A REPORT ON 2001 WATER LEVELS OF THE GREAT LAKES AND THE ST. LAWRENCE RIVER

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1.0 INTRODUCTION

This report describes the water levels in the Great Lakes - St. Lawrence River system in 2001. It also discusses briefly the impacts of water level fluctuations, and the Great Lakes water quantity management activities. Water level elevations are in metres above sea level at Rimouski, Quebec, on the International Great Lakes Datum (IGLD) of 1985. River flows and water supplies to the Great Lakes are in cubic metres per second (m^3/s). The geographic area covered in the report extends from Lake Superior to Montreal on the St. Lawrence River.

2.0 THE GREAT LAKES - ST. LAWRENCE SYSTEM

The Great Lakes - St. Lawrence River basin, including land and lake surface, covers an area more than one million square kilometres (see Figure 1). As shown in Figure 2, the Great Lakes comprise a series of natural reservoirs positioned in a step-wise manner, with Lake Superior as the highest step and Lake Ontario the lowest. Lakes Michigan and Huron are considered one lake in hydraulic terms; they are connected by the wide and deep Straits of Mackinac and stand at the same elevation.

Water levels fluctuate according to the climate of the region. Over-lake precipitation, evaporation and runoff are the main factors that affect water levels. Other factors include flow retardation due to ice in winter, and aquatic vegetation in the lake's outlet river in the summer. Weather disturbances cause short-term fluctuations in water level. Human impacts include regulation of lake outflows, dredging of outlet channels, water diversions and consumption of water.

Lakes Superior and Ontario are the two lakes that have their outflows regulated by structures at their outlets. The outflows of the un-regulated lakes are dependent on their water levels. For Lakes Michigan-Huron and Lake St. Clair, their outflows through the St. Clair - Detroit River system depend also to a minor extent on the levels of Lake Erie due to backwater effect on these rivers. Ice jams in the St. Clair - Detroit River system, though infrequent, can cause large variations in the water level of Lake St. Clair.

Water level fluctuations on Lake Ontario do not affect the level of Lake Erie. The cascades and Niagara Falls in the Niagara River separate the two lakes.

Lake St. Lawrence is that part of the St. Lawrence River extending from Iroquois to Cornwall, Ontario. The hydropower dam at Cornwall, located about 160 kilometres downstream of Lake Ontario, is used to regulate Lake Ontario's outflow. Several factors affect the water level on Lake St. Lawrence, and they are: Lake Ontario level, flow at the hydropower dam, ice in the river between Lake Ontario and the dam, extent of gate closure at Iroquois Dam, and winds. The Iroquois Dam is located about 45 km upstream of the hydropower dam.

Lake St. Francis extends from Cornwall to its outlets at the Beauharnois and Cedars hydro and navigation installations. Large water level fluctuations on Lake St. Francis are rare because Lake St. Francis is regulated within a narrow range by Hydro Quebec's control works. Besides the inflows from upstream and operations at the Beauharnois-Cedars installations, factors that affect Lake St. Francis levels are local runoff, winds, and ice on Lake St. Francis.

Lake St. Louis is located a short distance upstream of Montreal, at the confluence of the St. Lawrence River and the Ottawa River. Due to its relatively small area, the water level of Lake St. Louis can rise rapidly following snow melt on the Ottawa River basin and other local tributaries. Local runoff during heavy rain can also raise the levels rapidly.

Like Lake St. Louis, water levels at Montreal are affected by flows from Lake Ontario, the Ottawa River, local runoff and, in addition, downstream ice conditions. Winds and tides affect the level in the harbour but to a lesser extent.

3. HYDROLOGIC CONDITIONS IN 2001

3.1 Weather Conditions

The winter of 2000-2001 was relatively uneventful with few extreme temperatures. The first severe cold front arrived in about early December 2000, and by the middle of the month, extensive ice cover has formed in the Montreal region of the St. Lawrence River including the Beauharnois Canal. The dissipation, or melting of the ice on the Great Lakes and St. Lawrence River occurred generally during the second half of March 2001.

The spring and summer months were a bit on the dry and warm side. While rainfall amounts were near average and in some areas above average during this period, much of the fallen moisture was retained by the dry land resulting in no significant increase in runoff to the lakes. August had several days with heat wave that affected generally the entire northeastern North America. Autumn had slightly above-average precipitation and water supplies and thus slowed the decline in the water levels of the Great Lakes.

December was relatively mild with very little ice formed on the shores of the Great Lakes and virtually none in the St. Lawrence River between Lake Ontario and Montreal. The lack of ice cover increased evaporation of lake water to the atmosphere. The result was a significant snowfall on some traditional snow-belt areas during periods of strong westerly and southwesterly winds. These included the Buffalo-Fort Erie area, the Bruce Peninsula Georgian Bay areas.

There were no reports of damage due to flooding or erosion in 2001. This can be attributed to a lack of severe storms and the below average water level conditions on the Great Lakes. Preliminary data from Environment Canada point to 2001 as another year with mild temperature, and that the autumn of 2001 was the eighteenth consecutive season in Canada that was warmer than usual.

3.2 Precipitation

On average, about 820 millimetres (mm) of precipitation falls on the Great Lakes basin each year. Readings from about 100 precipitation stations scattered throughout the basin (excluding the St. Lawrence River) are used to measure precipitation. The density of stations is greater in the lower Great Lakes, and less in the upper Great Lakes region.

Table 1 compares the 2001 monthly Great Lakes basin precipitation with long-term averages since 1900. The comparison is also shown graphically in Figure 3. The total precipitation for 2001 was about 880 mm, which was 7% above average. A lake-by-lake comparison is included in Table 1.

In 2001, the Lake Superior basin received 108% of average precipitation. February, October and November had above average precipitation and April's amount was a record maximum for the month of April. March, July and December were on the dry side.

The Lakes Michigan-Huron basin precipitation in 2001 was 110% of average, while that on the Lake Erie basin was 103% of average. On the Lake Ontario basin, precipitation was 90% of average. Above-average precipitation occurred on all the basins generally during the September-November period.

3.3 Water Supplies to the Great Lakes

While precipitation, which is often quoted, is one component in the water balance equation, net basin water supply is a better indicator of hydrologic conditions affecting lake levels. Net basin supply is the combined effect of over-lake precipitation, basin runoff and evaporation from the lake. The net total water supplies to a lake consist of the net basin supplies for the lake, and the inflow from the upper lakes. The net total water supplies for the Great Lakes are computed in cubic metres per second for each month. The 2001 values, and how they compare with 2000 and long-term average are shown in Figures 4-7.

As shown in Figure 4, below average net basin supplies to Lake Superior occurred in March, and from June to September. The April 2001 water supply amount set a new record maximum and the water supply in November was above average. The very high water supply in during April raised the water level of Lake Superior sharply. This, together with below average outflows during the 2001 brought some improvements to the low water level situation compared to one year earlier.

The low Lakes Michigan-Huron water level conditions the past three years can be attributed to low water supplies (Figure 5) and inflows from Lake Superior during this period. The water supply in March was near the record minimum and July was another dry month. September and October were on the wet side. Like Lake Superior, the water supplies to Lakes Michigan-Huron in 2001 were higher than those in 2000.

Lake Erie receives the bulk of its total supplies from Lakes Michigan-Huron. With the flows from the upper lakes well below average, the water supplies to Lake Erie (Figure 6) in 2001 were below average. The abundant precipitation on the Lake Erie basin in October led to higher than average water supply for the month.

The monthly net total water supplies to Lake Ontario in 2001 were consistently below average. The supply in June was close to the record minimum for the month. The above-average rainfall amount in August-October slowed the downward trend slightly.

3.4 Water Levels and Outflows

Table 2 lists monthly mean water levels for the Great Lakes and several sites on the St. Lawrence River for 2001. The table also shows how water levels compare with historical monthly mean, maximum and minimum values. The daily mean water levels are also shown graphically in Figures 8 to 15. For the lakes, the water levels for 2000 are also plotted to illustrate the progressive changes in the water levels the past two years.

For Great Lakes water level comparisons, records since 1918 are used in accordance with the procedure agreed upon by Canadian and United States agencies. A network of gauges located around each lake is used to determine the mean daily and monthly water levels of the lakes. Water level records for Lake St. Lawrence, as measured at the gauge at the Long Sault dam, started in 1960 following completion of the St. Lawrence Seaway and power projects. Data at Pointe Claire, which gives the water levels on Lake St. Louis, extend back to 1915. But to be consistent with Lake Ontario regulation, data for the Pointe Claire gauge since 1960 are used for comparison purpose. For Montreal Harbour, data since 1967 are used, following the most recent significant physical changes to that part of the river.

Outflows of the Great Lakes are determined by adding up the flows through various structures and channels at the lakes' outlets. These include hydropower plants, navigation locks, and water diverted for industrial and domestic uses. On the un-regulated lakes (Lakes Michigan-Huron, St. Clair and Erie), stage-discharge equations based on current meter measurements are also used in conjunction with measured flows at the hydropower plants to determine the outflows of the lakes.

Lake Superior began 2001 (Figure 8) about 38 cm below the long-term average for that time of year, and about 20 cm below the lake's chart datum elevation of 183.2 m. The level continued its gradual decline until it reached the minimum at the end of March. The very high water supply in April raised the level on the lake sharply. However, dry conditions subsequently returned and kept the lake level below average the rest of the year. The lake level was below chart datum from about mid-October 2000 until early May 2001. The level was fairly stable during the last three months in 2001 and ended the year 11 cm below average.

As shown in Figure 9, the daily water levels of Lakes Michigan-Huron in 2001 were below average. Water levels on these lakes were below chart datum from about mid-October 2000 to about the end of May 2001. Like Lake Superior, the levels of these lakes underwent very little change in the last three months in 2001. Their levels started, and ended the year 2001, 58 cm and 34 cm below average, respectively.

Lake St. Clair and Lake Erie (Figures 10 and 11) were below average throughout 2001. A small but sharp rise in the level of Lake St. Clair occurred at the beginning of February, which was followed by a gradual decline several days later. This was likely due to the effect of ice cover on Lake St. Clair and in the Detroit River. Lake Erie started the year 21 cm below average, and end the year 16 cm below average.

Lake Ontario (Figure 12) started the year 4 cm below average, and remained very much below average by this amount throughout 2001. The dry June-July period hastened the seasonal decline

in the level somewhat, but the level recovered after that and by year-end, it was at average.

The daily mean Lake St. Lawrence levels for 2001, as measured at the gauge at the Long Sault dam, are shown in Figure 13. The levels were higher than average throughout 2001 due to the low flows at the Moses-Saunders hydropower dam at Cornwall and Massena. To prevent the levels from rising above flood stage, the gates at the Iroquois Dam, located at the upstream end of Lake St. Lawrence, were partially closed during May 29 - July 26.

Lake St. Louis levels (Figure 14) were well below average during 2001, as a result of low flows from Lake Ontario and other tributaries to that part of the St. Lawrence River. The levels shot up very briefly to above average during the snow melt on the Ottawa River basin. Beginning in June and the rest of the summer, the levels were kept at a fairly stable elevation, due to the increase in the Lake Ontario outflow directed by the International Lake St. Lawrence River Board of Control to maintain the minimum level of 20.6 m on Lake St. Louis. An increase in the rainfall along the St. Lawrence River valley and flows from the Ottawa River raised somewhat the levels in the last three months of the year.

Water level fluctuations at the Port of Montreal (Figure 15) closely resembled those of Lake St. Louis. New record monthly minimum levels occurred at the Port in January, February and March, and from July to October, for the period of record beginning 1967.

Table 3 lists the preliminary 2001 monthly outflows from each of the Great Lakes. Lake Superior outflows for the year averaged 1890 m^3/s, about 88 percent of average. The outflow from Lakes Michigan-Huron for the year was 87 percent of average, whereas Lake Erie's outflow was 91 percent of average. Lake Ontario's outflow was 90 percent of average.

4.0 WATER MANAGEMENT RELATED TO WATER LEVELS

4.1 Lake Superior Regulation

Lake Superior's Regulation Plan 1977-A specifies monthly outflows from the lake based upon this lake's level and the level of Lakes Michigan-Huron downstream. The procedure of taking downstream lake levels into account is termed systemic regulation. Assessment of the hydrologic conditions on the upper Great Lakes and overseeing outflow regulation are the responsibilities of the International Joint Commission's Lake Superior Board. In normal operations, Lake Superior outflows are as specified by the regulation plan. Under certain conditions, the International Joint Commission (IJC) approves deviations from the regulation plan on the advice of the Board.

The outflow of Lake Superior is regulated by a number of structures in the St. Marys River at Sault Ste. Marie, Ontario and Sault Ste. Marie, Michigan. Water leaving Lake Superior flows through either the hydropower plants, navigation locks, or the St. Marys River compensating works. The 16-gated compensating works was built early in the last century to offset the extra outflow capacity added to the St. Marys River by the hydropower developments. This structure is located immediately upstream of the St. Mary's Rapids. The northern half of the structure, with eight gates, is owned and operated by Great Lakes Power Limited in Canada. The other half, also with eight gates, is owned by the U.S. Army Corps of Engineers.

