water levels and flows, and on interests

Peaking and ponding operations provide an efficient use of the water for hydropower purposes. The additional hydropower generated during the high flow periods in the peaking cycle help the utilities meet peak electrical demands and reduce the need to purchase more power from other sources. Fluctuating water levels and flows in the St. Marys River remain a subject of interest and concern. However, except for navigation, the comments and views collected to-date did not identify any significant adverse impacts due to peaking and ponding operations.

The views and concerns of navigation interests vary somewhat amongst their members. They range from absence of concern to complaints of delays in ship transit during weekends when lesser flows reduce the water depths in the lower river. Some acknowledged that, during weekdays, the increased water levels resulting from higher flows in the peaking cycle could be beneficial for navigation. Based on the information obtained and analyzed to-date, the Board has been unable to quantify the magnitude of the transit delay, but has identified the Little

Rapids reach as the area of concern. Ponding operations can have an adverse impact on navigation when water level and flow in the river are low.

By letter dated January 28, 2002, the shipping interests stated that it is too early and premature to implement any changes on the way the water flows are managed and controlled. They also stated that the actual impacts of daily and weekly variations in the flows have (at this time) not been scientifically determined at several critical locations in the St. Marys River. Their letter did not request further intervention of the IJC towards regulation of peaking and ponding procedures at this time, and suggested that further study focus on the low water level issue. Notwithstanding this submission from the navigation interests, the Board completed this study in response to the questions raised in the Commission's December 10, 2001 letter to the Board.

Is continuation of peaking and ponding operations advisable and, if so, what would be the guidelines governing these operations?

Peaking and ponding operations enable efficient use of the water for power purposes. High flows in the daily peaking cycle can be beneficial to the navigation interests. Under certain conditions, sustained low weekend flows conducted as part of ponding operations could be detrimental to navigation and suspension of ponding operations would be advisable. The views and comments collected to-date have not identified any known adverse environmental or other impacts. Based on these considerations and the analysis of data from the past four years, the Board recommends that peaking and ponding operations be allowed to continue. Further study, and operational experience would be needed to have a better understanding of the relationships between water levels and peaking and ponding operations, and their impacts on the various interests. On this basis, the Board recommends that the IJC approve peaking and ponding operations for one more year under guidelines proposed in this report. This will permit further study and collection of operating experience. The proposed study of the Lake Superior regulation criteria is expected to help refine these guidelines.

The Board has developed interim guidelines, as follows:

(a) Subject to prior approval from the Board at the beginning of each month, peaking and ponding operations may be conducted in a manner that meets hydropower needs, and consistent with the mode of operation outlined in the February 8, 2002 joint submission by Great Lakes Power Limited and Edison Sault Electric Company.
(b) The Board may suspend ponding operations for the month if it is expected that ponding operations would result in sustained weekend levels at the U.S. Slip Gauge declining below chart datum elevation. The forecast of expected water levels shall be determined at the beginning of the month based on Lake Superior outflow, levels on Lakes Michigan-Huron, and peaking and ponding schedules as defined in the hydropower entities' February 8, 2002 submission.
(c) The power entities shall record hourly water level and flow data during this test period, and furnish these to the Board each month. They shall also report promptly to the Board any problems, or reports of concern related to peaking and ponding operations, or water level fluctuation in the St. Marys River.

(d) Further, under emergency conditions, the Board may alter or suspend peaking, or ponding, or both. These could be due to equipment failure at the hydropower facilities, ship incidents such as groundings, electrical system difficulties or other circumstances. At such times the Board shall direct outflows that are consistent with the Orders of Approval in consideration of the needs of the interests.

The role of the Board in Peaking and Ponding Operations

The Board would closely monitor the water levels throughout the St. Marys River, as well as on the Great Lakes. The Board would review, at the beginning of each month, the peaking and ponding schedule proposed by the power entities, and approve or direct modifications to peaking and ponding in accordance with the guidelines listed above. The Board would continue to issue to the public and navigation interests, at the beginning of each month, the schedule of hourly outflows for the month. During this one-year test period, the Board would record and assess any impacts that might arise as a result of peaking and ponding operations. At the end of the one-year test period, the Board would provide a report to the IJC on the results, and make recommendations on whether to continue with peaking and ponding operations, and on improvements to operating guidelines.

Other Comments

The St. Marys River is a complex system with water level changes resulting from many natural and human factors. To further increase our understanding of this system, and to develop better guidelines for peaking and ponding, the Board recommends more detailed study. The Board considered including a guideline specifying the minimum hourly St. Marys River flow during normal peaking and ponding operations, however, the lack of information on environmental impacts caused by flow fluctuations prevented the determination of a justifiable value. The Board recommends that more detailed information on the relationships between levels and flows in the lower St. Marys River be developed, perhaps employing a hydrodynamic model. The Board also recommends that the Commission consider undertaking an environmental study to examine the impacts of various flows on environmental interests. The Board also recognizes that studies to be conducted in the upcoming Lake Superior regulation criteria review could further enhance our understanding, and thus refine guidelines governing peaking and ponding operations.

The Board notes that in spite of channel improvements and deepening over the years, problems for navigation invariably arise from time to time when water levels and flows are low. The Board believes the proposed guidelines are a reasonable compromise given our current knowledge, and should enable both the power entities and navigation to operate with minimum adverse impacts.

During the IJC's public hearings, the Board heard a submission that one alternative to the low water level problem for navigation is to deepen the critical parts of the St. Marys River. The Board wishes to point out that dredging on the Great Lakes and their connecting channels is a subject of interest and could impact levels and flows, and distribution of flows around islands in

the St. Marys River. In this regard, we recommend that, prior to dredging, a detailed hydraulic analysis be conducted to assess the potential impacts.

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1. Purpose and Scope

By letter dated December 10, 2001, the International Joint Commission (IJC) asked the International Lake Superior Board of Control (Board) to conduct a review of peaking and ponding operations by hydropower plants in the St. Marys River. The IJC's letter to the Board is contained in Appendix A. This report summarizes the results of the Board's review, and contains the Board's findings and recommendations.

1.1 Background

The release of water from Lake Superior is made through the various structures located on the St. Marys River. The allocation of flow to these facilities is determined monthly, based on the outflow specified by the regulation plan and the conditions given in the IJC's Order of Approval. The distributions include water for purposes of: domestic, sanitary and industrial uses; meeting fishery requirements; operating navigation locks, and hydropower generation. Given their water allocations, the hydropower plants at times conduct peaking and ponding operations, which involve changing the flows at the plants to meet the demand for electricity that varies within the day and within the week. These peaking and ponding operations affect water levels and flows in the St. Marys River.

In 2000, some navigation interests first expressed concerns about the low water levels in the St. Marys River, and that these problems they experienced were exacerbated by peaking and, in particular, ponding operations. They also expressed a similar concern at the annual public meeting hosted by the Lake Superior Board on June 27, 2001 in Port Severn, Ontario. Subsequently, discussions took place between the shipping interests representatives and the Lake Superior Board staff. An outcome of the discussions was the issuing, at the beginning of each month to the shipping interests, the scheduled hourly flows in the St. Marys River for each day of the month.

As the water level of Lake Superior declined during the autumn of 2001, so did the Lake Superior outflow specified by the regulation plan. In November 2001, the Shipping Federation of Canada once again expressed concern about the lower weekend flows due to ponding operations and their impacts on the already low water level conditions. With the cooperation of Great Lakes Power Limited, the Board arranged short-term increases in the Lake Superior outflow on three successive weekends starting on December 1, 2001. These short-term flow increases, lasting about six hours each time, were reported to have reduced the delay time for the ships exiting the lower St. Marys River. The over-discharges were offset by under-discharges the remaining part of the month. Subsequently, the IJC considered it necessary to examine the issue of peaking and ponding for the longer-term, and their effects on not just the navigation interests, but also other interests in the river including the environment.

1.2 Scope of the Study

The Board was requested to provide, by February 28, 2002, a report that would: summarize the Board's review of past peaking and ponding operations; document the impacts of these

operations on water levels and flows, and on interests; recommend whether peaking and ponding operations are advisable to continue and, if so, possible guidelines governing these operations.

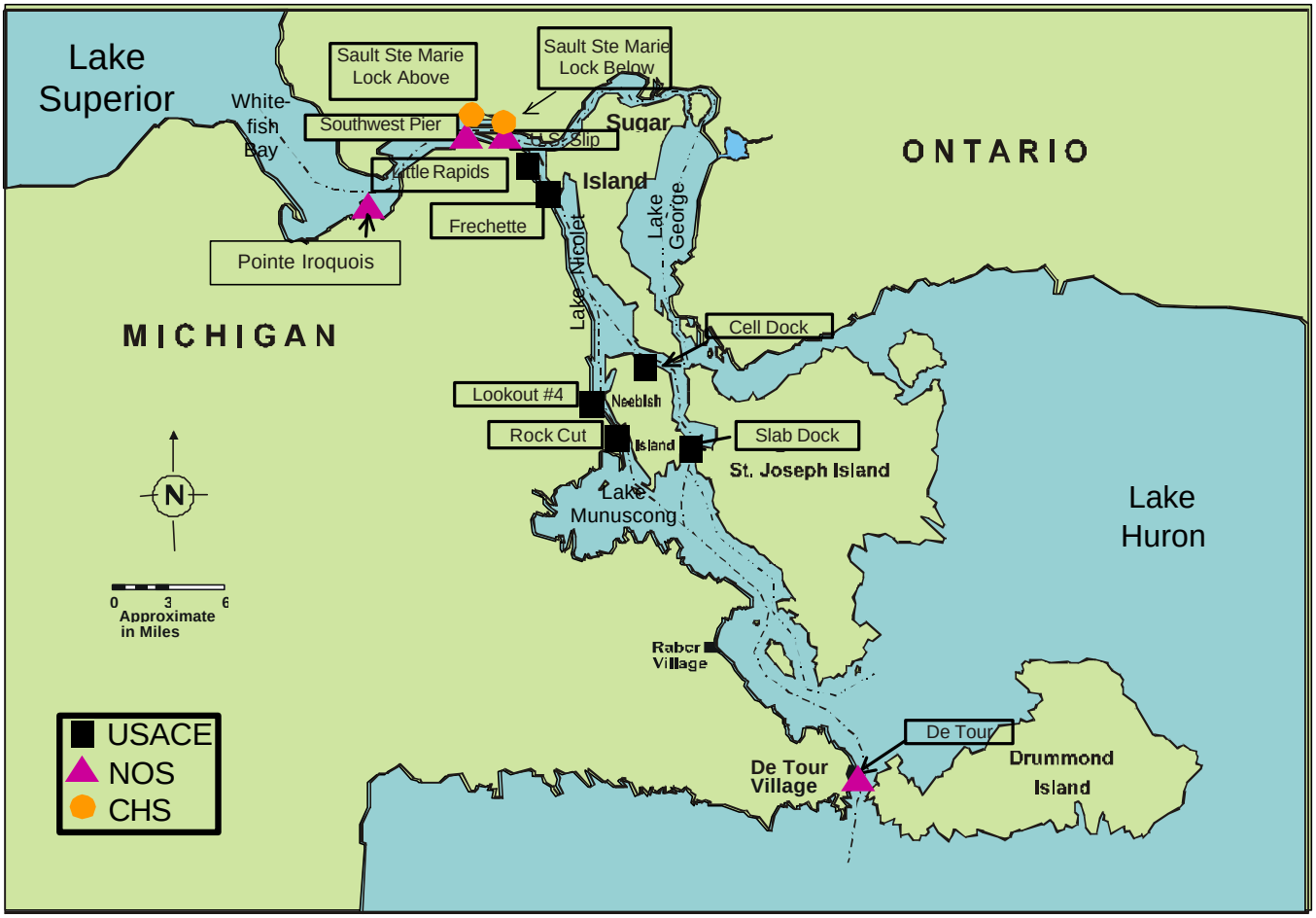
Given the time constraint imposed on the study, the Board focused its investigation in public consultation and analysis of readily available data. In late December 2001, the Board sent letters to the various interest groups in the St. Marys River asking for their views and comments by February 8, 2002. On January 28, 2002, the Board assisted the IJC in conducting its public hearings in Sault Ste. Marie, Ontario, and Sault Ste. Marie, Michigan. All comments collected from this consultation process have been taken into consideration in preparing this report.

