BRIEFING PAPER
ON
INTERNATIONAL RAINY LAKE BOARD OF CONTROL
INTERNATIONAL LAKE OF THE WOODS CONTROL BOARD

NOVEMBER 1984

SUBMITTED TO

THE INTERNATIONAL JOINT COMMISSION

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CANADA		UNITED STATES	
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PREFACE

The International Boards of Control for Rainy Lake and Lake of the Woods were requested by the International Joint Commission (IJC) to make a combined presentation to the Commission at its November 1984 Semi-Annual Meeting. As these Boards do not normally appear before the Commission, a comprehensive briefing paper was prepared. Its purpose was to brief the Commission on the regulatory agencies in the basin, on basin features, on current and historic water regulation and on current concerns.

This paper, except for minor revisions, is identical to the paper submitted to the IJC at that time. The paper is now being released for public distribution in the belief that it may provide useful information for others with an interest in water level regulation in the Rainy-Namakan and Lake of the Woods Basins.

The views presented herein are those of the Control Boards but not necessarily those of the IJC.

April 1985

This report has been slightly re-formatted from its original paper version in order to prepare an electronic version for posting on the web. The content is unchanged.

September 2006

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1. INTRODUCTION

The international boundary waters shared by Canada and the United States represent a vast and important natural resource. The abundant water resources found along the common boundary are utilized by various interests which include hydropower, water supply, forest products, navigation, tourism, parks, fisheries, and agriculture. To insure that this important resource would be used wisely, the governments of Canada and the United States signed, in 1909, the "Boundary Waters Treaty".

The Winnipeg River Drainage Basin, shown in the Appendix, was one of the first boundary waters areas in which the terms of this treaty were utilized to initiate comprehensive water resource studies and to subsequently establish and implement internationally approved water management policies. Four water management boards are currently active in this basin. One of these, involved with water quality, is the Rainy River Pollution Advisory Board. The other three are water quantity Control Boards. Two of these, the International Rainy Lake Board of Control (IRLBC) and the International Lake of the Woods Control Board (ILWCB), are international boards which report to the International Joint Commission (IJC). The portion of the Winnipeg River basin of concern to these Boards is highlighted in green on the basin map. The third Control Board, the Lake of the Woods Control Board (LWCB), is a wholly Canadian Board. A fifth board, now discontinued, was the International Prairie Portage Board of Control which existed from 1939 to 1975. Its purpose was to oversee the reconstruction of the dam at Prairie Portage which was seriously damaged in the flood of 1938.

This briefing paper will focus on the two current International Control Boards, with some information on the Canadian Board as necessary to complete the picture of water quantity management in the basin. Topics addressed will include a description of board jurisdictions, a basin description, a history of regulation, hydroclimatology perspectives on the future, board concerns, and concerns of water interest groups within the Lake of the Woods and Rainy Lake watersheds.

2. BASIN ADMINISTRATION

2.1 Control Boards

Following the Boundary Waters Treaty and the creation of the International Joint Commission (IJC) in 1909, the governments of Canada and the United States submitted the Lake of the Woods Reference (IJC Docket 3) to the Commission in 1912. This reference pertained to the regulation of the level of Lake of the Woods. The Commission issued its final report in 1917, which ultimately led to the 1925 Convention and Protocol between the two countries. This document created the International Lake of the Woods Control Board (ILWCB), called for the establishment of a Canadian Lake of the Woods Control Board (LWCB), and defined the duties of each Board. It also defined the objective of regulation and the range of lake levels to be utilized on Lake of the Woods. Basically the Canadian Board was given sole regulation responsibility as long as the level of Lake of the Woods remains in the 1056 - 1061 ft. range sea level datum (321.87 - 323.39 m), but with the total discharge being subject to the approval of the International Board whenever the lake level rises above or falls below this range. Subsequent to the Convention and Protocol, the International Board was established with the appointment of two members, one Canadian and one American, by their respective governments. Although this Board is not strictly an IJC Board since the IJC did not create it and does not appoint its members, nevertheless the Board reports to the IJC. As to the Canadian Board called for in the Convention and Protocol, it was actually established in 1921, in the expectation that the recommendations of the Lake of the Woods Reference (completed in 1917) would be adopted by the two governments. The ratification of the Convention and Protocol in 1925 confirmed the jurisdiction of this Board. The Canadian Board consists of 4 members. Initially two were appointed by the Canadian federal government and two were appointed by the government of the province of Ontario. Since 1958 one member represents the Canadian federal government, two members represent the province of Ontario and one member represents the province of Manitoba. This Board was also given responsibility, by legislation, for the regulation of other wholly Canadian waters, including Lac Seul on the English River, which is a major tributary to the Winnipeg River downstream of Lake of the Woods.