The IJC requires a minimum flow equivalent to one-half gate open at the compensating works in order to supply water to the main portion of the St. Marys Rapids. In addition, the most northerly gate is kept partially open to ensure a continuous supply of water to the fishery remedial channel. With these minimum gate open settings in place, changes to Lake Superior's outflow are usually accomplished by adjusting the water diversions through the hydropower plants. If the hydropower plants cannot fully use the available water, the excess is released through the compensating works by opening additional gates.

During 2001, the outflows of Lake Superior were as specified by the regulation plan with very minor deviations. These deviations had virtually no impact on the water levels of the upper lakes.

Throughout much of 2001, the gate setting at the Compensating Works supplying the main portion of the St. Marys Rapids was at an equivalent one-half of one gate open setting. During the period July 25-31, up to four gates were fully open to allow flow measurements at the structure. Gate 1, which supplies water to the Fishery Remedial Works, were set at its normal flow value of 15 m^3/s.

In December 2001, following the concerns expressed by the shipping interests, the IJC requested the Lake Superior Board to examine peaking and ponding operations at the hydropower plants on the St. Marys River. Peaking and ponding operations involve varying the flow within the day and within the week to use more water during the daylight hours and on weekdays, to be offset by lesser flows at the hydropower plants at night and on weekends to meet changing demand of electricity. The shipping interests have expressed the concern that these flow fluctuations exacerbate the already low water level conditions in the lower St. Marys River and thus cause delays in ship transits. The Board has been requested to submit a report with recommending on guidelines for peaking and ponding operations prior to the start of the 2002 navigation season.

4.2 Lake Ontario Regulation

The outflow of Lake Ontario is regulated using the hydropower dam and spillway in the St. Lawrence River near Cornwall, Ontario and Massena, New York. Lake Ontario Regulation Plan 1958-D specifies weekly outflows based upon Lake Ontario's level and trends in water supplies. The regulation plan helps prevent water level extremes, both upstream on Lake Ontario, and downstream in the Montreal area, and it attempts to balance the interests of shoreline property owners, commercial navigation and hydropower interests.

Lake Ontario outflow regulation is overseen by the IJC's International St. Lawrence River Board of Control. In normal operations, the Lake Ontario outflow is as specified by the regulation plan. However, the Board has some discretionary authority to direct flow deviations from the regulation plan to provide benefit or relief from adverse impacts associated with water level and flow fluctuations. In recent years, the Board has also taken into consideration recreational boating and environmental interests in making its regulation decisions.

During 2001, there were a number of deviations from the Lake Ontario regulation plan, as described in the following paragraphs:

At the beginning of 2001, there were 7.2 cm of water retained on Lake Ontario as a result of outflows less than specified by the regulation plan during 2000. Much of this water was later used, beginning in June, to provide relief to low water level conditions in the Montreal region including Lake St. Louis, to assist navigation at the Port of Montreal and to increase hydropower generation during the August heat-wave. The 7.2 cm storage was reduced to 1.3 cm by late October. Outflows less than specified by the regulation plan during parts of November and December brought the amount of water conserved to 2.9 cm at the end of the year.

4.3 Activities by Environment Canada

Environment Canada issues a monthly water level forecast for the Great Lakes and Montreal Harbour as a joint undertaking with the U.S. Army Corps of Engineers. A monthly newsletter is also published to update readers on water levels. The forecast bulletins and the newsletters are distributed each month by Fisheries and Oceans Canada in paper copy and on the Internet. In support of the International St. Lawrence River Board of Control, a weekly distribution of Lake Ontario and St. Lawrence River hydrologic data is made to subscribers on an E-mail list.

The department also issues monthly water level bulletins during the recreational boating season for locations on the St. Lawrence River between Kingston and Lake St. Louis. The bulletin is distributed to local media, shore property owners and marinas to advise of water level and flow conditions on the river. In addition, media advisories on water level conditions for the Great Lakes are issued during the year.

Environment Canada provides technical support to the IJC's Boards in the regulation of the outflows of Lake Superior and Lake Ontario, as discussed in Sections 4.1 and 4.2. The department also provides technical support to the IJC's International Niagara Board of Control which oversees compliance with IJC directives on levels in the Niagara River above the Falls and installation and removal of the Lake Erie – Niagara River Ice Boom, and to the International Niagara Committee which monitors and reports on hydropower diversions, flows over Niagara Falls and other uses in accordance with the requirements of the Niagara Treaty of 1950.

In December 2000, following the first round of government funding allocations in Canada and the United States, the IJC established the International Lake Ontario – St. Lawrence River Study Board. Several staff members from Environment Canada have been appointed to assist board in its study. During 2001, and over the next few years, the study board will conduct studies to identify possible improvements to Lake Ontario regulation to ensure the needs of all the users in the Lake Ontario – St. Lawrence River system are considered.

In August 2001, a staff from the department was appointed to an IJC's binational team to prepare a plan of study. The study would include a review of the IJC's Orders of Approval and the Lake Superior regulation plan. It would also identify the needs of the interest groups affected by water levels, potential climate changes that could affect water levels and flows, and possible improvements to Lake Superior outflow regulation. The group submitted its plan of study to the IJC in early January 2002. The document describes the tasks that would need to be conducted, schedules and costs. The study, expected to last three to five years, is expected to begin following IJC approval and government funding allocations.

A significant event related to the protection of Great Lakes water was the passing into law by Canada the amendments to the International Boundary Waters Treaty Act. The amendments will prohibit the bulk removal of water from Canadian boundary waters, including the Great Lakes. The prohibition on removals will apply principally to the Great Lakes and other boundary waters, such as the international sections of the St. Lawrence River and Lake of the Woods in Ontario and the St. Croix and Upper St. John rivers in New Brunswick. Separate from the prohibition, the amendments adopted will also set in place a licensing regime for boundary waters projects such as dams, obstructions or other works. The regulation and licensing regime established by the amendments to the Act will enable Canada to better meet its obligations under Article III of the 1909 Boundary Waters Treaty.

5.0 EFFECTS OF WATER LEVEL FLUCTUATIONS

5.1 Environment

Basin-wide low water levels in 2001 and preceding years has altered vegetation communities in coastal wetlands, increased the area of islands, and reduced base flow in tributary streams. As a result, fish and wildlife that rely on these Great Lakes ecosystems have been affected.

In areas such as Lake Erie and Lake St. Clair, where marshes are more extensive than in other lakes and shoreline slope is gradual, low water levels resulted in the exposure of large mudflats and the subsequent lakeward expansion of emergent vegetation. Low water levels in 2001 and the previous few years has resulted in the expansion of plant communities up to 500 metres from the Lake St. Clair shoreline -- restoring communities that were reduced significantly during previous years' high water conditions. Plant species such as cattail and bulrush have expanded significantly, however the invasive phragmites has also taken hold in areas. This species is capable of displacing weaker species, thus reducing the diversity of vegetative communities. The recent expansion of emergent vegetation has also been observed in some Lake Ontario coastal wetlands such as Oshawa Second Marsh, however the magnitude of expansion has been reduced due to regulation of lake levels.

Fish and Wildlife communities that utilize Great Lakes habitats have experienced both positive and negative influences. Lower than average water levels and tributary flows have resulted in reduced suitability and accessibility of breeding, migration and spawning habitats for some bird, amphibian and fish species. This is specifically the case for birds that nest in flooded emergent plant communities such as rails, grebes and bitterns. Cool and cold water fish species have also been negatively impacted by the accelerated warming of coastal wetlands and tributaries as well as reduced tributary flows. Conversely, exposure of mud flats and sand beach resulted in increased habitat availability for other migratory and breeding bird species. Increased availability of this habitat during the spring and fall has been particularly beneficial to migratory shorebirds and gull nesting.

Long term cyclic variability in Great Lakes water levels and in turn availability of habitat for fish and wildlife is a natural phenomenon. The diversity of beach, bluff, wetland and other near shore habitats is a product of long and short-term lake level fluctuations. As such, the hundreds of fish and wildlife species that utilize the Great Lakes near shore habitats have adapted to this

variability. A return to average lake levels following this most recent period of low levels will result in significant increases in the quality and quantity of many near shore habitat types, greatly benefiting many species that may have been temporarily impacted.

5.2 Shore Properties

There were no reports of serious flood or erosion damage on the Great Lakes and the St. Lawrence River in 2001. This can be attributed to the relatively low water levels and an absence of severe storms throughout the year.

Many shore property owners have not experienced the current low water levels in years past. The last time the Lake Superior levels were at or lower than in 2000 and 2001 occurred in 1925. Lakes Michigan-Huron have not been lower since the mid-1960s. There were some concerns expressed by owners who cannot use their boat ramps on the property. The low water levels provided owners an opportunity to repair their shore protection works and other installations.

The costs for pumping municipal and industrial water supplies were probably higher in some cases in 2001. There were likely also problems with low water levels at shore-wells. This started about the Fall of 1998 and the main problem area is eastern Lake Ontario and the Thousand Islands area of the St. Lawrence River.

Lake St. Lawrence was the only area in the Great Lakes – St. Lawrence system that experienced above average water level conditions in 1999, 2000 and again in 2001, due to its unique location. Partial closure of the Iroquois Dam, located at the upstream end of Lake St. Lawrence, was successful in suppressing Lake St. Lawrence levels and thus kept the lake below flood stage.

Water levels on Lake St. Louis and elsewhere in the Montreal region of the St. Lawrence River remained well below flood stage. The relatively low flows from Lake Ontario and other downstream tributaries during the spring snowmelt did not pose any serious threat of flood or erosion damage in 2001.

5.3 Commercial Navigation

The 2001 Seaway navigation season in the St. Lawrence River and the Welland Canal opened as scheduled on March 23 without problems related to water levels. For the first several days, there were some delays in ship transits due to ice in the Beauharnois Canal and at Cote St. Catharine area near Montreal. On April 9, the Seaway agencies in both Canada and the United States began permitting ships with maximum draft of 80 dm (26'3") to transit the Seaway system. The closing of the 2001 season ended when the last down-bound vessel exited the St. Lambert Lock near Montreal on December 24.

Similar to the year 2000, the generally low water levels in 2001 caused some traffic delays and affected shippers, who had to reduce loads. The areas affected included Lake Superior and Lakes Michigan-Huron where levels were below chart datum for a considerable period of time. Other affected areas included the Welland Canal and Lake St. Louis. Fluctuating water levels on Lake

St. Francis, just below the Moses-Saunders hydropower dam, were a concern during the last week of March.

The mild air temperatures in December prevent freeze-up in the St. Lawrence River. During the month, the water temperature from Kingston on Lake Ontario to St. Lambert near Montreal were above the record maximum for the period since 1960. As of early late January 2002, the entire stretch of this part of the river remained ice-free.

Like on the Great Lakes, problems associated with low water levels also occurred on Lake St. Louis and at the Port of Montreal. However, the problem was alleviated somewhat by action taken by the International St. Lawrence River Board of Control. During the period from late June to late October, the Board released much of the water it previously conserved on Lake Ontario to maintain a minimum level of 20.6 m on Lake St. Louis to assist Seaway navigation, and in the process also provided additional water depths for the Port of Montreal. On six occasions, the Board also released additional water from Lake Ontario to enable deep-draught vessels to enter the port.

5.4 Recreational Boating

Except for Lake St. Lawrence and Lake Ontario, recreational boaters on the Great Lakes and the St. Lawrence River, including Lake St. Louis, experienced below-average water level conditions in 2001. The problems included un-useable docks and ramps, reduced accessibility while on the lakes and rivers, increased frequency of hull and propeller damage, and a shortened boating season. Most of the concerns came from the Thousand Islands area of the St. Lawrence River, Lake St. Clair and Georgian Bay on Lake Huron.

5.5 Hydropower Generation

Due to the below-average outflows of the Great Lakes, hydropower generation in 2001 was less than average and much less than in 1997 and 1998 when levels and flows were higher.

The hydropower facilities in the St. Marys River used the full amounts of water specified by the regulation plan for power generation.

The Lake Erie outflows in 2001 were below average, andresulted in below average power production at the hydropower plants at Niagara Falls. Similarly, the Moses-Saunders power dam and the Beauharnois-Cedars installations in the St. Lawrence River had below-average flow for hydropower production.

On several occasions, the Lake Ontario outflow was increased to more than specified by the regulation plan, to increase hydropower generation at the Moses-Saunders plants at Cornwall and Massena. These periods include: July 24-25, August 1-2 and the heat-wave of August 7-10.

6.0 FORECAST OF FUTURE WATER LEVEL CONDITIONS

Water levels of the Great Lakes fluctuate according to weather conditions. Since it is not possible to accurately forecast weather conditions several months in advance, forecasts are made assuming average, wet and dry weather conditions for the next six months.

The forecast prepared at the beginning of January 2002, showed that, assuming average water supplies, the water levels of all the Great Lakes except Lake Ontario are expected to remain below average by amounts similar to those recorded at the end of 2001. Average water supply conditions would result in Lake Ontario levels very close to average the next six months. Very high water supplies would bring Lake Superior back to average by spring. Below average supplies, on the other hand, would cause the levels on Lake Superior and Lakes Michigan-Huron to fall again below their chart datum elevations.