2. Water Levels and Flows of the St. Marys River

2.1 Hydrology and Hydraulics

The St. Marys River, shown in Figure 1, connects Lake Superior, the uppermost of the Great Lakes, and Lake Huron. The Lake Superior's average outflow for the period 1918-2001 is 2,140 m^3/s (75,600 ft^3/s). In the upper 22 kilometres (14 miles) from Point Iroquois to the U.S. navigation canal at Sault Ste. Marie, Michigan, the river falls approximately 8 cm (3 in.). In the

Figure 1 – Map of St. Marys River



next two kilometres (1.5 miles), the river drops about 6 metres (20 ft.) most of which occurs at the St. Marys Rapids. The remaining fall, about 0.6 m (2 ft.), takes place in the 77 km (48 miles) between the rapids and Lake Huron. Because of this very mild slope to Lake Huron, long-term water levels at the foot of the rapids and in the vicinity of Sault Ste. Marie are significantly affected by the level of Lake Huron.

About four km (2.5 miles) below the rapids, the river divides into two channels, one passing to the north, the other to the west of Sugar Island. About 30% of the total outflow, on average, goes north of Sugar Island, while about 70% flows west of Sugar Island. The flow in the northerly channel continues into Lake George and thence north of St. Joseph Island into North Channel, then Lake Huron. The flow west of Sugar Island passes around Neebish Island into Lake Munuscong, past St. Joseph Island, and into Lake Huron. The navigation channels below Sault Ste. Marie are located west of Sugar Island, and also on both sides of Neebish Island.

Prior to hydropower and navigation developments, a rock ledge at the head of the St. Marys Rapids acted as a natural submerged weir controlling the flow of the rapids and thus the outflows of Lake Superior. The first ship canal was constructed on the south side of the rapids in 1855 by the State of Michigan, and the first utilization of the rapids for the production of hydropower was in 1822-1823 when a raceway and sawmill were built by the United States Army. Since then, successive developments have led to the present hydropower and navigation configurations in the river, as shown in Figure 2. To compensate for the effect on Lake Superior levels of power diversions around the rapids, a gated dam was constructed at the head of the rapids.

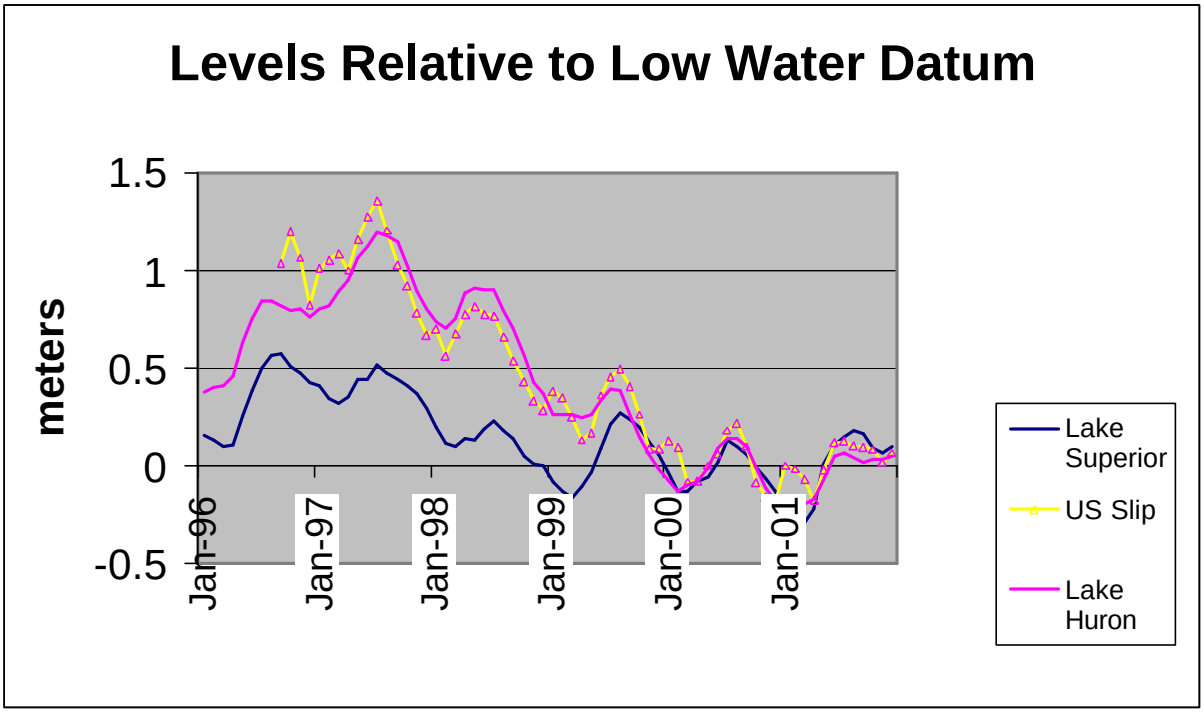
Figure 2 – Map of Sault Ste. Marie Showing Hydropower Plants and Other Works

The amount of water flow, and water levels in the St. Marys Rapids, are dependent on the number of gates open, the pattern of the gate open setting, and the level immediately upstream of the Compensating Works. Owing to the flow characteristics of the St. Marys Rapids and its location relative to the hydropower plants, flow fluctuations at the hydropower plants' discharge canals do not affect the levels in the rapids. However, the variations in the discharges from the power plants affect the water storage in the lower river adjacent to Sault Ste. Marie and thus can affect water levels at the foot of the rapids.

The water levels of the upper Great Lakes and flows in the St. Marys River change in response to many factors. Overlake precipitation, surface water runoff, and groundwater flows provide water to the system, while evaporation and outflows decrease water quantities in the lakes.

Seasonal variation in the levels, with rising levels in the spring and summer followed by a gradual decline during the fall and winter, reflect the effect of snow melt on the basins, evaporation and runoff patterns. Persistently high or low water supplies over several years are the main factors causing extreme high or low lake levels. Beginning in the latter part of 1997, water supplies to the upper Great Lakes diminished, causing the levels of these lakes to decline (see Figure 3). In 2000 and again in 2001, the monthly mean levels of Lake Superior were as much as 37 cm (15 in.) below average. In 2000 and 2001, the monthly mean levels of Lakes Michigan-Huron were as much as 57 cm (22 in.) and 59 cm (23 in.), respectively, below average. At times, levels on these lakes were below chart datum during this period.

Figure 3 – Water Levels, 1996 - 2001



Other natural factors affecting water levels and flows are flow restrictions due to ice or submerged aquatic vegetation in the rivers. In the St. Marys River, however, the effect of aquatic vegetation on flow is minor. Ice in the river can have a significant retarding effect on flows. A break-up of ice cover could lead to a serious ice jams. Rapid changes in air pressure and storms can cause large short-term water level changes in the St. Marys River, including those at the upstream and downstream ends of the hydropower facilities at Sault Ste. Marie.

Human activities affecting levels and flows of the upper lakes include dredging in the St. Marys River for navigation, water diverted into, and out of the Great Lakes basin (Long Lac, Ogoki, and Chicago diversions), and Lake Superior outflow regulation.

2.2 IJC Orders of Approval

In 1914, the IJC issued Orders of Approval permitting Algoma Steel Corporation in Canada and the Michigan Northern Power Company in the United States to divert some St. Marys River water for hydropower generation. The 1914 Orders specified a list of conditions to be met in the construction and operation of the hydropower facilities. In this and subsequent supplementary orders, one of the conditions is that all the works authorized by the IJC shall be so operated to achieve objectives specified by the IJC, and in such a manner as not to interfere with navigation. The Orders authorized the regulation of the outflows of Lake Superior, which is overseen by the IJC's International Lake Superior Board of Control.

The IJC has issued Supplementary Orders over the years to meet the changing conditions and requirements in the upper Great Lakes system. A 1978 Supplementary Order permitted the redevelopment of the Canadian hydropower facilities at Sault Ste. Marie, Ontario. In 1979, the IJC amended its 1914 Orders to adopt the principle of systemic regulation to provide benefits throughout the upper Great Lakes system. The 1979 amendment, which continues to govern today, requires that the levels of Lakes Michigan-Huron also be taken into account in determining Lake Superior outflows. In 1985, the IJC authorized, under separate supplementary orders, construction of the fishery remedial works in the St. Marys Rapids area, and subsequently issued minimum flow requirements for the remedial works to protect the sport fishery in the rapids section of the St. Marys River.

2.3 Regulation Plan 1977-A

Plan 1977-A is the current plan used to regulate Lake Superior's outflow. It was put into effect in June 1990. Like its predecessors, Plan 1977 and Plan SO-901, Plan 1977-A uses a technique that attempts to balance the levels of Lakes Superior and Michigan-Huron about their mean levels, giving consideration to their historical ranges. Plan 1977-A determines, at the beginning of each month, the monthly mean Lake Superior outflow for the month taking into account the current water levels on all three upper Great Lakes.