Levels at the Port of Montreal are expected to remain below average for the first few months in 2002. The levels during the remaining of this winter period will depend not only on the flows from upstream, but also on the ice conditions below it and on Lake St. Pierre. As of late January 2002, very little ice existed on Lake St. Pierre. The amount of snow fall, and the rate of snowmelt on the Ottawa River, will determine how the levels in the Montreal region would be this coming spring.

7.0 SUMMARY AND CONCLUSIONS

Great Lakes water levels (except Lake Ontario) in 2001 were below average as a result of low water supplies to the lakes that began in 1997 on the upper lakes. Some improvements took place especially during the last several months of the year thus resulting in year-end levels higher than those at the beginning of the year.

Although water supplies to Lake Ontario were below average during the year, the below-average outflows had an offsetting effect and thus kept the lake's level closer to average.

Due to low flows from the Ottawa River and other tributaries to the Montreal region of the St. Lawrence River, levels at the Port of Montreal set new record lows for several months in 2001.

Basin-wide low water levels in 2001 and preceding years has altered vegetation communities in coastal wetlands, increased the area of islands, and reduced base flow in tributary streams. As a result, fish and wildlife that rely on these Great Lakes ecosystems have been affected.

There were no reports of serious flood and erosion damage on the shores of the Great Lakes and the St. Lawrence River. This is attributed to the low water levels and lack of major storms.

The low water levels resulted in below-average hydropower generation in the St. Marys River, the Niagara River and St. Lawrence River. They also required some ships to reduce their cargo. Other problems included un-useable docks and ramps, and reduced water depths on the lakes and rivers for recreational boaters. Shallow shore-wells were affected and there were additional operating costs related to water withdrawal for some domestic and industrial users.

The regulation plan for Lake Superior performed as designed to help balance the water level conditions upstream on Lake Superior and downstream on Lakes Michigan-Huron. Water level conditions on the three lakes were such that no deviations from the regulation plan were directed.

The releases of the water during 2001, which was conserved on Lake Ontario during 2000, provided some relief to the users in the St. Lawrence River affected by low water levels. This action prevented excessively lowering of the water levels in the Montreal region and thus provided relief to navigation and shore property and municipalities who depend on water levels for their water supply. Assistance was also given to hydropower interests by releasing some of the stored water during the August heat-wave when demand for electricity was very high.

Given the water level conditions at the end of 2001, the risk of serious shoreline flood and erosion damage in 2002 should remain very low. Should dry conditions continue to prevail, low water supplies and low water level conditions in 2002 could cause considerable concern to Great Lakes-St. Lawrence River basin interests.

Table 1 Comparison of 2001 Great Lakes Basin Precipitation and Long-Term Average (millimetres)

Lake Superior Basin

	2001	Percentage of average	Average 1900-2000	Previous Maxima and Minima (Year of Occurrence) Maximum	Minimum
Jan	42 mm	86%	50 mm	91 (1935)	22 (1961)
Feb	49	133	37	84 (1939)	11 (1993)
Mar	24	54	44	102 (1979)	10 (1910)
Apr	135	271 R	49	106 (1960)	17 (1949)
May	71	102	69	129 (1970)	21 (1948)
Jun	71	86	83	151 (1943)	23 (1910)
Jly	57	68	84	142 (1952)	28 (1936)
Aug	85	104	82	186 (1988)	26 (1930)
Sep	79	88	89	164 (1941)	33 (1967)
Oct	101	145	70	140 (1995)	16 (1947)
Nov	79	124	64	120 (1985)	11 (1939)
Dec	37	73	51	90 (1984)	9 (1913)
Sum	830 mm	108%	770 mm		

Lakes Michigan-Huron Basin

	2001	Percentage of average	Average 1900-2000	Previous Maxima and Minima (Year of Occurrence) Maximum	Minimum
Jan	41 mm	78%	54 mm	95 (1997)	20 (1956)
Feb	67	155	44	86 (1908)	14 (1969)
Mar	25	46	54	117 (1998)	15 (1958)
Apr	69	106	66	126 (1929)	26 (1946)
May	116	154	76	142 (1983)	31 (1925)
Jun	80	101	80	144 (1969)	29 (1988)
Jly	35	45	77	132 (1952)	30 (1936)
Aug	94	122	78	136 (1972)	24 (1927)
Sep	114	129	88	213 (1986)	30 (1979)
Oct	137	190	72	147 (1954)	14 (1924)
Nov	73	104	70	128 (1985)	19 (1904)
Dec	55	94	58	106 (1971)	14 (1913)
Sum	910	110%	820 mm		

Lake Erie Basin

	2001	Percentage of average	Average 1900-2000	Previous Maxima and Minima (Year of Occurrence) Maximum	Minimum
Jan	46 mm	76%	63 mm	160 (1950)	14 (1961)
Feb	57	108	52	117 (1990)	10 (1987)
Mar	44	62	70	171 (1913)	11 (1910)
Apr	64	81	80	152 (1961)	24 (1946)
May	103	124	84	176 (1943)	17 (1934)
Jun	80	92	88	168 (1937)	19 (1988)
Jly	37	43	84	190 (1992)	29 (1930)
Aug	76	93	81	180 (1975)	33 (1969)
Sep	100	125	80	176 (1926)	19 (1908)
Oct	153	219	69	196 (1954)	11 (1924)
Nov	86	119	72	192 (1985)	10 (1904)
Dec	72	108	66	160 (1990)	21 (1943)
Sum	920 mm	103%	890 mm		

Table 1 (continued)

Lake Ontario Basin

	2001	Percentage of average	Average 1900-2000	Previous Maxima and Minima (Year of Occurrence) Maximum	Minimum
Jan	46 mm	68%	70 mm	138 (1999)	28 (1981)
Feb	67	111	60	112 (1971)	23 (1969)
Mar	82	121	67	143 (1936)	18 (1915)
Apr	29	40	73	127 (1929)	29 (1915)
May	79	102	78	145 (1943)	16 (1920)
Jun	59	77	79	159 (1972)	30 (1912)
Jly	33	42	79	160 (1992)	32 (1933)
Aug	87	109	79	142 (1977)	32 (1907)
Sep	93	115	82	159 (1945)	24 (1964)
Oct	89	114	76	212 (1955)	13 (1963)
Nov	73	91	79	168 (1927)	15 (1904)
Dec	73	99	73	140 (1990)	27 (1943)
Sum	810 mm	90%	900 mm		

Great Lakes Basin

	2001	Percentage of average	Average 1900-2000	Previous Maxima and Minima (Year of Occurrence) Maximum	Minimum
Jan	43 mm	78%	56 mm	100 (1950)	22 (1961)
Feb	61	136	45	80 (1908)	17 (1969)
Mar	34	61	55	111 (1976)	15 (1910)
Apr	82	127	64	106 (1929)	29 (1915)
May	98	131	75	116 (1983)	33 (1934)
Jun	75	93	82	121 (1968)	36 (1910)
Jly	41	51	80	124 (1992)	32 (1936)
Aug	88	111	80	128 (1977)	29 (1930)
Sep	100	116	87	66 (1986)	39 (1948)
Oct	124	172	72	127 (1954)	21 (1924)
Nov	76	109	70	137 (1985)	18 (1904)
Dec	54	92	59	92 (1983)	17 (1913)
Sum	880 mm	107%	820 mm		

Source: Preliminary data provided by NOAA, Corps of Engineers compiled from stations in the U.S. and Canada. Original values computed in inches to two decimals. R denotes record monthly value.

Table 2 Great Lakes Monthly Mean Water Levels in 2001 and 2000 and Their Comparison with Previous Records (Metres, IGLD-1985)

Lake Superior

	2000	2001	Average 1918-2000	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	183.16	182.98	183.35	183.70 (1986)	182.83 (1926)
Feb	183.08	182.94	183.29	183.63 (1986)	182.76 (1926)
Mar	183.08	182.91	183.26	183.61 (1986)	182.74 (1926)
Apr	183.12	183.02	183.28	183.68 (1986)	182.72 (1926)
May	183.16	183.24	183.38	183.74 (1986)	182.76 (1926)
Jun	183.24	183.33	183.47	183.76 (1986)	182.85 (1926)
Jul	183.33	183.36	183.53	183.82 (1950)	182.96 (1926)
Aug	183.31	183.39	183.56	183.86 (1952)	183.02 (1926)
Sep	183.27	183.37	183.56	183.86 (1985)	183.12 (1926)
Oct	183.20	183.30	183.54	183.91 (1985)	183.10 (1925)
Nov	183.15	183.29	183.49	183.89 (1985)	183.01 (1925)
Dec	183.06	183.30	183.43	183.81 (1985)	182.92 (1925)

Lakes Michigan-Huron

	2000	2001	Average 1918-2000	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	175.92	175.77	176.35	177.18 (1987)	175.60 (1965)
Feb	175.87	175.78	176.34	177.11 (1986)	175.59 (1964)
Mar	175.90	175.78	176.35	177.12 (1986)	175.58 (1964)
Apr	175.92	175.85	176.44	177.23 (1986)	175.61 (1964)
May	176.00	175.95	176.54	177.28 (1986)	175.74 (1964)
Jun	176.10	176.06	176.60	177.33 (1986)	175.76 (1964)
Jul	176.13	176.05	176.63	177.39 (1986)	175.78 (1964)
Aug	176.13	176.03	176.61	177.39 (1986)	175.77 (1964)
Sep	176.09	176.01	176.56	177.38 (1986)	175.76 (1964)
Oct	175.98	176.03	176.49	177.50 (1986)	175.70 (1964)
Nov	175.89	176.05	176.43	177.38 (1986)	175.65 (1964)
Dec	175.81	176.05	176.38	177.26 (1986)	175.62 (1964)

Lake St. Clair

	2000	2001	Average 1918-2000	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	174.63	174.72	174.85	175.80 (1986)	173.88 (1936)
Feb	174.44	174.69	174.79	175.80 (1986)	173.89 (1926)
Mar	174.66	174.70	174.91	175.80 (1986)	174.05 (1934)
Apr	174.76	174.74	175.05	175.82 (1986)	174.32 (1926)
May	174.85	174.79	175.14	175.83 (1986)	174.42 (1934)
Jun	174.96	174.89	175.18	175.92 (1986)	174.45 (1934)
Jul	175.05	174.89	175.20	175.93 (1986)	174.50 (1934)
Aug	175.03	174.81	175.17	175.90 (1986)	174.41 (1934)
Sep	174.93	174.75	175.10	175.84 (1986)	174.34 (1934)
Oct	174.80	174.73	175.01	175.96 (1986)	174.27 (1934)
Nov	174.65	174.70	174.92	175.82 (1986)	174.18 (1934)
Dec	174.74	174.74	174.92	175.80 (1986)	174.24 (1964)

Table 2 (Continued)

Lake Erie

	2000	2001	Average 1918-2000	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	173.84	173.77	173.99	174.86 (1987)	173.21 (1935)
Feb	173.76	173.85	173.99	174.78 (1987)	173.18 (1936)
Mar	173.84	173.95	174.07	174.88 (1986)	173.20 (1934)
Apr	173.96	174.03	174.22	174.98 (1985)	173.38 (1934)
May	174.08	174.05	174.30	174.97 (1986)	173.44 (1934)
Jun	174.19	174.10	174.34	175.04 (1986)	173.45 (1934)
Jul	174.27	174.04	174.32	175.03 (1986)	173.45 (1934)
Aug	174.23	173.95	174.26	174.94 (1986)	173.43 (1934)
Sep	174.10	173.84	174.17	174.83 (1986)	173.38 (1934)
Oct	174.01	173.82	174.07	174.94 (1986)	173.30 (1934)
Nov	173.89	173.81	174.00	174.85 (1986)	173.20 (1934)
Dec	173.84	173.88	173.99	174.90 (1986)	173.19 (1934)

Lake Ontario

	2000	2001	Average 1918-2000	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	74.50	74.49	74.55	75.16 (1946)	73.81 (1935)
Feb	74.45	74.55	74.59	75.27 (1952)	73.78 (1936)
Mar	74.58	74.65	74.67	75.37 (1952)	73.94 (1935)
Apr	74.82	74.84	74.87	75.65 (1973)	74.03 (1935)
May	75.10	74.93	75.01	75.73 (1973)	74.11 (1935)
Jun	75.26	74.99	75.04	75.76 (1952)	74.19 (1935)
Jul	75.24	74.97	74.99	75.66 (1947)	74.14 (1934)
Aug	75.06	74.82	74.88	75.58 (1947)	74.00 (1934)
Sep	74.81	74.63	74.74	75.41 (1947)	73.91 (1934)
Oct	74.61	74.52	74.61	75.22 (1945)	73.82 (1934)
Nov	74.46	74.47	74.54	75.18 (1945)	73.75 (1934)
Dec	74.47	74.52	74.52	75.20 (1945)	73.74 (1934)

Lake St. Lawrence

	2000	2001	Average 1960-2000	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	73.37	73.36	72.86	73.62 (1967)	71.78 (1977)
Feb	73.03	73.23	72.40	73.31 (1983)	71.38 (1978)
Mar	73.67R	73.43	72.77	73.67 (2000)	71.58 (1993)
Apr	73.79	73.78	73.52	73.94 (1962)	73.15 (1972)
May	73.80	73.81	73.64	73.99 (1973)	73.01 (1987)
Jun	73.76	73.84	73.58	73.96 (1964)	72.98 (1987)
Jul	73.63	73.81	73.51	73.92 (1967)	72.84 (1987)
Aug	73.44	73.71	73.35	73.91 (1966)	72.77 (1987)
Sep	73.27	73.49	73.18	73.89 (1967)	72.74 (1985)
Oct	73.27	73.55	73.08	73.78 (1962)	72.62 (1994)
Nov	73.30	73.51	73.02	73.71 (1962)	72.64 (1997)
Dec	73.48	73.58	73.08	73.66 (1962)	72.53 (1981)

Table 2 (Continued)

Lake St. Louis

	2000	2001	Average 1960-2000	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	21.11	20.90	21.35	21.73 (1978)	20.81 (1965)
Feb	21.02	20.89	21.39	21.97 (1978)	20.73 (1965)
Mar	20.92	20.87	21.38	22.12 (1973)	20.35 (1965)
Apr	21.16	21.36	21.71	22.41 (1976)	20.54 (1965)
May	21.29	20.96	21.63	22.55 (1974)	20.51 (1964)
Jun	21.26	20.71	21.41	22.26 (1974)	20.39 (1965)
Jul	21.43	20.65	21.30	22.01 (1973)	20.44 (1965)
Aug	21.33	20.65	21.23	21.81 (1972)	20.50 (1964)
Sep	21.14	20.65	21.19	21.74 (1986)	20.47 (1964)
Oct	20.86	20.70	21.19	21.81 (1986)	20.47 (1964)
Nov	20.71	20.81	21.23	21.86 (1986)	20.42 (1964)
Dec	20.81	20.91	21.26	21.80 (1986)	20.48 (1964)

Montreal Harbour

	2000	2001	Average 1967-2000	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	6.26	5.85 R	6.87	8.96 (1968)	6.11 (1999)
Feb	6.19	5.95 R	7.06	9.04 (1967)	6.19 (2000)
Mar	6.27	5.99 R	7.08	8.36 (1973)	6.13 (1989)
Apr	6.70	6.80	7.57	8.82 (1976)	6.23 (1995)
May	6.66	6.00	7.32	8.93 (1974)	5.67 (1999)
Jun	6.33	5.56	6.77	8.12 (1974)	5.56 (1999)
Jul	6.52	5.40 R	6.55	7.49 (1973)	5.52 (1999)
Aug	6.32	5.29 R	6.43	7.27 (1972)	5.32 (1999)
Sep	6.08	5.34 R	6.35	7.08 (1986)	5.42 (1999)
Oct	5.68	5.53 R	6.40	7.16 (1986)	5.68 (2000)
Nov	5.50	5.78	6.52	7.31 (1967)	5.50 (2000)
Dec	5.74	5.94	6.59	7.24 (1972)	5.60 (1998)

Preliminary data based on a network of gauges on each lake.

Table 3 Outflows from the Great Lakes in 2001 and 2000
(cubic metres per second)

Lake Superior

	2000	2001	Average 1918-2000	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	1890	1600	1940	2630 (1971)	1250 (1922)
Feb	1780	1570	1920	2610 (1969)	1270 (1922)
Mar	1720	1540	1900	2690 (1969)	1290 (1982)
Apr	1840	1530	1970	2940 (1951)	1300 (1922)
May	1860	1980	2140	3450 (1951)	1250 (1931)
Jun	1720	2110	2210	3480 (1951)	1220 (1922)
Jul	2070	2280	2290	3570 (1938)	1270 (1922)
Aug	2170	2240	2380	3600 (1950)	1270 (1926)
Sep	1920	2230	2350	3570 (1950)	1160 (1955)
Oct	1560	1960	2280	3570 (1996)	1250 (1926)
Nov	1560	1740	2240	3740 (1985)	1250 (1981)
Dec	1570	1940	2040	3170 (1950)	1310 (1981)
Annual	1800	1890	2140		

Lakes Michigan-Huron

	2000	2001	Average 1918-2000	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	4200	3830	4550	6060 (1987)	3060 (1934)
Feb	3940	4210	4500	5720 (1974)	3000 (1942)
Mar	4580	4350	4880	5830 (1986)	3510 (1931)
Apr	4530	4340	5140	6260 (1986)	3680 (1984)
May	4580	4500	5360	6370 (1986)	4390 (1964)
Jun	4620	4640	5440	6430 (1985)	4420 (1964)
Jly	4630	4730	5510	6570 (1974)	4500 (1964)
Aug	4650	4700	5510	6630 (1986)	4530 (1964)
Sep	4690	4710	5460	6600 (1986)	4470 (1933)
Oct	4620	4700	5410	6740 (1986)	4420 (1933)
Nov	4540	4800	5350	6650 (1986)	4390 (1934)
Dec	4260	4820	5180	6230 (1986)	3990 (1935)
Annual	4490	4530	5190		

Table 3 (Continued)

Lake Erie

	2000	2001	Average 1918-2000	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	5340	5190	5670	7420 (1987)	4050 (1936)
Feb	5130	5350	5580	7050 (1987)	3340 (1936)
Mar	5190	5440	5760	7480 (1986)	4110 (1934)
Apr	5420	5530	6030	7700 (1974)	4390 (1935)
May	5690	5680	6280	7760 (1974)	4590 (1934)
Jun	5860	5550	6280	7820 (1986)	4560 (1934)
Jly	5970	5370	6170	7670 (1986)	4450 (1934)
Aug	5880	5340	6060	7420 (1986)	4470 (1934)
Sep	5680	5130	5950	7140 (1997)	4450 (1934)
Oct	5500	5380	5840	7450 (1986)	4420 (1934)
Nov	5580	5280	5850	7280 (1986)	4280 (1934)
Dec	5490	5630	5850	7620 (1985)	4330 (1934)
Annual	5560	5410	5940		

Lake Ontario

	2000	2001	Average 1918-2000	Previous Recorded Maxima & Minima (Year of Occurrence) Maximum	Minimum
Jan	5930	5940	6330	8470 (1987)	4700 (1935)
Feb	5910	6020	6480	8310 (1997)	4360 (1936)
Mar	5840	6420	6810	9490 (1998)	5010 (1935)
Apr	5940	6640	7130	9200 (1973)	5070 (1964)
May	6770	6730	7400	10100 (1993)	4980 (1965)
Jun	7530	6260	7500	10010 (1993)	5350 (1965)
Jly	8200	6320	7430	9910 (1976)	5520 (1934)
Aug	7920	6520	7270	9340 (1974)	5300 (1934)
Sep	7510	6400	7090	9230 (1986)	5100 (1934)
Oct	6910	6130	6920	9170 (1986)	4960 (1934)
Nov	6410	5900	6800	9570 (1986)	4810 (1934)
Dec	6010	6030	6680	9260 (1986)	4810 (1934)
Annual	6740	6280	6990		

Preliminary data provided by Great Lakes - St. Lawrence Regulation Office, MSC-Ontario, Environment Canada.