A minimum outflow of 1560 m^3/s (55,000 ft^3/s) is incorporated into Plan 1977-A. However, to prevent excessively low Lake Superior levels, an IJC criterion specifies that, when Lake Superior's monthly mean level declines below 183.4 m (601.7 ft), the outflow be restricted to no greater than that which would have occurred at the prevailing stage and under the outlet

conditions existing prior to 1887. When Lake Superior levels fall below 182.96 m (600.26 ft), the monthly outflow will be less than 1560 m^3/s (55,000 ft^3/s). Finally, the regulation plan contains maximum allowable outflow limits during the winter months to reduce the risk of ice jams in the St. Marys River.

In accordance with the IJC requirements, a minimum gate setting of one-half gate open at the Compensating Works, or its equivalent, is required at all times to supply water to the main rapids. In addition, Gate 1, at the north end of the structure, is set to provide a constant amount of water flow for the fishery remedial works. Gate openings are adjusted at the beginning of each month to achieve, along with the flows through the other facilities, including the U.S. and Canadian locks, the monthly mean Lake Superior outflow specified by Plan 1977-A.

When the regulation plan calls for a reduction in the Lake Superior's outflow, a reduction in the allocation of water for hydropower generation usually occurs. At times of extreme high flows, all gates at the compensating works can be opened to discharge water in addition to the maximum flows through the hydropower plants.

At the beginning of each month, the Board determines Lake Superior's mean outflow for the month according to Regulation Plan 1977-A. After deducting the amounts needed for the fishery, municipal/industrial water use, and expected navigation lockage, the remaining water is allocated, on monthly mean basis, equally between Canada and the United States for hydropower purposes. The Canadian share of the water is allocated to Great Lakes Power Limited. The U.S. portion of the water is typically allocated first to the U.S. Government plant, with the balance diverted by Edison Sault Electric Company.

Under certain conditions, the IJC may direct outflows different from the regulation plan on the advice of the Board. These deviations may include outflow variations to accommodate repairs at hydro facilities or the compensating works, to support flow measurements, sea lamprey control, survey or environmental study of the rapids, or to deal with unusual water supply conditions.

To ensure accurate determination of the flows at all the facilities, the Lake Superior Board oversees flow measurements that are carried out periodically. Flow measurements to verify the accuracy of reported flows at the hydropower plants require that the flows at these facilities be maintained steady during the measurements. At the present time, these measurements are conducted on an annual basis and are completed within one or two days. At the Compensating Works, flow measurements, which take place during the daytime, require adjusting the gates at various gate open settings and thus can result in large (but short-term) water level and flow changes below the structure. The timing of flow measurements at the compensating works is typically scheduled after consultation with the fishery experts and biologists to minimize the adverse impacts on fauna in the rapids. These measurements have recently been performed once a year in early August and last five to seven days.

2.4 Navigation Facilities

The St. Marys River provides the means of transporting waterborne freight between Lake Superior and the other Great Lakes. The present system of locks and channel deepening was

completed by the 1960s. Since then, maintenance dredging has taken place, along with further deepening of parts of the river. Depending on the location in the river, the channel depths range from 8.2 m to 9.1 m (27 ft to 30 ft) when levels are at low water datum. Vessel sizes that transit the St. Marys River vary in their depth requirements. For example, in 2001, ocean-going vessels required transit draft that ranged from about 7.7 m (25 feet 2 inches) to 8.0 m (26 feet 3 inches). When water levels permit, vessels may transit the system at even deeper drafts.

In Canada, there is one navigation lock that was refurbished in 1998 to serve pleasure craft and tour boats. Four other navigation locks are located at Sault Ste. Marie, Michigan. These locks use a relatively small amount of the St. Marys River flow. In 2000, the monthly mean amount of water used for lockage purposes was about 14 m^3/s (500 ft^3/s). Commercial navigation in the river normally extends from March 25 to January 15.

3. Hydropower Operations in the St. Marys River

3.1 Hydropower Facilities

In 1982, Great Lakes Power Limited (GLPL) completed its hydropower redevelopment with construction of its Francis Clergue Generating Station. Equipped with three generators, this plant has a flow capacity of about 1140 m^3/s (40,300 ft^3/s), which is approximately double the capacity of the old plant. The plant is located north of Whitefish Island and the Canadian lock. It is fed by a 1.7 km (1 mile) power canal that diverts water from just upstream of the rapids. The diverted water is returned via a 0.2 km (0.1 mile) tailrace canal that joins the river below the rapids.

There are two plants on the U.S. side of the St. Marys River. The U.S. Government's main plant, equipped with four units, is located at the foot of the rapids with a separate unit located at the head of the rapids. The Edison Sault Electric Company (ESELCO) plant, equipped with 74 units and located below the rapids, is served by a 4 km (2½ miles) long diversion canal. As with the other plants, the ESELCO plant withdraws water from upstream of the rapids, but returns the diverted water to the river further downstream of the rapids than the other plants. The capacity of the U.S. Government plant is about 410 m^3/s (14,500 ft^3/s) while that of Edison Sault is up to about 860 m^3/s (30,400 ft^3/s) with high Lake Superior levels. Due to a slightly higher operating head, the US Government plant takes the first portion of the U.S. water allocation, with the balance being used by ESELCO.

Thus, the total capacity of the three plants is up to 2410 m^3/s (85,100 ft^3/s). This assumes all the units at the plants are available to pass water and generate power, and water level conditions both upstream and downstream of these plants can hydraulically support such flow. The minimum amount of water allocation for power purposes can be estimated as 1100 m^3/s (38,800 ft^3/s) assuming Lake Superior is at its record minimum level. During the non-navigation season, the higher priority water uses would take about 100 m^3/s (3,500 ft^3/s), leaving 1000 m^3/s (35,300 ft^3/s) for power purposes. Thus, under the most extreme condition, the combined monthly mean flow at the hydropower plants has an expected range of about 1410 m^3/s (49,800 ft^3/s).

The efficiency point at each plant, in terms of energy produced per volume of water used, is at a flow somewhat less than the plant's flow capacity.

3.2 Flow Variations due to Peaking and Ponding

As discussed earlier, the amount of water allocated for power purposes is on a monthly basis. As the amount of the allocations decrease below the hydropower plants' flow capacities, the opportunity for them to peak and pond increases. During such periods, the plants operate at flows more than their monthly mean allocations during the day and evening hours when demand for electricity is high, and lesser flows at night and on weekends to make more efficient use of their allocated water. Peaking is the variation of the flow about the daily mean flow. Ponding is the variation of the daily mean flow about the weekly mean flow. Figures 4 and 5 show a simple flow hydrograph at a plant during peaking and ponding operations, respectively.

Figure 4 – Example of Peaking Operations

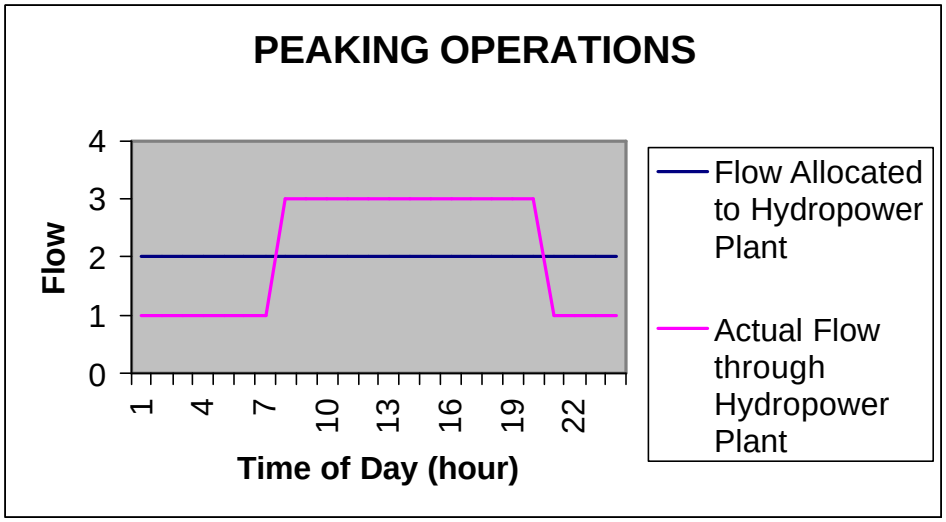
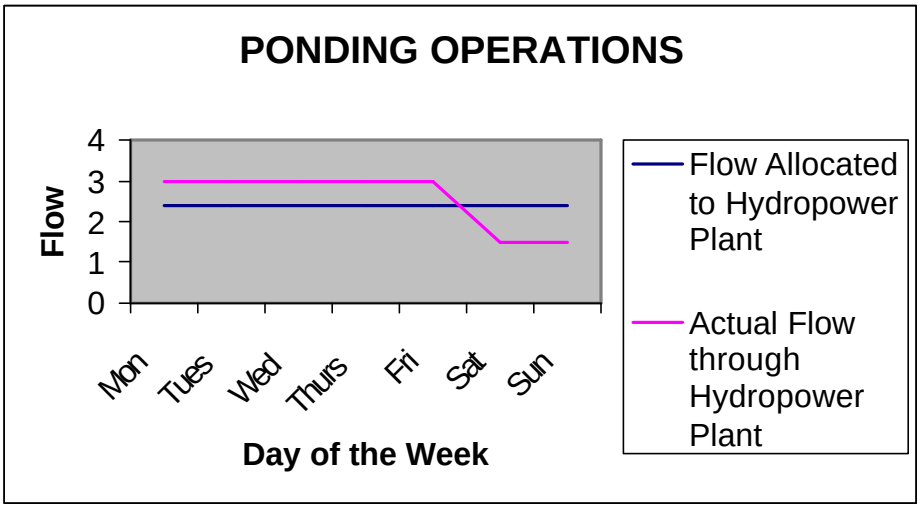