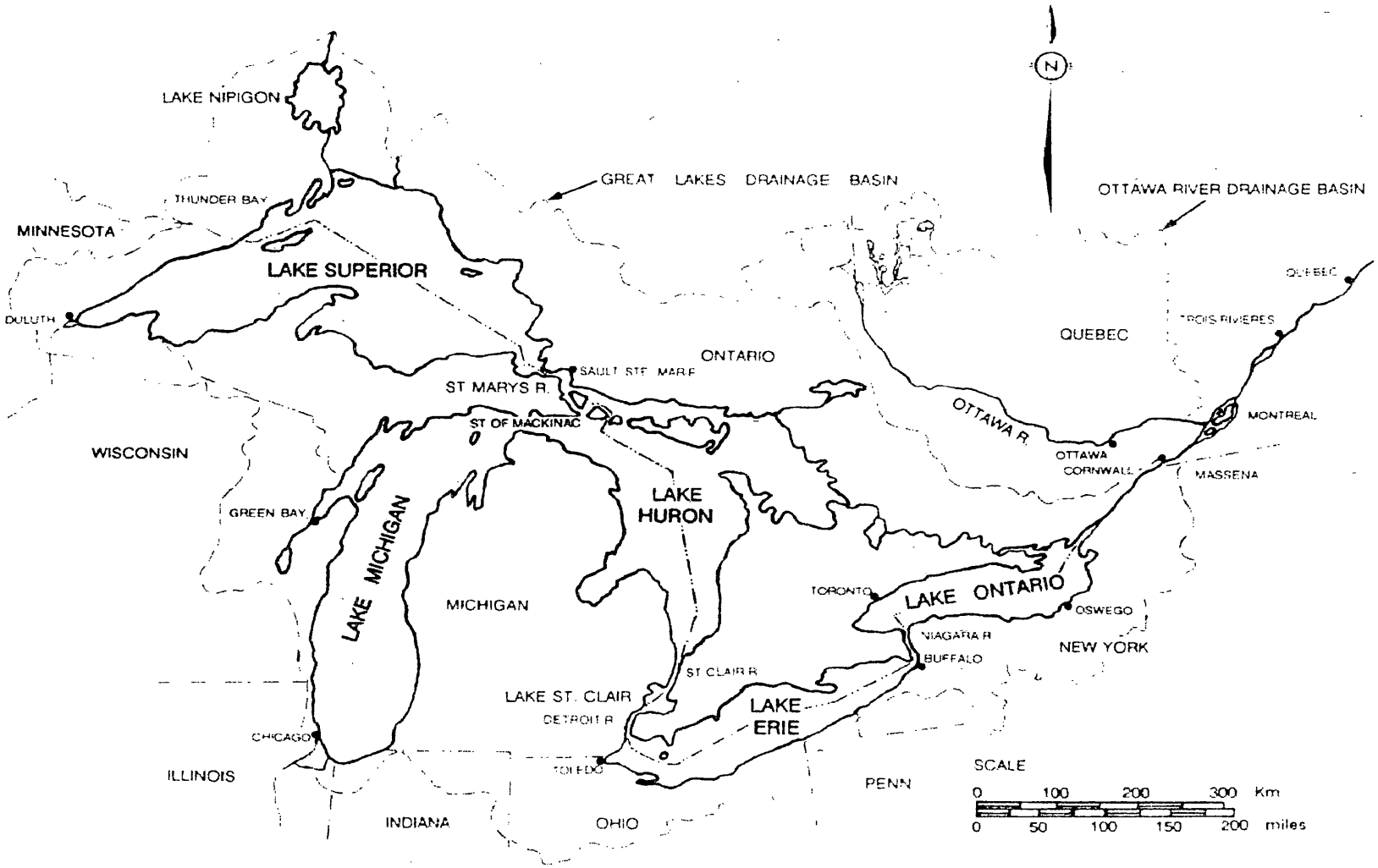


Figure 1 Great Lakes - St. Lawrence River Basin

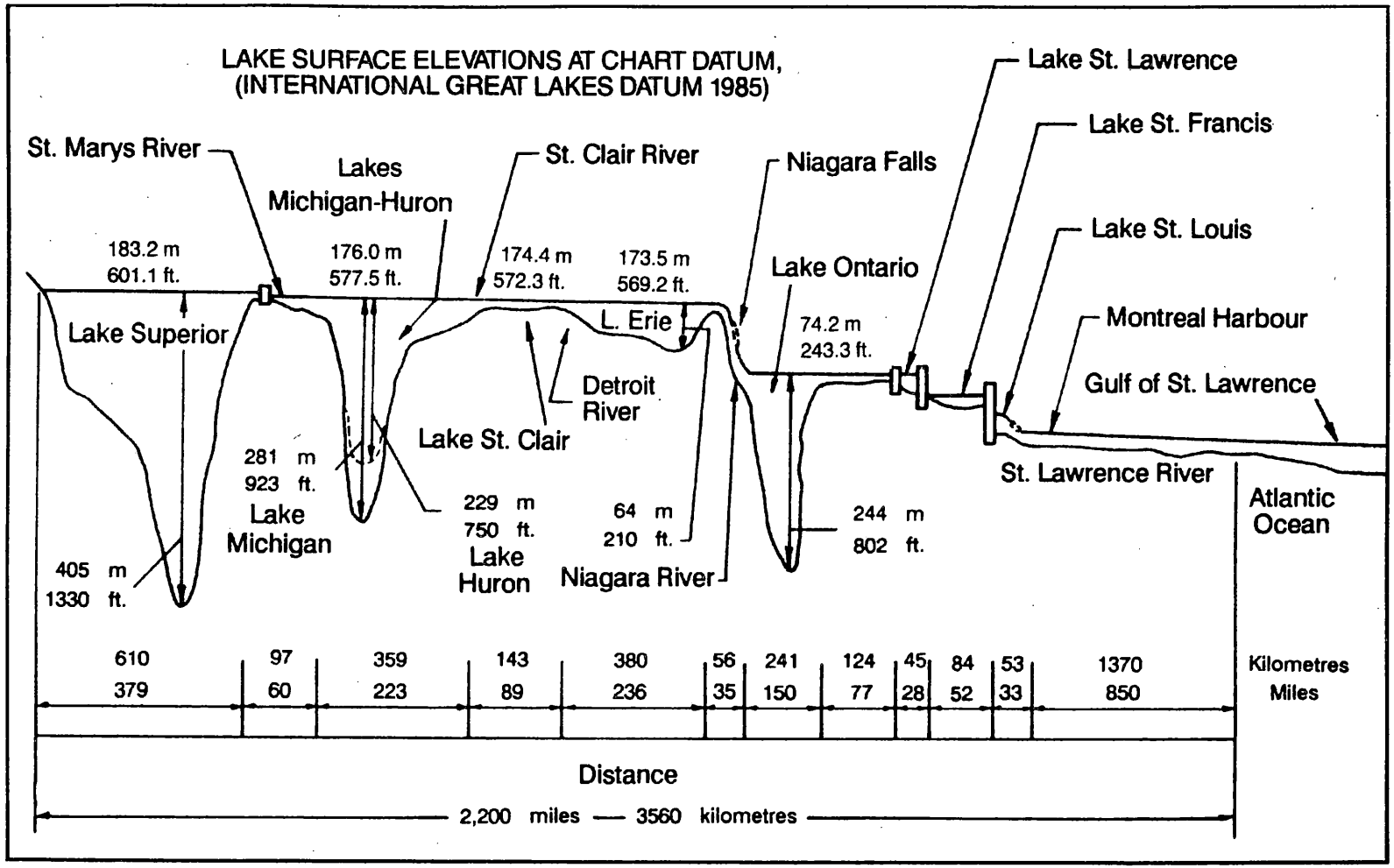


Figure 2 Profile of Great Lakes - St. Lawrence River System

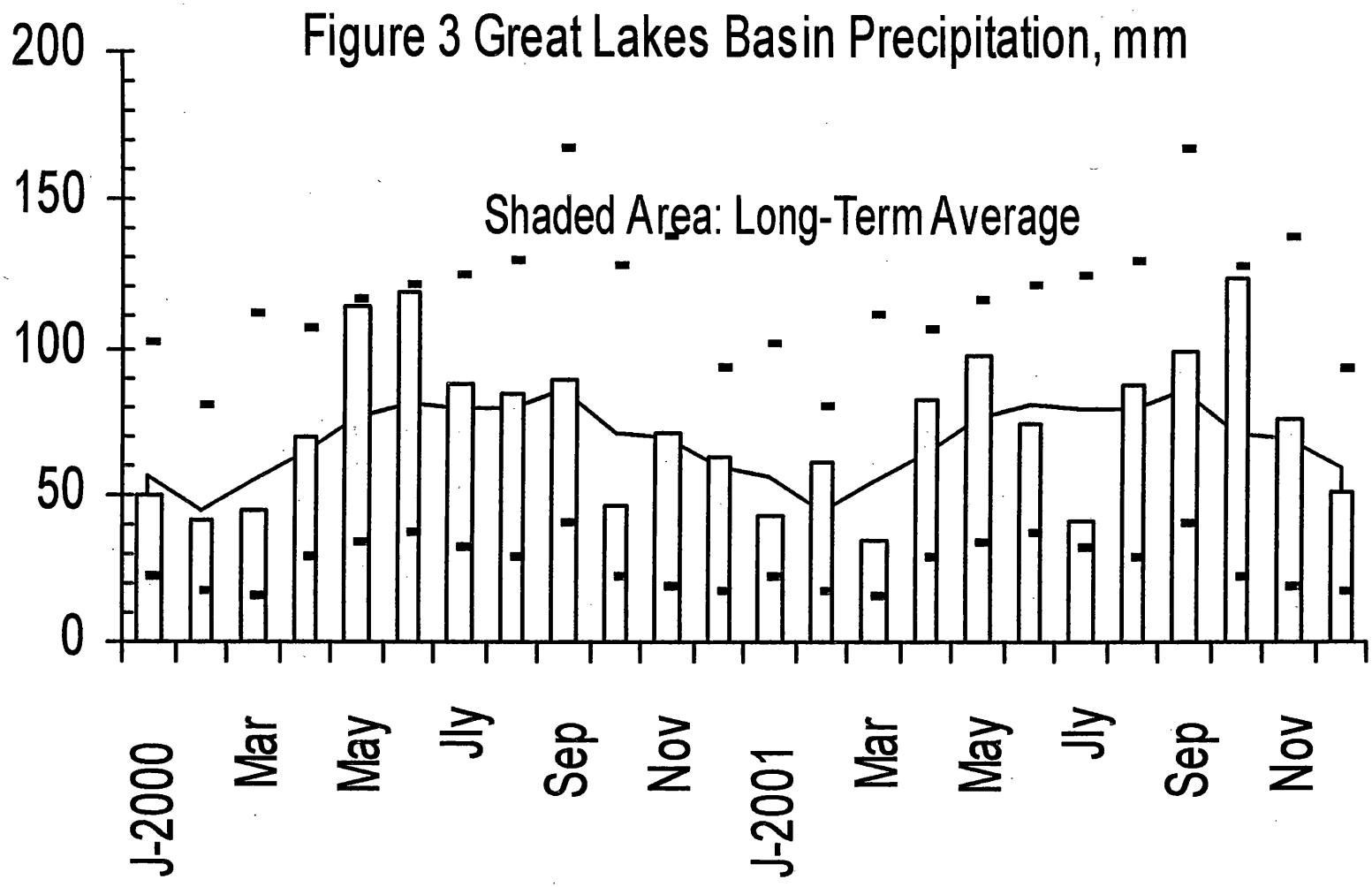


Figure 3 Great Lakes Basin Precipitation, mm
Shaded Area: Long-Term Average
200
150
100
50
0
J-2000
Mar
May
Jly
Sep
Nov
J-2001
Mar
May
Jly
Sep
Nov