Figure 5 – Example of Ponding Operations

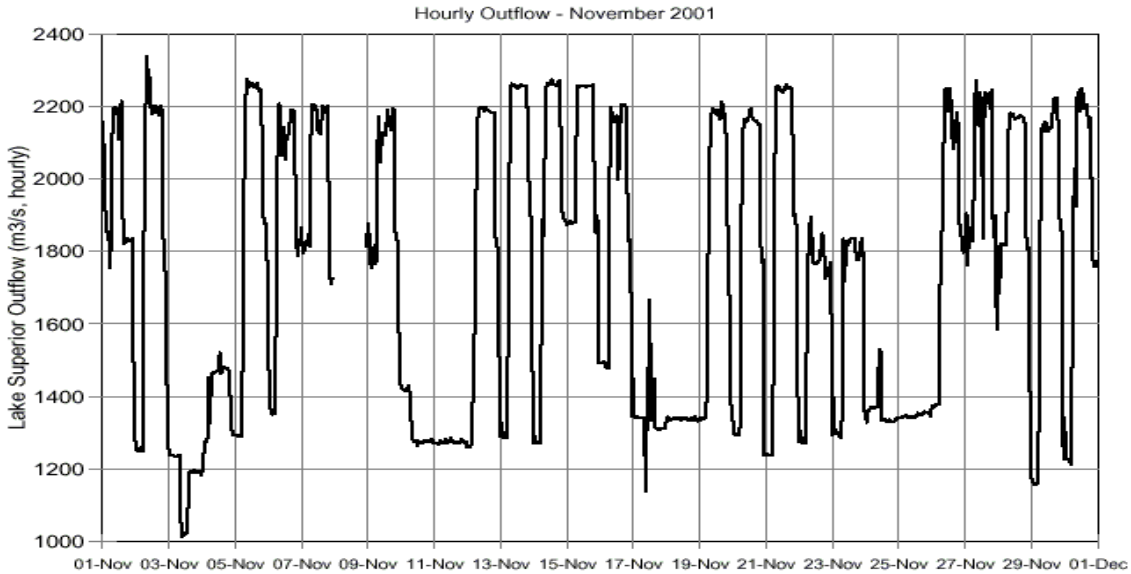


Neither the current regulation plan, nor the IJC Orders, explicitly approve or prohibit peaking and ponding operations by the power entities. The completion of redevelopment by Great Lakes Power Limited in 1982 increased its flow capacity and enabled peaking and ponding operations at times of low flows in the river. Prior to 1982, the capacity of the GLPL plant was about 500 m^3/s (17,600 ft^3/s). Until two years ago, these flow variations did not generate any concerns, due perhaps to the lack of low Lake Huron levels since 1982. However, with the recent significant decrease in levels of the St. Marys River, peaking and ponding operations have apparently become of more interest. By letter dated December 10, 2001, the IJC provided temporary authority to the power entities to conduct limited peaking and ponding operations until March 20, 2002, while the Board reviews the situation.

The Board focused its study on peaking and ponding operations the past four years 1998-2001. A more detailed discussion on the analysis of the data is presented in Section 6. The following describes some of the most recent peaking and ponding operations using November 2001as an example.

During November 2001, both GLPL and ESELCO conducted peaking and ponding operations while the flow at the U.S. Government plant was fairly steady through the month. The regulation plan specified a flow of 1730 m^3/s (61,100 ft^3/s) for the month, and the combined water allocated for power purposes for the month was 1614 m^3/s (57,000 ft^3/s). Combined maximum hourly hydropower diversion during the month was about 2220 m^3/s (78,400 ft^3/s), and the minimum hourly diversion was 895 m^3/s (31,600 ft^3/s), making it a range of 1325 m^3/s (46,800 ft^3/s). The St. Marys River's maximum and minimum hourly flows (which includes domestic, industrial use, lockages, and flow in the Rapids) coinciding with these maximum and minimum hourly total hydropower flow were about 2338 m^3/s (82,600 ft^3/s) and 1013 m^3/s (35,800 ft^3/s), respectively. The Lake Superior hourly outflows during November are shown in Figure 6. The daily mean flows in November 2001 ranged from 1170 m^3/s (41,300 ft^3/s) to 2065 m^3/s (72,900 ft^3/s), a range of 895 m^3/s (31,600 ft^3/s).

Figure 6: Total Lake Superior
Hourly Outflow - November 2001



The data from November 2001 demonstrate how peaking and ponding operations can alter the daily and hourly flows in the St. Marys, for a given low Lake Superior outflow condition. It has not been determined how “typical” these peaking and ponding operations were. In their "Joint Submission of Great Lakes Power Limited and Edison Sault Electric Company to the IJC" dated February 8, 2002, GLPL and ESELCO describe their usual method of peaking and ponding operations. This will be used by the Board in coordinating with the power entities proposed peaking and ponding schedule at the beginning of each month. However, it should be noted that the schedule and magnitude of peaking and ponding operations at either GLPL or ESELCO depend also on other factors such as energy demand at the time and availability of units. Another point is that on some nights when energy demand is low or not as profitable to generate, much lower flows may occur at the ESELCO plant.

The Board has conducted a brief review of its records in order to estimate when outflows were sufficiently low to allow peaking and ponding. The presumption was that the hydropower plants would flow at maximum efficient flow (estimated about 2200 m^3/s or 77,700 ft^3/s) capacity if they were allocated sufficient water. A brief examination of the monthly total flows shows that the power canal flows have been less than 2300 m^3/s (81,200 ft^3/s), about 75 percent of the months since 1983.

3.3 Other Flow Variations

While peaking and ponding cause frequent fluctuations in hydropower releases, there are other factors involved. There can be emergency reductions, such as when a bridge collapse closed the ESELCO canal in the mid-1980s. Repairs to the canal can cause flow reductions in order to create safe working conditions. Routine maintenance can take units off-line, decreasing outflow capacity. There have also been times when unscheduled transformer outages at GLPL have forced outflow reductions through their power plant. In each case, the temporary reduction would be made up during the month by the affected party, or, if that were not possible, by another hydropower entity, or, lastly, by opening Compensating Works gates. When looking at the historic record, such factors could cause the hydropower plant(s) to be flowing at capacity during the balance of the month, even though the average flow for the month is less than capacity. Thus, comparing historic monthly average outflows to hydropower plant capacity may provide a false indication of instances of peaking and ponding.

4. Hydropower Operations at Niagara and in the St. Lawrence River

Peaking and ponding are standard modes of operation for many hydropower plants around the world, including on the Great Lakes. This section describes how these operations take place in other parts of the Great Lakes – St. Lawrence River system.

At Niagara Falls, the Niagara Treaty of 1950 requires that a minimum amount of water (2832 m^3/s, or 100,000 ft^3/s) flows over Niagara Falls during the daylight hours of the tourist season from April through October for aesthetic purposes. At night and from November to March, the minimum flow requirement for Niagara Falls is 1416 m^3/s (50,000 ft^3/s). Any Lake Erie

outflow, in excess of that reserved for Niagara Falls, domestic and sanitary purposes, and for purposes of navigation, may be diverted for power purposes. These requirements aim to preserve the scenic beauty of Niagara Falls and provide the most beneficial use of the waters for power purposes. The signing of the treaty led to hydropower expansions on both sides of the border at Niagara.

Thus, the Niagara Treaty permits water diversions from the Niagara River that vary within the day and with the season. The Canadian and U.S. hydropower plants, some located at Niagara Falls and others close to the Falls, withdraw water from the Chippawa-Grass Island Pool just upstream of Niagara Falls. After passing the water through the turbines, these plants return the water to the Niagara River below the Falls. At night, when the minimum flow requirement for Niagara Falls is reduced, more water becomes available for power purposes and, since not all of the amount can be used, the un-used portion is stored temporarily in pump-generation reservoirs, which is then released the following day when demand for electricity increases again.

As the intakes for the power plants at Niagara are located in the Chippawa-Grass Island Pool, which is downstream of the natural hydraulic flow restriction of the river at Buffalo and Fort Erie, these diversions have very small hydraulic impacts on the outflows of Lake Erie. Their within-the-day flow variations, however, can cause large impacts on the water levels of the Chippawa-Grass Island Pool and the Maid-of-the-Mist Pool. The International Niagara Board of Control oversees the water level management operations in the Chippawa-Grass Island Pool, and hydropower operations at Niagara Falls.

In the international reach of the St. Lawrence River, peaking operations first took place, as a test, in November 1959, with the approval of the IJC and under the supervision of its International St. Lawrence River Board of Control. Subsequent tests, all with IJC approval, culminated in the issuing of the most recent directive by the IJC, called "Addendum No. 3 to the Operational Guides for Plan 1958-D", dated October 13, 1983. This directive continues to govern peaking and ponding operations today in the St. Lawrence River.

Peaking and ponding operations take place at the Moses-Saunders hydropower dam at Cornwall, Ontario and Massena, New York. The power dam is jointly operated by Ontario Power Generation (OPG) and New York Power Authority (NYPA). The St. Lawrence Board's Operations Advisory Group (OAG) monitors the conditions in the Lake Ontario – St. Lawrence River system, and each week advises the St. Lawrence Board's Regulation Representatives on the feasibility of conducting peaking and ponding operations. The OAG has representatives from NYPA, OPG, the Canadian Coast Guard, and the Canadian and United States Seaway agencies. The request to conduct peaking and ponding operations comes, typically as a joint request from both NYPA and OPG. Peaking and ponding operations can only be carried out with the consent of all the OAG members, and in accordance with the Board's regulation strategy. Ponding operations are not permitted during the navigation season.

The IJC's 1983 addendum requires that the power entities assume full responsibility for any damage that may result from peaking and ponding operations. The addendum sets out the limits governing peaking and ponding operations. For example, during the navigation season, peaking

operations may be conducted within a range of 850 m^3/s (30,000 ft^3/s) above, to 850 m^3/s (30,000 ft^3/s) below, the daily mean flow with hour-to-hour variations in flow limited to 570 m^3/s (20,000 ft^3/s). Ponding operations may be conducted wherein the daily mean flows may vary between minus 570 m^3/s (usually two days, Saturday and Sunday), and plus 230 m^3/s (8,100 ft^3/s, usually five days Monday through Friday) from the weekly mean flow specified by the St. Lawrence Board. Variations in flows due to peaking and ponding operations shall not result in hourly flows in excess of 7930 m^3/s (280,000 ft^3/s). For comparison purposes, the long-term average Lake Ontario outflow is about 7000 m^3/s (247,000 ft^3/s). Thus, the percentage of flow variation at Cornwall/Massena in the St. Lawrence River is much less than at Sault Ste. Marie in the St. Marys River.

5. Public Consultation

In addition to its own research and analyses, the Board requested input from a number of interests on the potential impact of peaking and ponding operations. Following is a discussion of the interests contacted and information received.

5.1 Navigation Interests

In 2000, the navigation interests first expressed to the Board staff their concerns about fluctuating water levels in the St. Marys River. On June 27, 2001, during the Board's meeting with the public in Port Severn, Mr. Ivan Lantz of the Shipping Federation of Canada expressed concern about the adverse impact of peaking and ponding, and the lack of knowledge of anticipated flow changes. Following the public meeting, a meeting was convened in August 2001 between representatives of the Board, the hydropower entities, and Mr. Lantz. The Board agreed to be the vehicle for information exchange and subsequently its staff prepared and issued a schedule of expected daily flows at the beginning of each month, including flow changes within each day (if any).

On November 21, 2001, the Board conducted a conference call with the Shipping Federation of Canada, the Lake Carriers' Association, the U.S. Great Lakes Shippers Association, Fednav Limited, as well as representatives of the hydropower entities. The teleconference provided a forum for the hydropower and navigation interests to exchange their views and concerns, and promoted better understanding of each other's operational needs. The views and concerns of navigation interests vary somewhat amongst their members. They range from absence of concern to complaints about delays in ship transit during weekends when lesser flows reduce the water depths in the lower river. The representatives of the hydropower entities emphasized the importance of peaking and ponding for their operations. At the request of the Board staff, Fednav subsequently provided some information on ship draft requirements and reports on transit delays in 2001.

The Shipping Federation of Canada acknowledged that, during weekdays, the increased water levels resulting from higher flows in the peaking cycle could be beneficial for navigation. Based on the information obtained and analyzed to-date, the Board has been unable to quantify the magnitude of the transit delay, but Fednav has stated that the low levels in Little Rapids reach is of greatest concern to the navigation interests and that consistent low weekend flows during

ponding operations can have an adverse impact on navigation when water level and flow in the river are low.

By letter dated January 28, 2002, the shipping interests stated that it is too early and premature to implement any changes on the way the water flows are managed and controlled. They also stated that the actual impacts of daily and weekly variations in the flows have (at this time) not been scientifically determined at several critical locations in the St. Marys River. Their letter did not request further intervention of the IJC towards regulation of peaking and ponding procedures at this time, and suggested that further study focus on the low water level issue. Notwithstanding this submission from the navigation interests, the Board completed this study in response to the questions raised in the Commission's December 10, 2001 letter to the Board.

The Board received another letter, dated February 7, 2002, from the Lake Carriers' Association. Among the points stated in the letter were that the Association "--reiterate the problem (related to safe navigation) is low water due to environmental factors, not power plant factors". The letter cited atmospheric pressure, wind and current primarily caused by the number of gates [at the Compensating Works] authorized to be open. The letter continued to state that: "---We have looked at the historical data available to us on the Internet displaying the actual water level at the U.S. Slip over the past three months of the shipping season, including the month of December 2001. Lake Carriers' Association reviewed these data and was unable to correlate any predictive impact of water level changes caused by the power plants' practices at that geographic point. It appears that the environmental impacts of atmospheric pressure and wind were the significant factors impacting water levels most of the time. The managers of the Laker vessels did not view the peaking and ponding impact in 2001 as any impediment to safe passage".

Another subject raised in the February 7, 2002 letter from the Lake Carriers' Association, is dredging. It was also heard in the power entities' presentation at the public hearings on January 28, 2002. The LCA and other members of the navigation interests believe, in order to overcome the low water problem in the St. Marys River, some dredging in the area between the Soo locks and Rock Cut would be required. This dredging, according to the navigation interests, "… should solve their navigation concerns, unless, of course, there is some unusual large dramatic drop in the water levels."

By letter dated February 27, 2002 to the Board, the Shipping Federation of Canada suggested that one immediate solution to the low water level problems "deep sea navigation" faces is to significantly increase the monthly Lake Superior outflows. As a mid-term solution, they suggested dredging to remove the high spots in the St. Marys River. Recognizing that neither of these solutions may come about in the near future, they suggest that temporary relief from low water levels would be provided by a scheme of seven day per week peaking whereby navigation could benefit from maximum flows during the peak flow periods each day.

5.2 Fishery and Other Environmental Interests

The Board sent letters to several government agencies requesting their views on the subject of peaking and ponding operations. The replies from the agencies generally agreed that peaking and ponding might have an impact on the fishery and other environmental interests. However,

no significant adverse impacts have been identified as to their location, or nature of any concern. The following is a summary of some of the replies:

The U.S. Environmental Protection Agency and the Michigan Department of Environmental Quality (MDEQ) are working together toward remediation of a site of environmental contamination in the St. Marys River upstream of the power canal. In its reply dated January 15, 2002, MDEQ stated that the "The existing water level fluctuations do not appear to pose too great a difficulty, assuming present water levels remain the same, and current ponding and peaking water effects remain the same".

The letter from the Ontario Ministry of Natural Resources (OMNR), dated January 14, stated that they are not aware of any fisheries issues associated with peaking and ponding operations. Their conclusion was arrived at after consultation with the Ministry staff who have worked on the river and with the president of a local angling club. No concerns were identified. However, OMNR 's most significant concern with water velocities and levels is associated with any sudden or high volume water releases at the Compensating Works that are outside the normal operating procedures for monthly water releases. OMNR understands that these practices at the Compensating Works can have serious negative outcomes to field studies, habitat restoration efforts and may interfere with critical life processes of fish and other aquatic life. The Board notes that there is already a procedure in place whereby prior consultation with the fishery experts take place on any significant gate movements at the Compensating Works (for example, in connection with flow measurements or repairs at the structure). Better coordination between the parties could be explored.

According to the Sea Lamprey Control Centre, their biggest concern about water level and velocity fluctuations is on their adult sea lamprey assessment program. At certain times of the year, the centre operates traps at the Great Lakes Power Limited and the U.S. Government hydropower facilities. Fluctuating water levels make it necessary for their staff to raise or lower their traps in response to changing water levels, making it time consuming and costly.

The Chippewa Ottawa Resource Authority, representing five tribes in Michigan, requested the Board conduct studies of the impact of peaking and ponding operations on the St. Marys Rapids and on fish species such as sturgeon, lake whitefish, lake herring and other species. The Authority also asked that the Board consider the effects of contaminated sediments that exist in the river due to current and past industrial activities. It stated that peaking and ponding operations could disturb those sediments and thus affect the river's biota and could also become a human health issue.

5.3 Hydropower Interests

Peaking and ponding operations provide the hydropower entities in the St. Marys River an ability to better meet the needs of their customers using their monthly water allocations. These operations minimize purchases of outside power (which include those generated from fossil fuels) and thus reduce cost to ESELCO and GLPL. According to a joint statement from ESELCO and GLPL at the January 28 public hearing, their combined annual economic impact is about $3.5 million to $4.0 million (Canada), or $2.2 million to $2.5 million (U.S.) annually in a

low water level period. By letter dated February 8, 2002, ESELCO and GLPL provided additional information as a part of their submission to the IJC's public hearings. According to ESELCO and GLPL, elimination or restriction of peaking will have significant economic repercussions. The February 8, 2002 submission also describes the current peaking and ponding practices at the two plants.

Several local residents also spoke at the public hearings in support of peaking and ponding operations because they help provide low cost electricity.

5.4 Municipalities, Industries and Others

The City of Sault Ste Marie, Michigan informed that there are no impacts on water intakes or outfalls, and minimal impacts on marinas.

The City of Sault Ste. Marie, Ontario informed that the low water levels below the St. Marys Rapids caused by climatic conditions of the last couple of years is the main concern. Under these present conditions any change in water flows from Lake Superior or wind direction that causes a fluctuation of water level can cause a problem, that is, water depths in their marina's and waterfront docking. Fluctuation of water flows through the power dams does not have any appreciate impact on the general water levels below the rapids, according to the city official.

Algoma Steel noted that low levels increase shipping costs.

Neebish Island Ferry noted no significant change in water levels.

Some industries, Manistique Papers Inc., for example, supports peaking and ponding operations since they bring about low electricity costs and thus attract and keep industries and jobs in the State of Michigan.

6. Technical Investigations by the Board

A statistical analysis of the available hourly outflow and water level data was made to determine the amount of the total daily variation in the levels at the St Marys River gauge sites that is due to peaking, and the amount of the total weekly variation in daily mean levels that is due to ponding. The substantial amount of variation in hourly levels in the St Marys River due to factors other than peaking and ponding necessitated an analysis that could separate peaking and ponding from these other effects. Given the available data, tools and time for the study, a statistical analysis using linear regression techniques was determined to be most effective.

6.1 Outflow Data Preparation

Data on hourly water diversions for hydropower purposes and power production from 1998-2001 provided by each of the three hydropower plants were examined. Hourly data were necessary since the effects of peaking occur within the course of one day. Data in electronic format for the

Edison Sault Electric Company (ESELCO) power plant were not available prior to 1998, so the analysis was limited to the 1998-2001 period.

The discharge data from ESELCO and the U.S. Government Plant (USGP) were checked for quality control and parsed into spreadsheets by the U.S. Army Corps of Engineers, Detroit District. The ESELCO data were available at half-hour increments, but for this analysis, only data at the "top" of every hour were used to coincide with the other data. The ESELCO data for the period prior to September 2001 were adjusted to correct for the under-reporting error that existed with their former flow reporting system. The investigators also adjusted the discharge data for the USGP to correct for the under-reporting error that continues at that plant. It was necessary to assume constant hourly flows at USGP from daily averages, since hourly records are not available. Discharge and electrical power data from GLPL were compiled by Environment Canada. Owing to apparent differences in the synchronization of the instrumentation that record power and the flow at GLPL, it was necessary in many instances to estimate the hourly flows using power data. Logs of known outages at all three plants were then prepared and missing data were flagged.

Estimated hourly outflows through the Compensating Works and the remaining structures at Sault Ste. Marie (that is, lockage, domestic and industrial usages) were assumed to equal the reported monthly means.

For dates when the U.S. Government Plant was not running at capacity, or on dates wherein there were gate movements at the Compensating Works, the estimates based on the assumption of constant hourly flows throughout the day were likely in error. Outflow data for these dates were removed from the analysis.

Finally, total corrected hourly Lake Superior outflows were calculated for the period 1998-2001.

6.2 Water Level Data Preparation

Hourly water level data from 1998-2001 from each of eight gauge locations listed below that are located along the St. Mary's River were analysed. The operating agency of these gauges are listed in parentheses, and the gauge locations are shown in Figure 1.