Figure 4 Lake Superior Net Basin Supplies, m^3/s

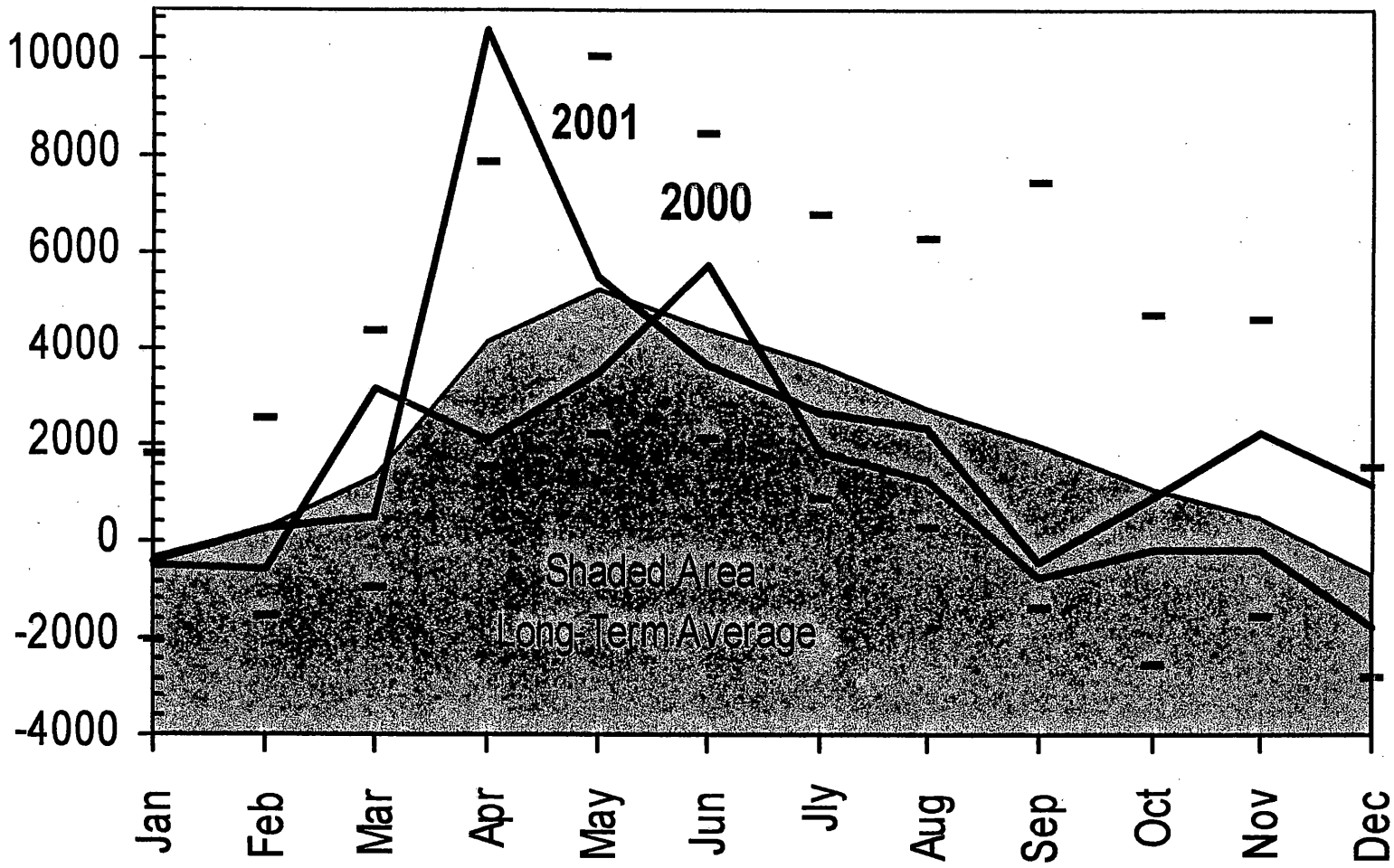


Figure 5 Lakes Michigan-Huron Net Total Supplies, m^3/s

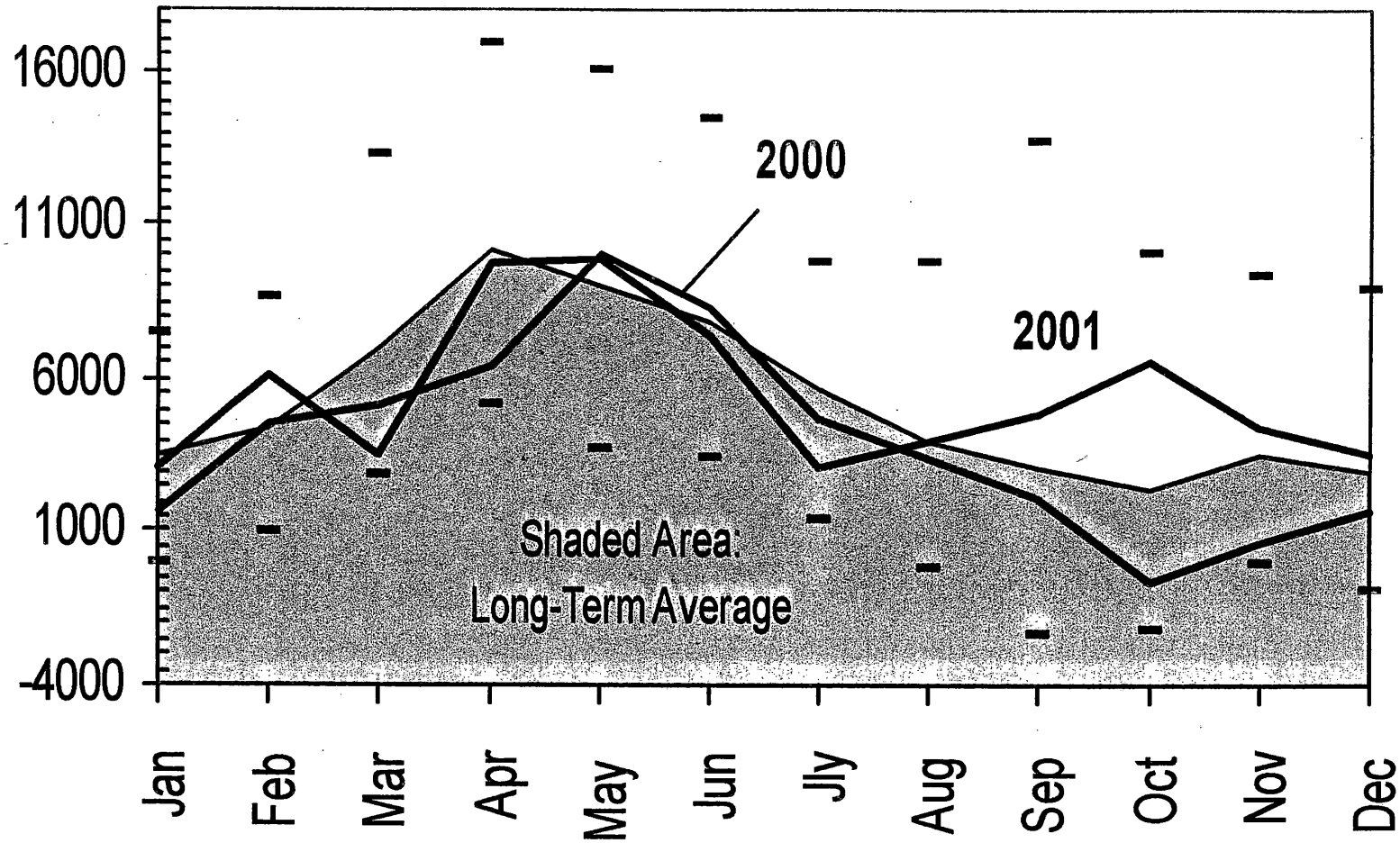


Figure 6 Lake Erie Net Total Supplies, m^3/s

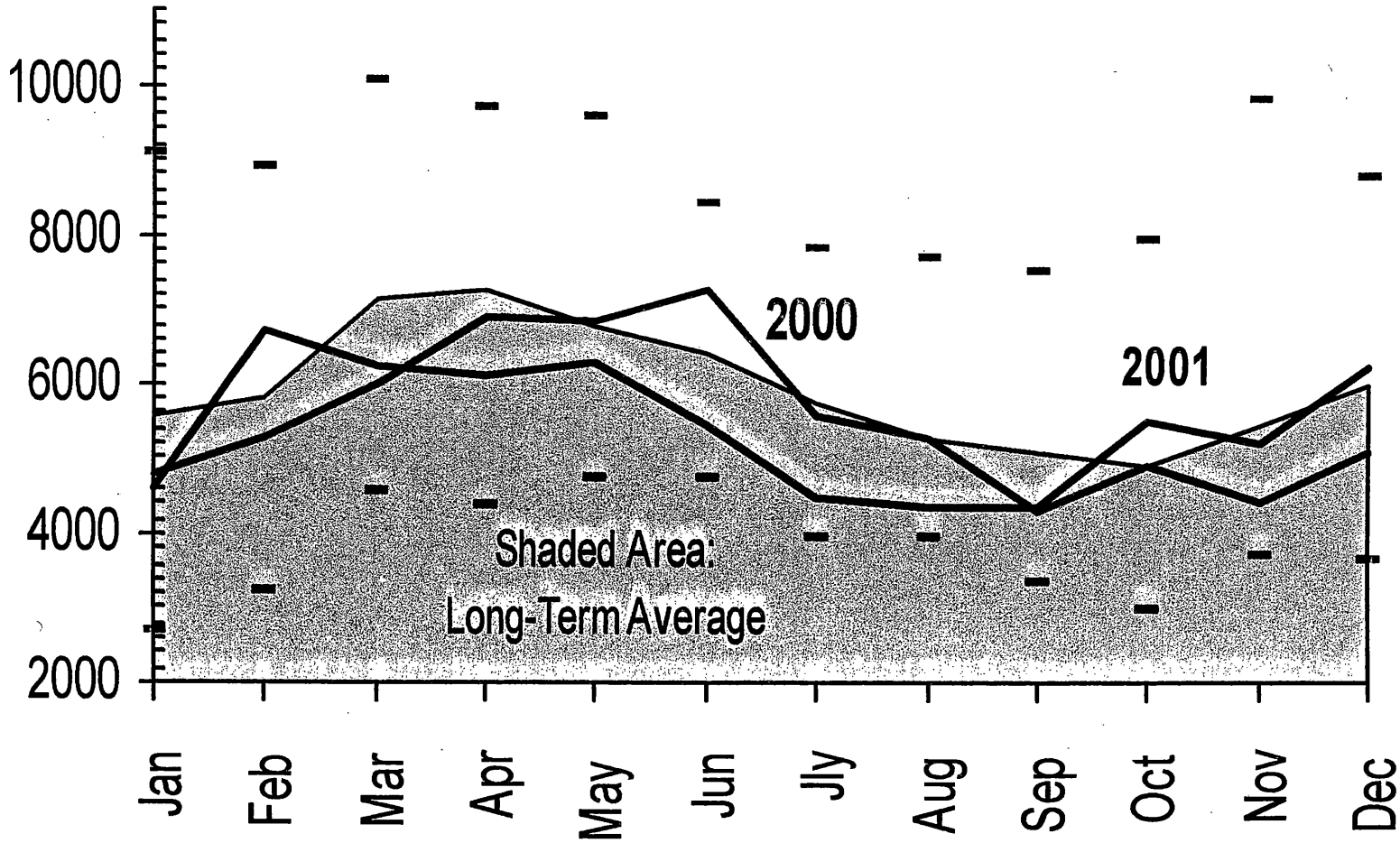


Figure 7 Net Total Water Supplies to Lake Ontario, m^3/s

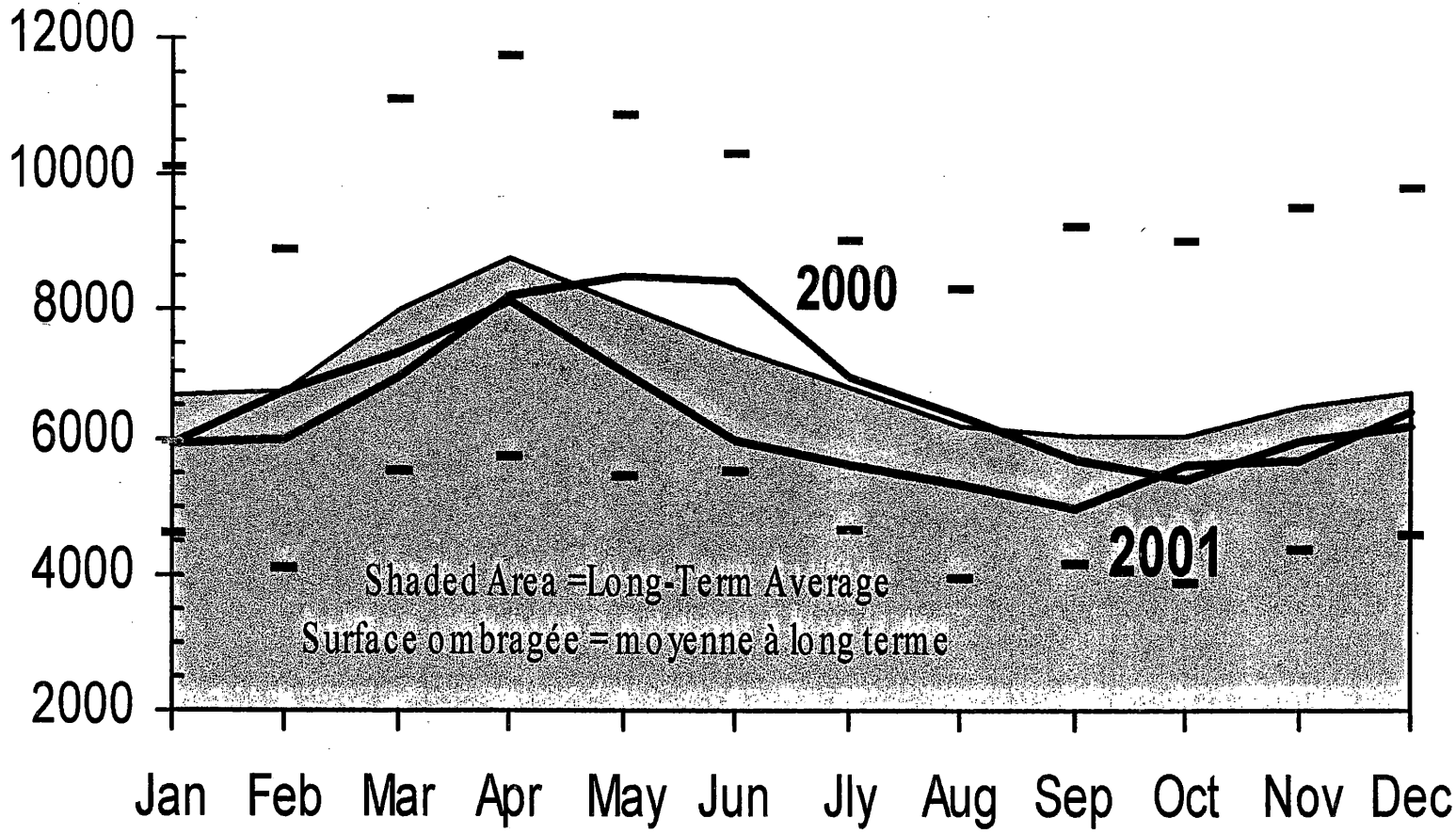


Figure 8 Lake Superior Daily Levels, metres

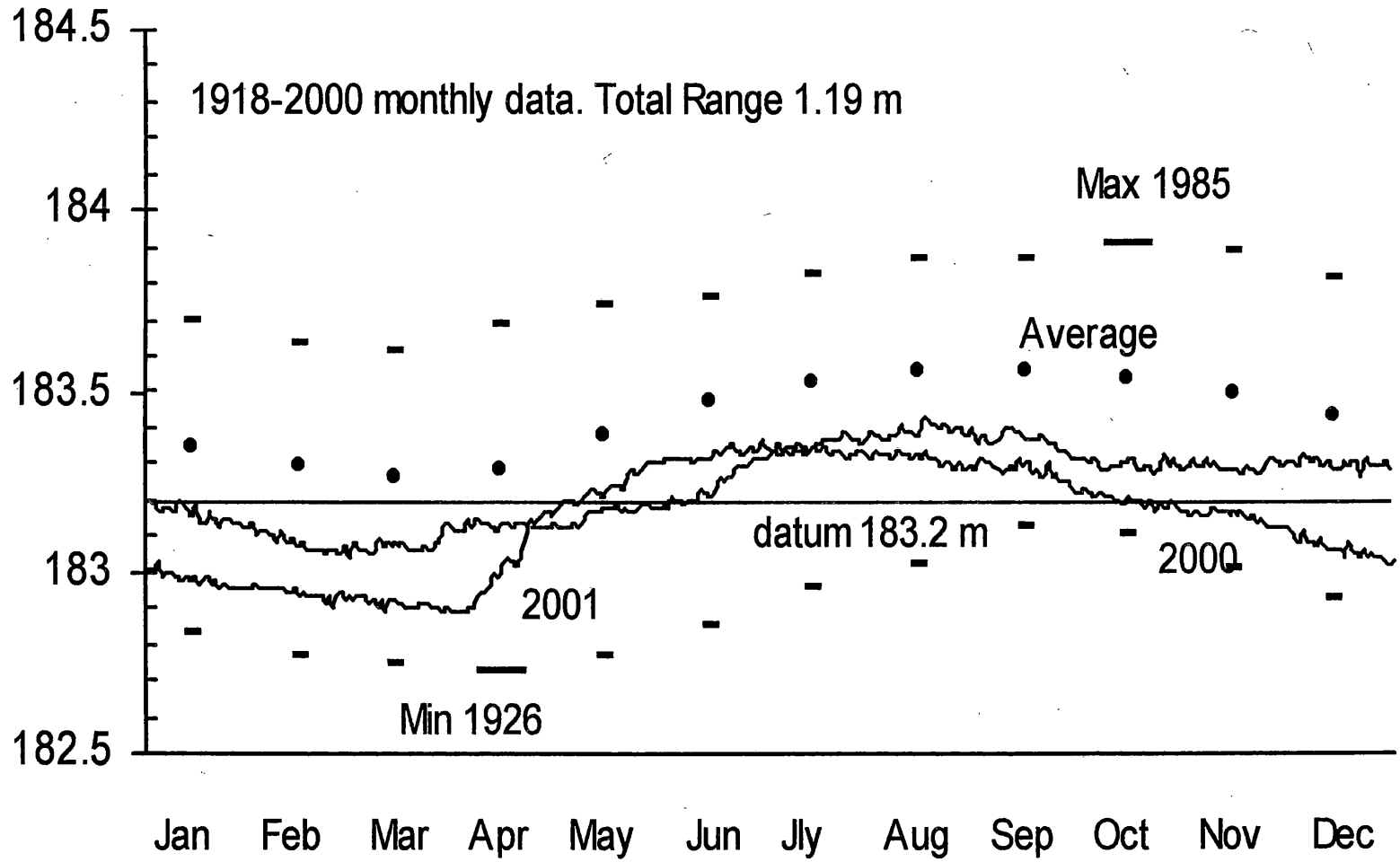