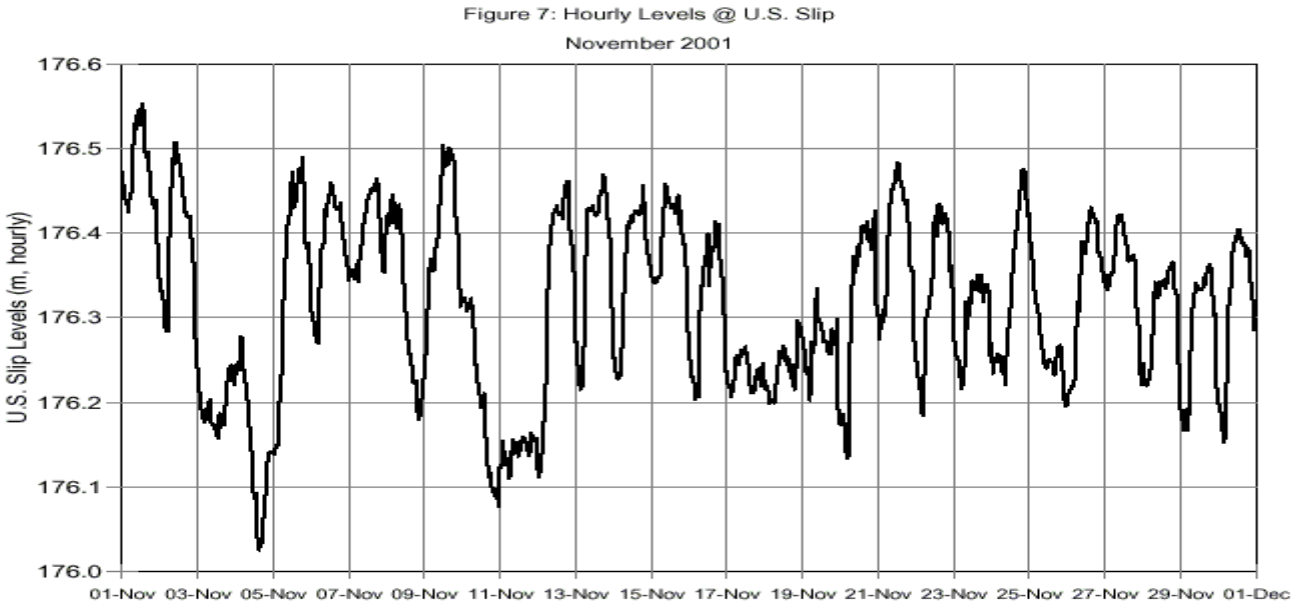
1) Southwest Pier (NOS),
2) U.S. Slip (NOS),
3) Little Rapids (USACE),
4) Frechette (USACE),
5) St. Mary's River near Garden River (WSC),
6) Lookout #4 (USACE),
7) Rock Cut (USACE), and
8) De Tour Village (NOS).

All data were checked for quality control. Missing and erroneous data were flagged and individual spreadsheets prepared to summarize available hourly level data at each of the above

gauge sites from 1998-2001. Figure 7 shows the hourly water levels at U.S. Slip for November 2001.

6.3 Data Analysis

As mentioned previously, the amount of peaking and ponding a hydropower plant is able to conduct in a month depends upon how close the monthly water allocation is to its capacity. As the water allocation declines, the range for peaking and ponding increases. Ideally an analysis should encompass a dataset that included a wide range of months with water allocations ranging from minimum flows to flows at the capacity of the hydropower plants. Although four years of data were available, there were only a handful of months when all of the hydropower plants were either not peaking and ponding (henceforth termed “no peaking & ponding”) or were varying



flow on a day-to-day or week-to-week basis over a broad range (henceforth termed “full peaking & ponding”). In fact, the only satisfactory example of “full” peaking & ponding available proved to be a short period from mid-November to the end of December in 2000. Unfortunately, there were significant gaps in many data sets for these few available example periods. For instance, there proved to be only 22 dates available where full peaking and ponding was observed, and many of these were actually at somewhat diminished ranges. As a result, it was necessary to perform an aggregate analysis.

A brief literature review was conducted, including "A Report to the International St. Lawrence River Board of Control on Effects of Peaking and Ponding Within the St. Lawrence Power Project Study Area, Analyses of Historical Data, Joint Report of Ontario Hydro and the New York Power Authority, March 1994". This report suggested that there are several factors that can affect St. Marys River water levels, and they include:

1) Lake Superior water level,
2) Lakes Michigan-Huron water level,
3) Lake Superior outflow,
4) Local tributary inflows,
5) Wind,
6) Atmospheric pressure changes, and
7) Ice and aquatic vegetation.

Further, to determine the extent to which each factor affects water levels at any one location (which is dependent on the characteristics of the fluctuations by each factor), the 1994 report suggested the following be considered:

1) Range in water levels (maximum to minimum),
2) Frequency of occurrence (of a given change),
3) Duration, and
4) Season (open water/winter; navigation/non-navigation season).

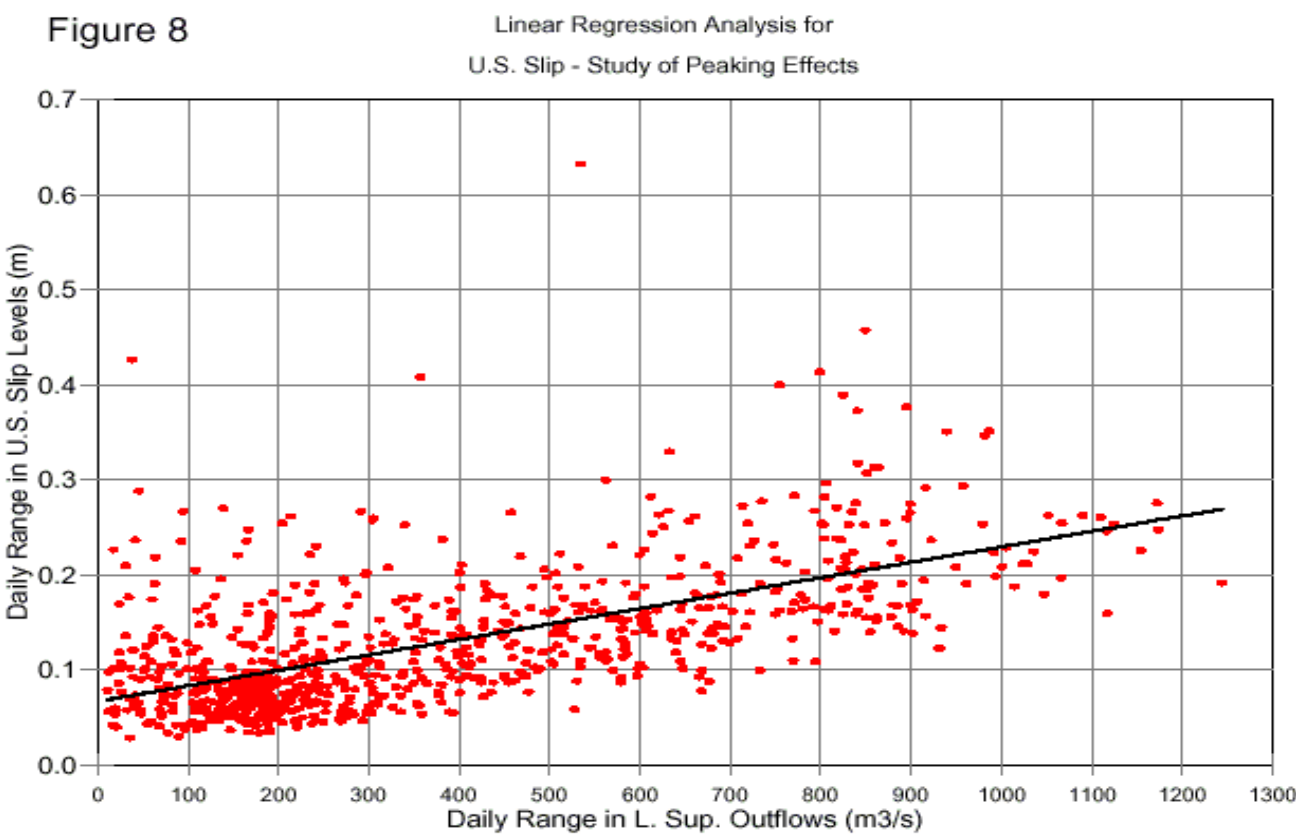
Water level changes caused by flow changes are a function of not only the magnitude of the flow change, but its duration, and the distance downstream of the control structures. Due to the water storage capacity in the river, the response of the water levels to flow changes was not expected to be instantaneous, but rather was expected to gradually occur over the course of a few hours to possibly days. Thus it was expected that water level changes due to peaking and ponding would be less than those resulting from an equal change in flows whereby the flow change is sustained for longer durations than part of a day.

Due to the lack of data available for both “no” and “full” peaking and ponding, it was necessary to analyze the data in such a way as to include as many values as possible, so that each of the above factors and characteristics could be considered using a statistically significant dataset. To this end, all available data from 1998-2001 were used for each gauge location. Assuming ice in the river would affect the behavior of levels, these data were then separated into two sets: one for the open-water season (assumed to be April 16 to December 15), and another for the ice season (December 16 through April 15) each year.

Two separate analyses were carried out to determine the relationships between flow variations due to peaking and ponding and water level variations in the St. Marys River.

To determine the effects of peaking on levels, a study of within-the-day changes was performed considering hourly fluctuations in both levels and flows from 0000 hrs to 2400 hrs each day. Results of a least squares regression analysis demonstrate that for the levels at the U.S. Slip, Little Rapids, Frechette, Garden River, and Lookout #4 gauges, there is a significant relationship between the range of hourly flows within the day (that is, variation due to peaking and unit outages) and the range of hourly levels within the day. The analysis indicates that the magnitude of the relationship diminishes from the most upstream gauge (that is, U.S. Slip) to the further downstream gauges.

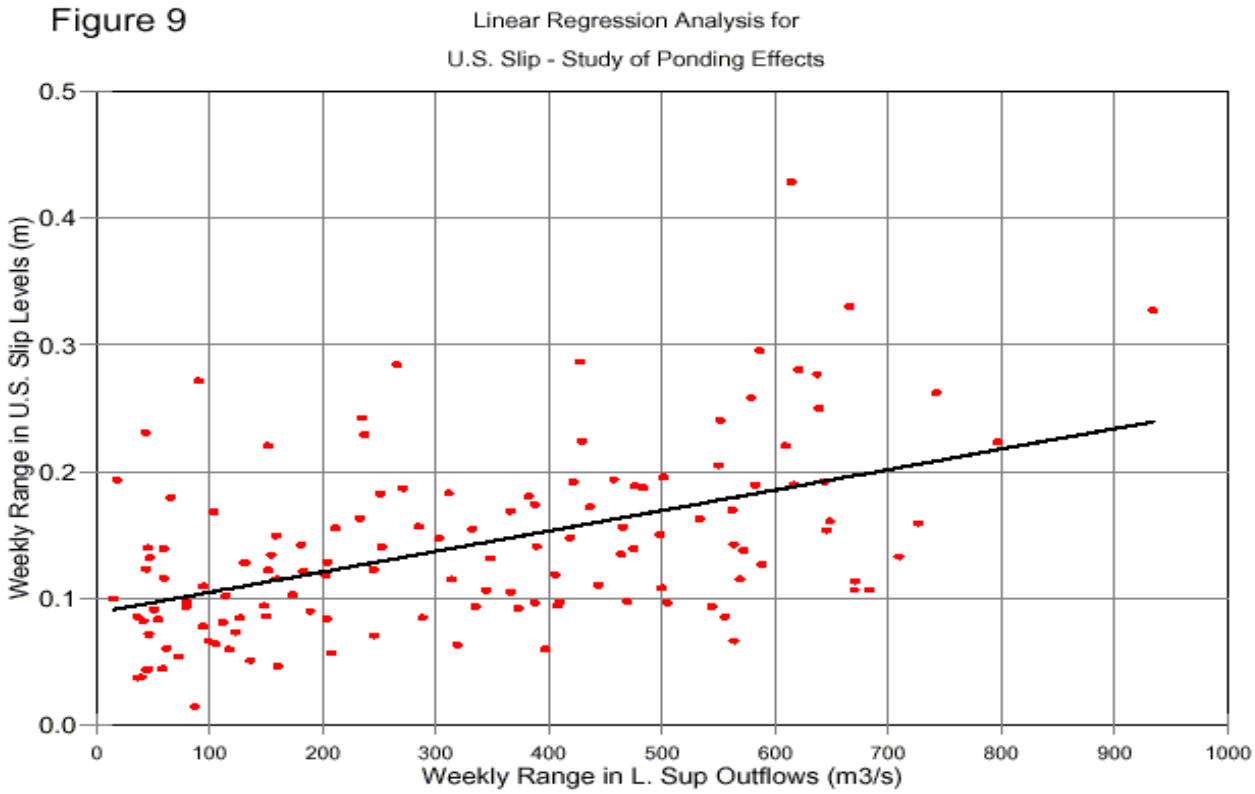
Figure 8 shows the linear relationship developed from the regression analysis and the peaking data for the US Slip gauge. Note that since the effects of winds, atmospheric pressure differences, seiches, etc. were not removed, there is a considerable "scatter" in the data. Indeed, the results of the regression analysis show that the variation of flow within the day accounts for only about 40% of the total variance of the range of levels within the day at US Slip. The amount of the total variance in levels that is explained by the regression also diminishes the further downstream the gauge, such that at the Lookout #4 gauge, the fluctuation in flow explains only about 7% of the total variance. Nonetheless, the linear regression analysis indicates that a significant relationship exists between the range of hourly flows within the day and the water level variation for each of these gauge locations. The range of hourly levels within the day due to peaking is approximately 16 cm (6.4 in.) at U.S. Slip per 1000 m^3/s (35,300 ft^3/s) variation in flow, 11 cm (4.3 in.) per 1000 m^3/s at Little Rapids, 8 cm (3.1 in.) per 1000 m^3/s at



Frechette, and about 6 cm (2.4 in.) per 1000 m^3/s at both Lookout #4 and Garden River. The analysis for the gauges at SW Pier, Rock Cut and Detour showed no significant relationship between the range of hourly flows and levels within the day. On average, within the day fluctuations of levels of $\pm$ 6 cm (2.4 in.) can be expected due to non-flow factors at the U.S. Slip gauge and between $\pm$4 to $\pm$7 cm ($\pm$1.6 to $\pm$2.8 in.) at the other downstream gauges on the St Marys River. At the SW Pier gauge on the upper St Marys, within the day fluctuations of levels of $\pm$14 cm (5.5 in.) can be expected due to non-flow factors.

An analysis of the variation in the daily mean flows and daily mean levels over the week was performed to determine the effects of ponding operations. Since the ponding cycle consists of higher weekday mean flows and lower weekend mean flows, the weekly fluctuations in both daily levels and daily flows from Wednesday at 0000 hours to Tuesday at 2400 hours were analyzed to demonstrate the additive effect that ponding has on level fluctuations. A least squares regression analysis similar to that used to analyze peaking was conducted. The analysis indicates that at the U.S. Slip and Little Rapids gauges, there is a significant relationship between the range of daily mean flows within the week (that is, variation due to ponding) and the range of daily mean levels within the week. The magnitude of the relationships are very similar to those found for peaking: approximately 16 cm (6.3 in.) variation in daily mean level at U.S. Slip per 1000 m^3/s (35,300 ft^3/s) variation in daily mean flow, and 11 cm (4.3 in.) per 1000 m^3/s at Little Rapids. For the other gauge locations the analyses did not result in a statistically significant relationships between the range of daily mean flows and daily mean levels within the week (perhaps due to the relatively small number of weeks available in the sample). Figure 9 shows the linear relationship developed from the regression analysis and the weekly data for the US Slip gauge. Similar to the peaking case, there is considerable "scatter" in the daily mean level variations within a week, since the effects of winds, atmospheric pressure differences, seiches, etc. were not removed. The regression analysis shows that the variation of daily mean flow within the week accounts for only about 26% of the total variance of the range of daily mean levels within the week at US Slip.

Figure 9



During November 2001, the daytime (8 a.m. to 8 p.m.) levels on weekdays averaged 176.40 m (578.74 ft) at U.S. Slip while the daytime levels on weekends averaged 176.21 m (578.12 ft). At Little Rapids Cut, daytime (8 a.m. to 8 p.m.) levels on weekdays averaged 176.33 m (578.51 ft) while the daytime levels on weekends averaged 176.18 m (578.02 ft).

Similar analyses were done for the ice season (assumed to be from December 15 to April 15). The analysis of peaking effects on hourly levels produce about the same relationships as the open water case for the US Slip, Little Rapids and Garden River gauge sites. At the other gauge sites further downstream, and the SW Pier site, the analyses did not demonstrate significant relationships between the within the day ranges of hourly flows and hourly levels in the ice season. The lack of demonstrated statistically significant relationships at the downstream gauge sites during the ice season may be due to the small sample size due to the shorter period, or the less prevalent peaking typical during this season, rather than the effects of ice, since the average within-the-day fluctuations of levels are almost identical to those in the ice-free season.

These statistical analyses were able to demonstrate the relationship between the range of flows and levels due to peaking and ponding, but did not address the frequency of occurrence (of a given change). The 1998-2001 dataset is not sufficiently long to calculate a representative frequency distribution of the occurrence of peaking and ponding of various amounts. Within this four-year (48 month) period, regular peaking and ponding operations were conducted at ESELCO during ten months, while at GLPL they were conducted during 31 months.

7. Other Discussions

The Board focused its investigation on public consultation and analysis of readily available data. The views and comments collected demonstrate that fluctuating water levels remains a subject of interest and concern among the various interests. However, none of the information collected to-date have identified any significant adverse effects on interests other than navigation. Peaking and ponding operations provide an efficient use of water for power purposes. However, during periods of low Lake Superior outflows and low Lake Huron levels, these operations can have an impact on navigation. Although the data analysis conducted by the Board has been limited, the results show the extent of the impacts in the lower St. Marys River. Considering the concerns of the navigation interests and the needs of the hydropower entities, the Board proposes guidelines that would enable continued peaking and ponding operations and, at the same time, minimize any adverse impacts on navigation.

The Board recognizes that, in recent years, the maximum allowable Seaway draft on the Great Lakes and the St. Lawrence River has been increased. In spite of channel improvements and deepening over the years, problems for navigation invariably arise from time-to-time when water levels and flows are low. In parts of the St. Marys River, the design channel depth is 8.23 m (27 feet) when the water level is at low water datum, however, parts of the river provide up to 9.14 m (30 feet). The designed maximum vessel draft is 7.77 m (25.5 feet) when the water level is at low water datum to allow for wind effects on levels, the squat of the vessel under power, and a margin of safety. Ship masters are well aware of these limitations. The vessels that were brought to the Board's attention as being delayed by low levels required drafts of up to 8 metres

(26’3”). It may be, but is not known for certain, that they could have passed through the St. Marys River had they been only loaded to the design channel draft. Loading to their maximum capacity for the deep-draft ships represents an element of risk and uncertainty that ship masters sometimes choose to take.

The Remedial Action Plan report “The St. Marys River Area of Concern – Environmental Conditions and Problem Definitions, Remedial Action Plan, Stage 1, March 1992” discussed dredge spoils and their disposal, areas in the St. Marys River where there are concerns with polluted sediments. However, the report did not identify whether fluctuating water levels and flows due to peaking and ponding operations would affect the stability or transport of these sediments. The 1992 report also listed the wetlands and fish habitats in the river, but did not identify the relationships between the health of these wetlands and habitats and water level fluctuations, and fluctuations due to peaking and ponding operations.

8. Conclusions and Recommendations

Based on the study results described in this study, the Board provides the following findings and recommendations to respond to the questions raised in the IJC’s letter of December 10, 2001:

(a) A Review of Past Peaking and Ponding Operations, Emphasizing Times of Known Concern

The amount of water available for hydropower purposes in the St. Marys River is determined each month in accordance with the regulation plan for the outflows of Lake Superior, and the IJC’s Orders of Approval and supplementary orders. At times, the amounts of water available for hydropower purposes are less than the capacities of the plants in the river. During such periods, the hydropower plants may choose to operate at higher flows during the day and evening hours when demand for electricity is high, and lesser flows at night and on weekends to make more efficient use of their allocated water.

The study analyzed the available hourly water level and hydropower plant flow data of the past four years (1998-2001), at the time of declining water levels and flows on the upper Great Lakes. Compatible hourly data prior to 1998 are not as readily available. Peaking and ponding operations are reported to have also taken place prior to 1998, but perhaps at a magnitude and frequency less than those of the past four years. The hydro re-development by Great Lakes Power Limited on the St. Marys River in 1982 increased its plant’s capacity and thus provides more opportunity to carry out peaking and ponding operations.

In 2000, some navigation interests first expressed concerns about the low water level in the St. Marys River, and that these problems they experienced were exacerbated by fluctuations due to peaking and, in particular, consistent low weekend flows during ponding operations. As the water level of Lake Superior declined during the autumn of 2001, so did the Lake Superior outflow specified by the regulation plan. In November 2001, the Shipping Federation of Canada once again expressed concern about the lower weekend flows due to ponding operations and their impacts on the already low water level conditions.

(b) Impacts of Past Peaking and Ponding Operations on Water Levels

The Board focused its analysis on readily available data. The technical study included analysis of the hourly flows through the various structures and hydropower plants in the St. Marys River for the period 1998-2001 when levels on the upper Great Lakes were mainly on the decline. During this period, peaking and ponding operations took place at various times and by varying degree. Peaking and ponding operations became more prominent beginning in the late autumn of 2000.

The higher flows during the day raise the water levels below the hydropower plants and in the St. Marys River downstream of Sault Ste. Marie. These higher flows extend as late as 11:00 p.m. The offsetting overnight flows and the reduced flows during the weekends lower the water levels in the lower river. Using one recent month (November 2001) as an example, daily total hydropower outflows were as much as about 21% above and 35% below the monthly allocation. Hourly flows had a wider variation, with flows as much as 38% above and 45% below the allocation.

Peaking and ponding operations have their maximum water level impacts immediately downstream of the power plants. It was found that the level at U.S. Slip changes by about 16 cm (6.4 inches) for a 1,000 m^3/s (35,300 ft^3/s) change in the flow. The impacts diminish as one proceeds further downstream until at Rock Cut, near the mouth of the St. Marys River, they become negligible. Although there are other factors affecting water levels in the river, such as winds, barometric pressure changes, and Lake Huron levels, the separate effects due to each of these possible sources were not addressed in this study. On average, these other effects cause a fluctuation of $\pm$ 6 cm ($\pm$2.4 inches) during the day at U.S. Slip, and $\pm$ 4 to $\pm$ 7 cm ($\pm$1.6 to $\pm$2.8 inches) at the other gauges on the lower St. Marys River. At the Southwest Pier (on the upper St. Marys River), within-the-day fluctuations of levels of $\pm$ 14 cm ($\pm$ 5.5 inches) can be expected due to non-flow factors.