Figure 9 Lakes Mich-Huron Daily Levels, metres

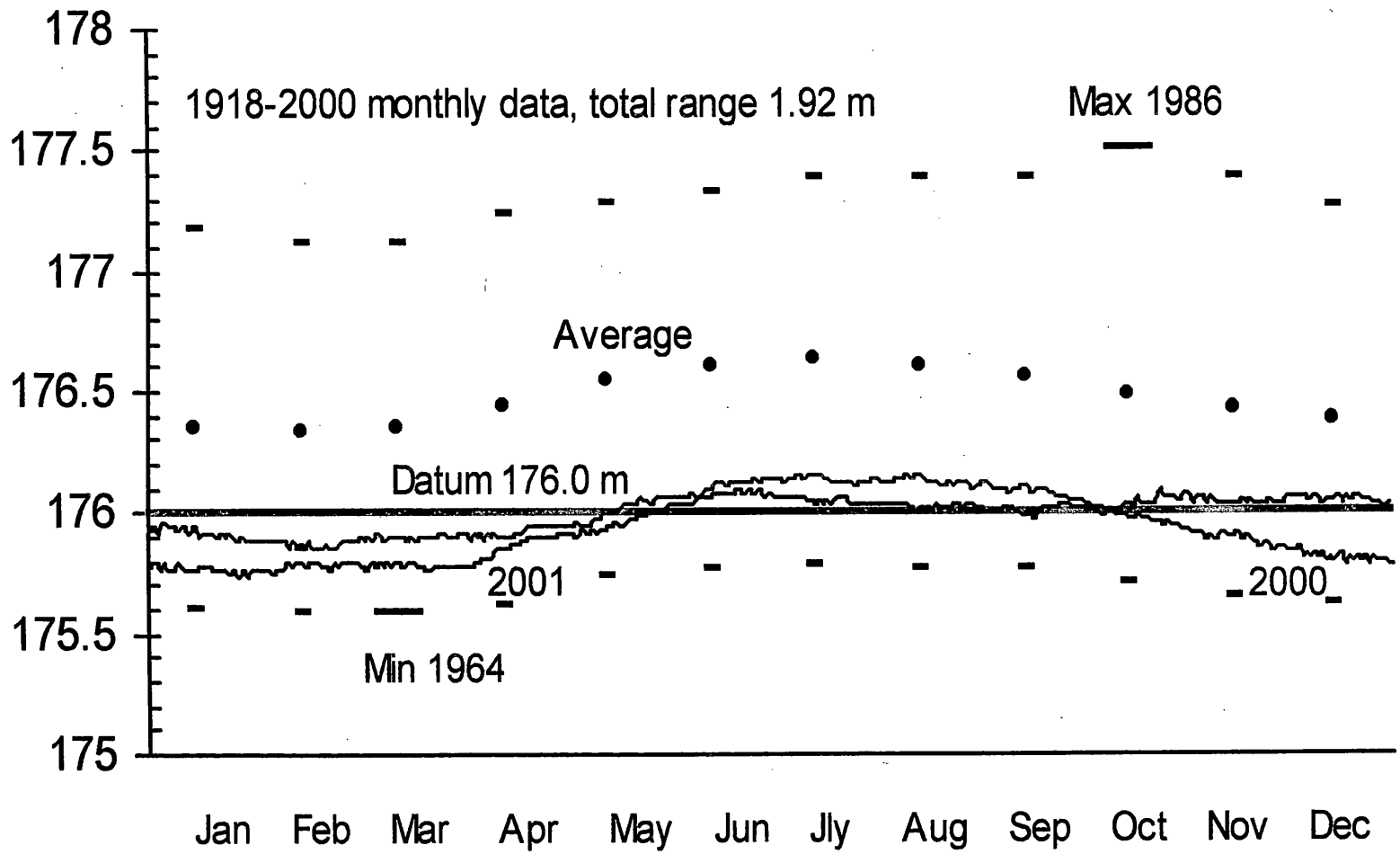
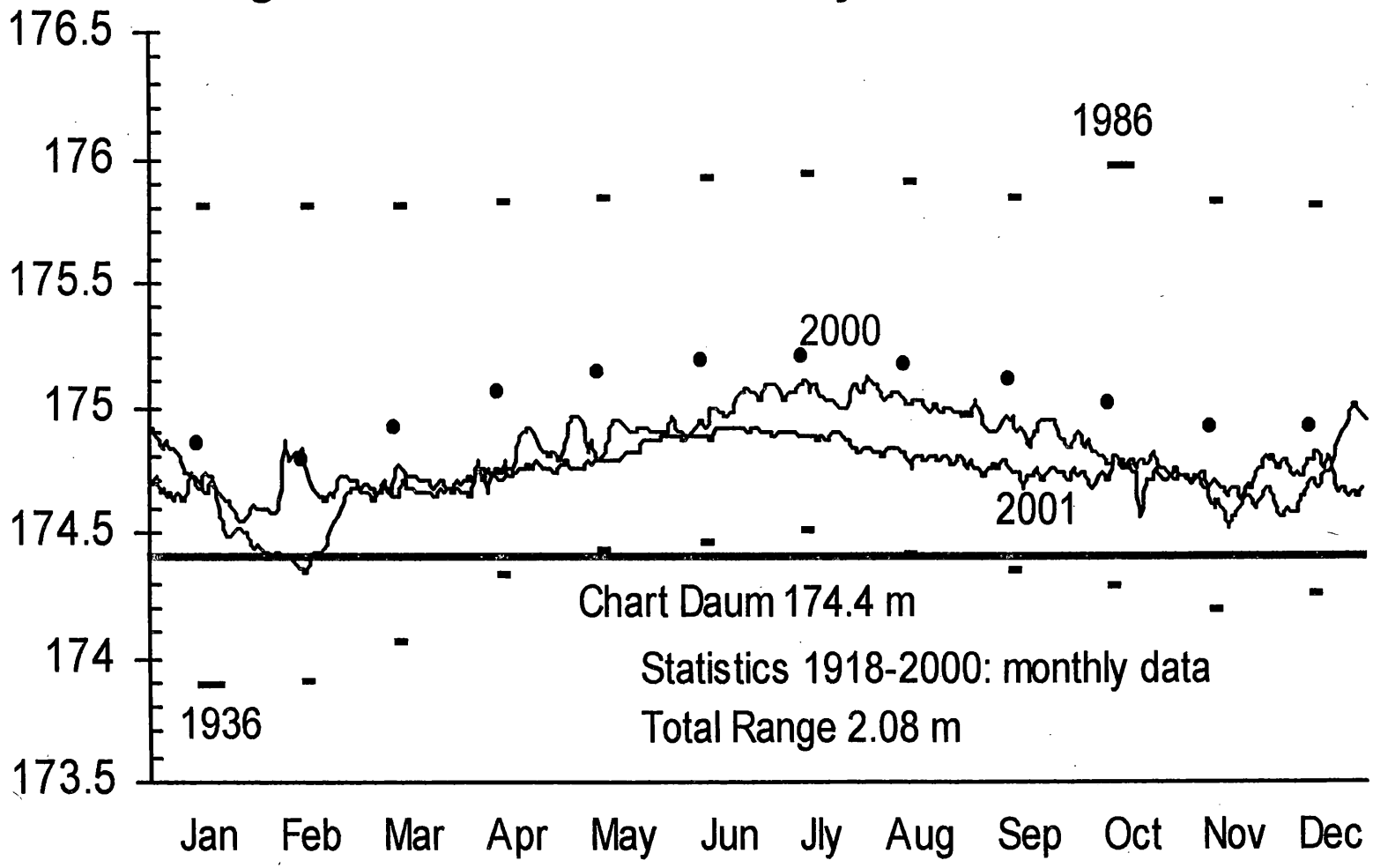


Figure 10 Lake St. Clair Daily Levels, metres



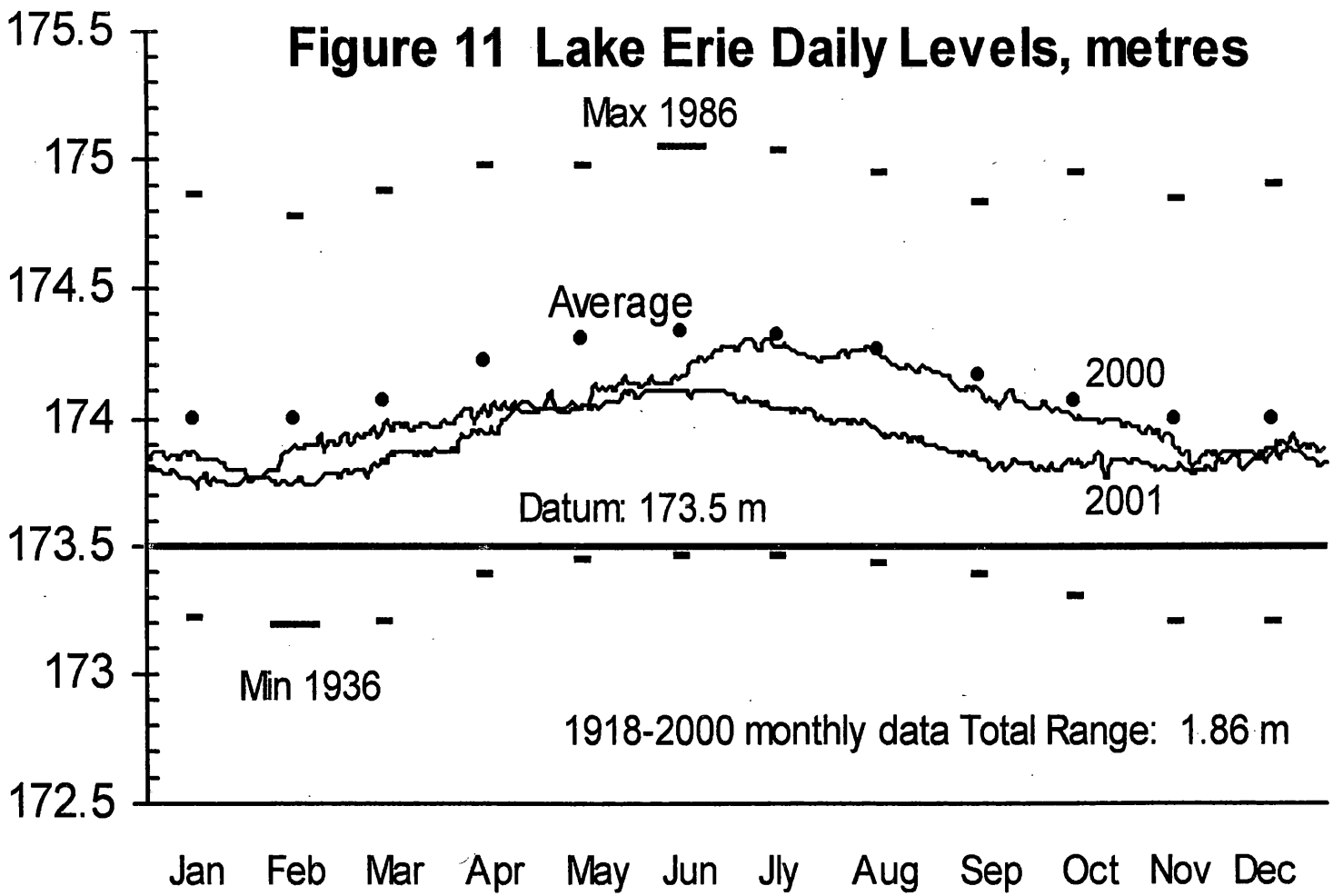


Figure 11 Lake Erie Daily Levels, metres
Max 1986
Average
2000
2001
Datum: 173.5 m
Min 1936
1918-2000 monthly data Total Range: 1.86 m
175.5
175
174.5
174
173.5
173
172.5
Jan
Feb
Mar
Apr
May
Jun
Jly
Aug
Sep
Oct
Nov
Dec