In examining the data, it is noted that meteorological disturbances can have large, short-term impacts on water levels in the river. Peaking and ponding operations are found to have a negligible impact on the water levels upstream of Sault Ste. Marie. The analysis of the data in this study employed statistical techniques. Additional information may be provided from study employing a hydrodynamic model of the river.

(c) Impacts of Peaking and Ponding Operations on Interests Affected by Changing Water Levels and Flows

Peaking and ponding operations provide an efficient use of the water for hydropower purposes. The additional hydropower generated during the high flow periods in the peaking cycle help the utilities meet peak electrical demands and reduce the need to purchase more power from other sources.

Fluctuating water levels and flows in the St. Marys River remain a subject of interest and concern. However, except for navigation, the comments and views collected to-date did not identify any significant adverse impacts due to peaking and ponding operations.

The views and concerns of navigation interests vary somewhat among their members. They range from absence of concern to complaints of delays in ship transit during weekends when lesser flows reduce the water depths in the lower river. Some acknowledged that, during weekdays, the increased water levels resulting from higher flows in the peaking cycle could be beneficial for navigation. Based on the information obtained and analyzed to-date, the Board has been unable to quantify the magnitude of the transit delay, but has identified the Little Rapids reach as the area of concern to the navigation interests. Ponding operations can have an adverse impact on navigation when water level and flow in the river are low.

(d) The Advisability of Peaking and Ponding Operations

Peaking and ponding operations enable efficient use of the water for power purposes. High flows in the daily peaking cycle can be beneficial to the navigation interests. Under certain conditions, sustained low weekend flows conducted as part of ponding operations could be detrimental to navigation and suspension of ponding operations would be advisable. The views and comments collected to-date have not identified any known adverse environmental or other impacts. Based on these considerations and the analysis of data from the past four years, the Board recommends that peaking and ponding operations be allowed to continue. Further study, and operational experience would be needed to have a better understanding of the relationships between water levels and peaking and ponding operations, and their impacts on the various interests. On this basis, the Board recommends that the IJC approve peaking and ponding operations for one more year under the condition specified below. This will permit further study and collection of operating experience. The proposed study of the Lake Superior regulation criteria is expected to help refine these guidelines.

(e) Proposed Guidelines Governing Peaking and Ponding Operations

The Board notes that in spite of channel deepening over the years, problems for navigation invariably arise from time-to-time when water levels and flows are low. The Board believes the following proposed guidelines are a reasonable compromise given our current knowledge, and should enable both the power entities and navigation to operate with minimum adverse impacts:

1. Subject to prior approval from the Board at the beginning of each month, peaking and ponding operations may be conducted in a manner that meets hydropower needs, and consistent with the mode of operation outlined in the hydropower entities' February 8, 2002 submission to the IJC.

2. The Board may suspend ponding operations for the month if it is expected that ponding operations would result in sustained weekend levels at the U.S. Slip Gauge declining below chart datum elevation. At such times, the Board directs that the same on-peak flow rates be maintained each day of the week, including weekends. This will assist ships loaded to the

design draft to pass without undue delays (that is, usually within 24 hours of reaching the river). The forecast of expected water levels at U.S. Slip shall be determined at the beginning of the month based on Lake Superior outflow, levels on Lakes Michigan-Huron, and peaking and ponding schedules as defined in the February 8, 2002 submission.

3. The power entities shall record hourly water level and flow data during this test period, and furnish these to the Board each month. They shall also report promptly to the Board any problems, or reports of concern related to peaking and ponding operations, or water level fluctuations in the St. Marys River.

4. Further, under emergency conditions, the Board may alter or suspend peaking, or ponding, or both. These could be due to equipment failure at the hydropower facilities, ship incidents such as groundings, electrical system difficulties or other circumstances. At such times the Board shall direct outflows that are consistent with the Orders of Approval in consideration of the needs of the interests.

(f) The role of the Board in Peaking and Ponding Operations

The Board will closely monitor the water levels throughout the St. Marys River, as well as on the Great Lakes. The Board will review, at the beginning of each month, the peaking and ponding schedule proposed by the power entities, and approve or direct modifications to peaking and ponding in accordance with the guidelines listed above. The Board will continue to issue to the public and navigation interests, at the beginning of each month, the schedule of hourly outflows for the month. During this one-year test period, the Board will record and assess any impacts that might arise as a result of peaking and ponding operations. At the end of the one-year test period, the Board will provide a report to the IJC on the results, and make recommendations on whether to continue with peaking and ponding operations, and on improvements to operating guidelines.

Other Comments and Issues

The St. Marys River is a complex system with water level changes resulting from many natural and human factors. To further increase our understanding of this system, and to develop better guidelines for peaking and ponding, the Board recommends more detailed study.

The Board considered including a guideline specifying the minimum hourly St. Marys River flow during normal peaking and ponding operations, however, the lack of information on environmental impacts caused by flow fluctuations prevented the determination of a justifiable value. The Board recommends that more detailed information on the relationships between levels and flows in the lower St. Marys River be developed, perhaps employing a hydrodynamic model. The Board also recommends that the Commission consider undertaking an environmental study to examine the impacts of various flows on environmental interests. The Board also recognizes that studies to be conducted in the upcoming Lake Superior regulation criteria review could further enhance our understanding, and thus refine guidelines governing peaking and ponding operations.

During the IJC's public hearings, the Board heard from some submissions that one alternative to the low water level problem for navigation is to deepen the critical parts of the St. Marys River. The Board wishes to point out that dredging on the Great Lakes and their connecting channels is a subject of interest and could impact levels and flows, and distribution of flows around islands in the St. Marys River. In this regard, we recommend that, prior to dredging, a detailed hydraulic analysis be conducted to assess the potential impacts.

Available literature has identified wetland, fish and wildlife habitat in the St. Marys River. However, the relationships between the health of these habitats and water level fluctuation are not well understood. The Board also recommends that the Commission consider undertaking an environmental study to examine the impacts of various flows on environmental interests. Studies such as those proposed in the review of Lake Superior regulation criteria, would also enhance our understanding and thus enable better water level and flow management to minimize any adverse impacts on interests.

Appendix A

December 10, 2001

Dear Mr. Cuthbert:

The current low water situation and recent inquiries have highlighted concerns with peaking and ponding operations in the St. Marys River. As we discussed during our semi-annual meeting in October, the Commission would like the Board to conduct a review of these operations and provide us with its findings and recommendations.

To the degree allowed by readily accessible information and by the timeframes outlined later in this letter, the Commission asks the Board to undertake the following and provide the Commission with a written report.

- Review past peaking and ponding operations during a variety of water level and flow conditions, emphasizing times of known concern.

- Document the impacts of past peaking and ponding operations on water levels and flows, and on interests affected by changing water levels and flows, such as domestic and sanitary uses, hydropower, navigation, fisheries, and the environment.

- Develop possible guidelines for considering future peaking and ponding operations during a variety of water level and flow conditions.

- Recommend to the Commission whether, in the Board's opinion, continued peaking and ponding operations are advisable. If so,
  - recommend under what conditions they might be permissible,
  - recommend how they might be conducted, including consideration of such things as tolerance limits in terms of fluctuating levels/flows at critical locations in the navigation channel,
  - recommend the role the board might take concerning such operations, and
  - document the expected impacts of such operations on water levels and flows and on interests affected by changing water levels and flows.

- Address any other issues that the Board believes important concerning this request.

In order that the Commission may fully consider all relevant information in advance of the 2002 navigation season, we ask that the Board submit its report by February 28, 2002. We expect that we will hold a public hearing in Sault Ste. Marie regarding peaking and ponding and are initially targeting January 28, 2002. This date should allow the Board to consider the input received when drafting its report. We will almost certainly require the board's assistance in conducting the public hearing. We also ask the Board to brief the Commission on the status of its efforts

during the Commission's February 12-14, 2002 executive meeting in Ottawa, and will be in touch to determine a mutually convenient time.

With respect to the amount of water available at any time in the St. Marys River for hydropower generation, the Commission's Orders of Approval, as amended, and Regulation Plan 1977A together provide a means of determining and apportioning an appropriate monthly outflow from Lake Superior. This plan-determined and apportioned monthly flow will remain available to the power entities. The focus of our request is on how the power entities deviate from their flow allocation within the month. We note that the Commission's Orders of Approval, as amended, and Plan 1977A do not authorize peaking or ponding operations by any of the power entities, and that they do not authorize deviations from the plan-determined monthly flows. Should any of the entities wish to conduct peaking or ponding operations, authority from the Commission is required to do so. To date, there has been no request for such authority. Nevertheless, the Commission has determined that it will provide temporary authority to the power entities to conduct limited peaking and ponding operations while the Board reviews the situation. Until March 20, 2002, the power entities may continue peaking and ponding in a manner generally consistent with the practice to date, provided that such peaking and ponding is undertaken under the supervision of the board and with continuing monitoring by the board. The Board is authorized to limit, interrupt, or curtail peaking and ponding operations should the Board determine that peaking and ponding is interfering with navigation. The Commission views peaking and ponding during this period as a test to provide information through the Board for use in assessing future peaking and ponding. Apart from the foregoing peaking and ponding and apart from emergencies where immediate action is necessary, the Commission's advance approval should be obtained through the board for any other deviations from the plan-determined monthly flows.

The Commission will determine, in light of the board's report and input from the public hearings, whether to provide authority to the power entities to conduct further peaking and ponding operations subsequent to March 20, 2002 and, if so, under what conditions. The Commission notes that the power entities may submit a joint application for permission to conduct peaking and ponding operations following March 20, 2002. We would expect that any such application would be informed by the board's report and public input. Consistent with its responsibilities under the Boundary Waters Treaty of 1909, the Commission will consider any such application on an expedited basis.

We are informing both the two federal governments and the power entities operating in the St. Marys River of this request.

Should you have any questions or concerns, either regarding the request itself or the initial schedule, please let us know. A similar letter is being sent by the Secretary of the U.S. Section of the Commission to the U.S. Secretary of the Board.

Sincerely,

Murray Clamen
Secretary
Canadian Section

cc: Mr. Peter Yee, Canadian Secretary, International Lake Superior Board of Control
Mr. Colin Clark, Vice President of Generation, Great Lakes Power Limited
Mr Bruce Levy, Director, U.S. Transboundary Division of the Department of Foreign Affairs and International Trade