Figure 12 Lake Ontario Daily Levels, metres

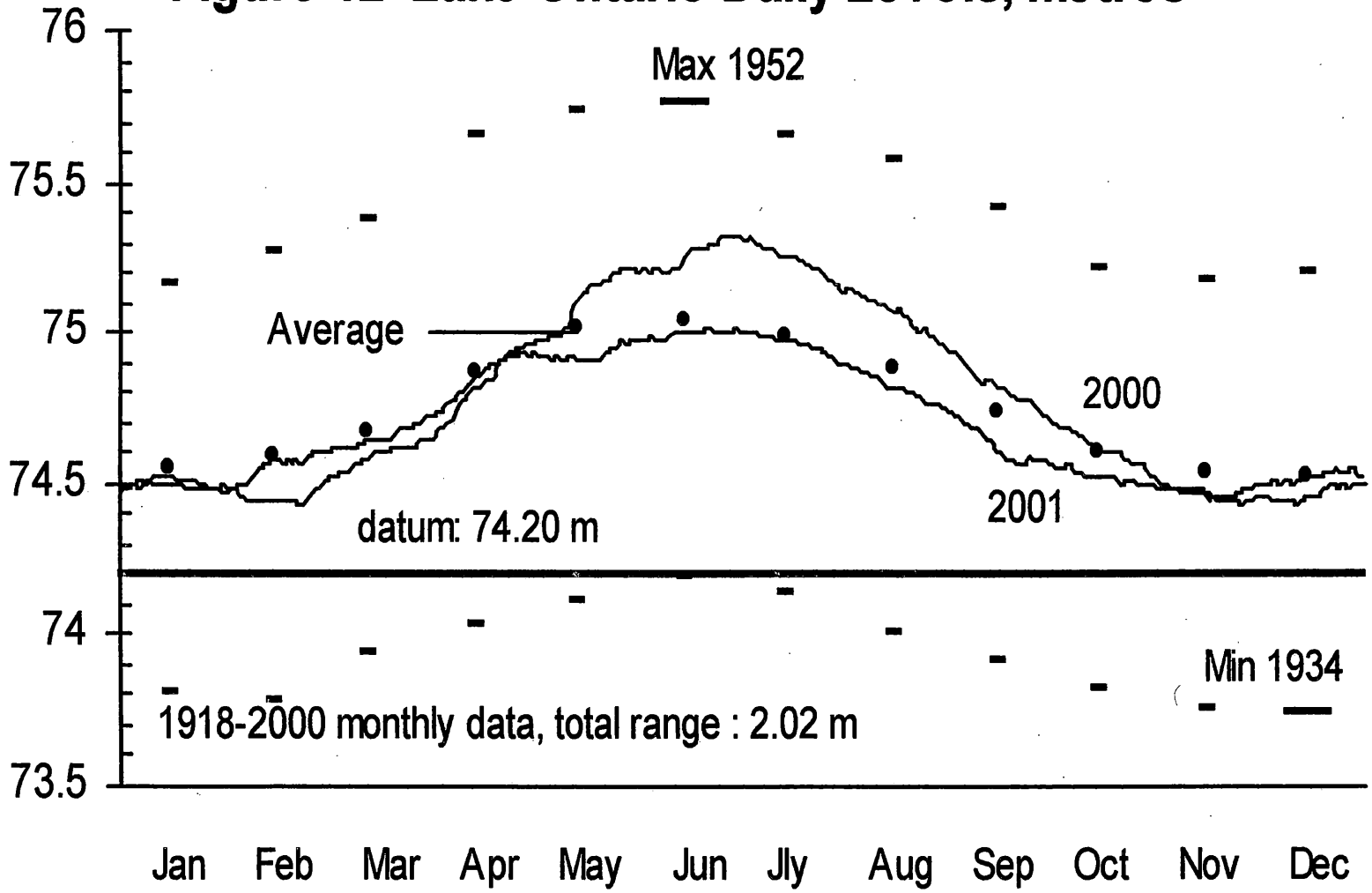


Figure 13 Lake St. Lawrence Daily Levels at Long Sault Dam, m

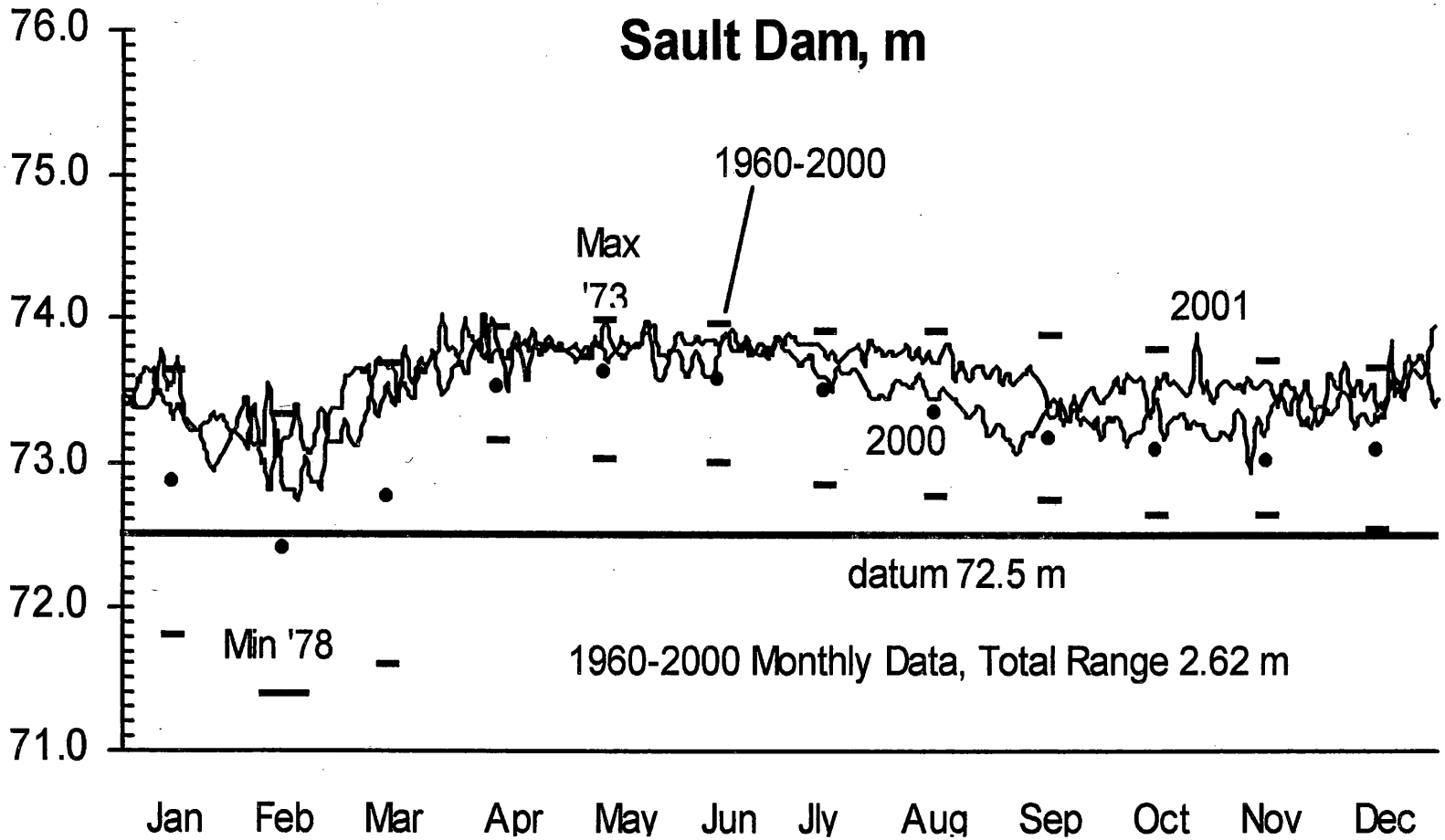


Figure 14 Lake St. Louis Daily Levels, m

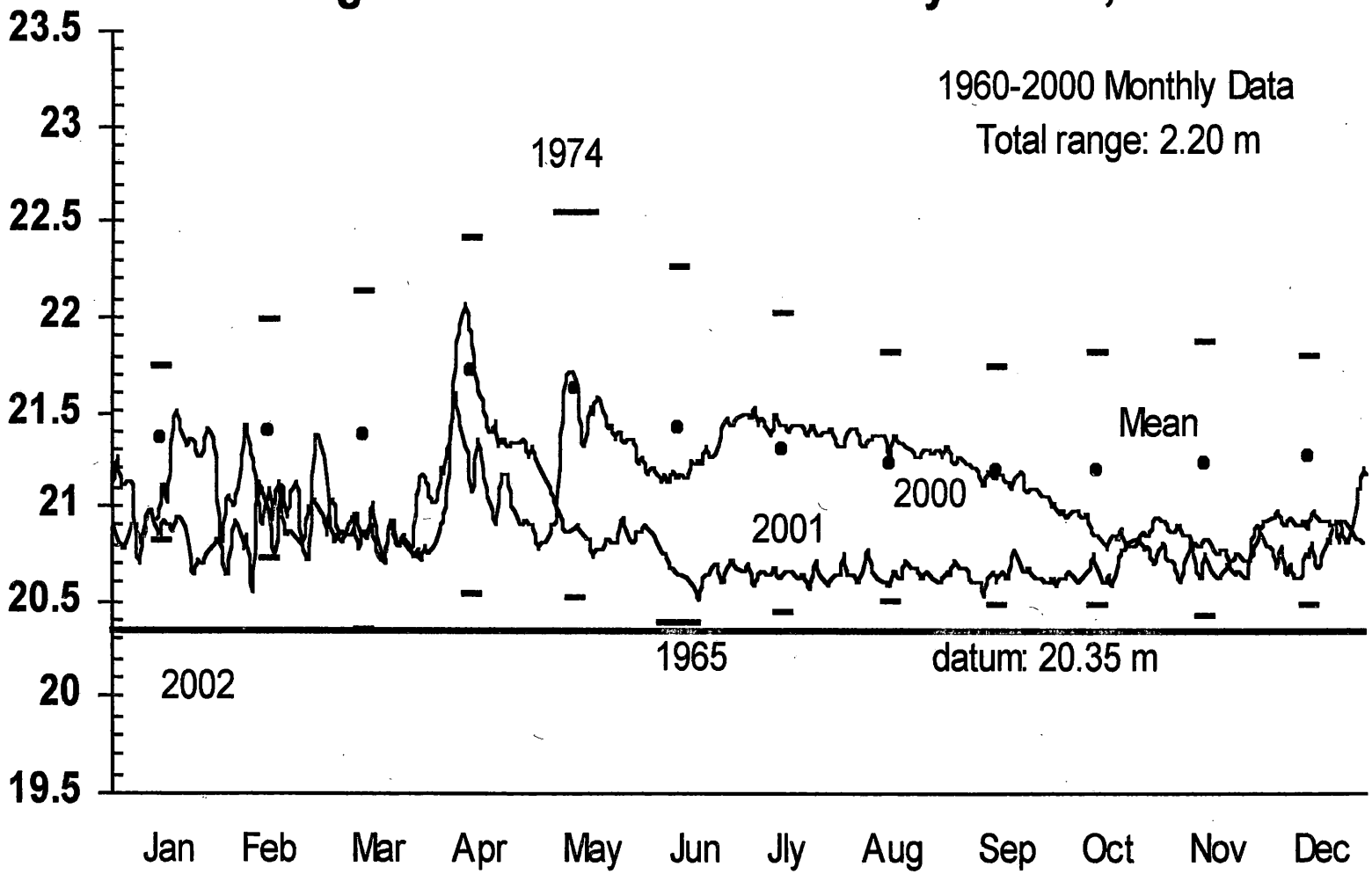
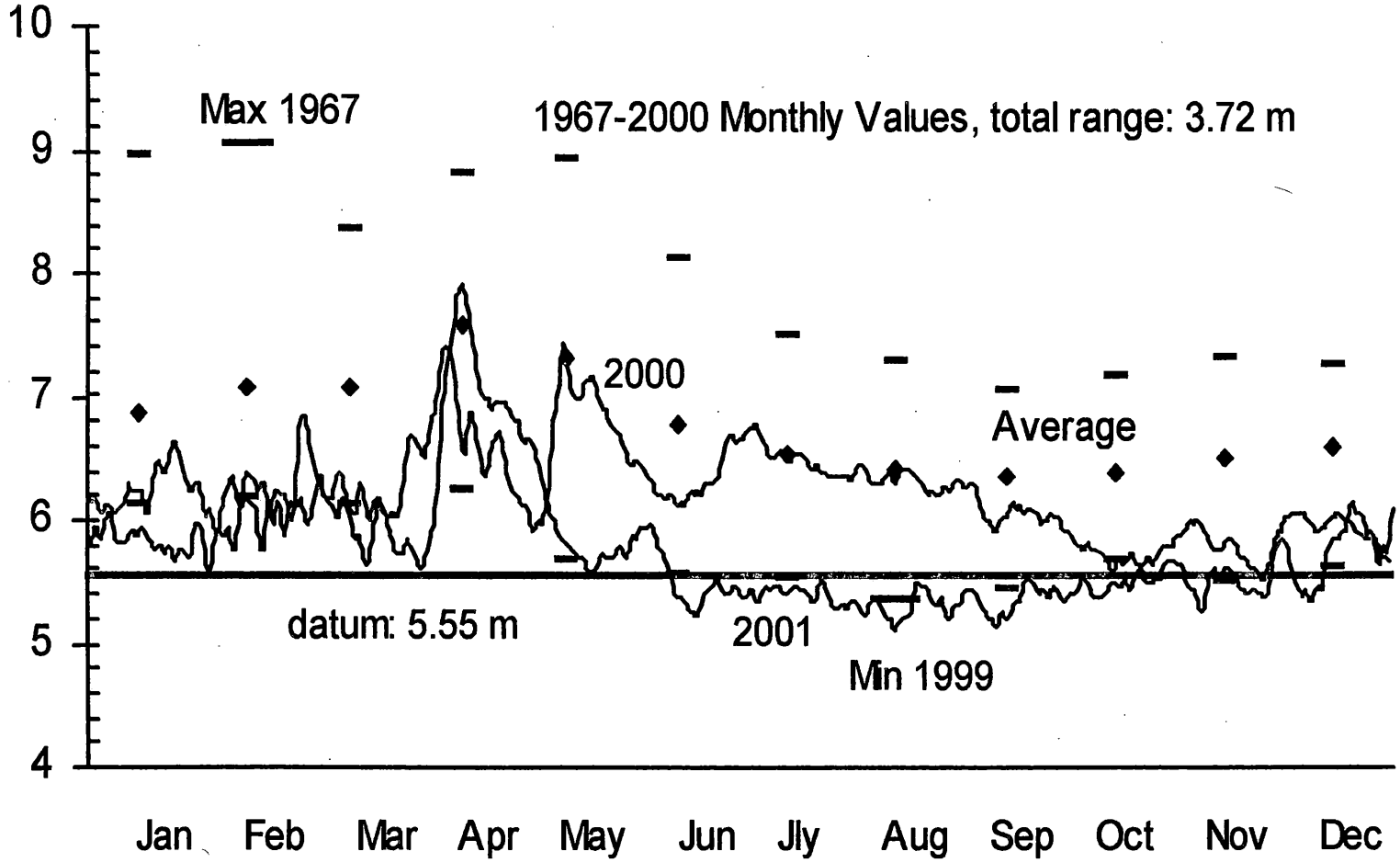



Figure 15 Montreal Harbour Levels, m