Concurrent with the signing of the 1925 Convention and Protocol and actually included as one of its terms, the governments of Canada and the United States submitted the Rainy Lake Reference (IJC Docket 20) to the Commission. This reference pertained to the regulation of levels of Rainy and Namakan Lakes and the provision of storage facilities on the boundary waters above Namakan Lake. The Commission issued its final report in 1934. This led to the 1940 Convention between the two countries, which empowered the Commission to determine when emergency conditions exist in the Rainy Lake watershed due to either high or low water and to adopt control measures as required at the dams in the basin during such conditions. The Commission subsequently created the International Rainy Lake Board of Control (IRLBC) and appointed its first members, one Canadian and one American, in 1941. This Board initiated studies to fulfill the Commission's obligations under the 1940 Convention. These studies led to the issuance of the IJC's 1949 Order defining when emergency conditions exist and prescribing the method of regulating levels to preclude the occurrence of such conditions on Rainy and Namakan Lakes. This Order, through further input from the public and advice from the Board, was subsequently amended by Supplementary Orders in 1957 and 1970. These Orders also defined the duties of the IRLBC, these being primarily to monitor the regulation of Rainy and Namakan Lakes to ensure that the dam owners follow the Orders, and to advise the IJC concerning watershed conditions as necessary. More recently, since the construction in 1975 of a permanent dam at Prairie Portage just upstream of Basswood Lake, the International Prairie Portage Board of Control was discontinued and any further duties related to this site were added to the jurisdiction of the IRLBC.

To ensure coordination within the basin and between the two countries, the membership of the two International Boards has traditionally been identical and the Canadian member on the International Boards has traditionally been the Canadian federal member on the Canadian Board. Figure 1 summarizes the origins of the three active Control Boards outlined above. It also shows the relation of these Boards with their support groups and the dam owners in the basin. Figure 2 presents a basin schematic summarizing the jurisdictions of the three Boards. Figure 3 summarizes the appointment process and current membership of the three Boards.

2.2 Support Groups

As shown in Figure 1, the three Control Boards are assisted in their duties by two engineering support groups, one in Canada and one in the United States. In Canada support is provided by the Lake of the Woods Secretariat. This unit, although housed in Ottawa in the offices of the Inland Waters Directorate of Environment Canada, is an autonomous unit which reports directly to the Canadian LWCB and is jointly funded by the governments of Canada, Ontario and Manitoba. Its main duties include the monitoring of conditions in the Winnipeg River Basin, provision of information and recommendations, production of reports and Board administration work. By agreement between the LWCB and the Inland Waters Directorate, the Secretariat also addresses the regular needs of the two International Boards. These include monitoring of lake levels, contact with dam owners as necessary, participation in annual public meetings and annual report preparation. In this role the Secretariat reports directly to the Canadian member on the International Boards. In summary the Secretariat is involved full-time with regulation in the Winnipeg River Basin but not always for the same jurisdiction.

In the United States support is provided by the Water Control Center of the U.S. Army Corps of Engineers District Office in St. Paul. This unit carries out regulatory duties with respect to Corps projects in the Red, Rainy, Souris and Upper Mississippi River Basins. It also provides support as needed to IJC Boards in the first three of these Basins. A major duty is control of the navigation system on the Upper Mississippi River. The role played by the Water Control Center in supporting the United States member of the IRLBC and ILWCB is similar to that described above for the Secretariat.

Close liaison is maintained between the two support groups. Contacts in each are given in Figure 3.

2.3 Dam Owners and Operators

The dams and powerhouses by which regulation of Lake of the Woods, Rainy Lake and Namakan Lake is effected are owned and operated by Boise Cascade Corporation. The structures controlling Lake of the Woods are administered by the company office in Kenora. Outflows from Lake of the Woods are determined and specified by the Canadian LWCB, either solely or in consultation with the ILWCB. The company then makes the appropriate changes to turbine and/or sluiceway stop-log settings in order to release the required flow.

The structures controlling Rainy and Namakan Lakes are administered by the company office in Fort Frances. Regulation of these lakes is normally conducted by Boise Cascade in accordance with the rules defined by the IJC Orders. The IRLBC monitors the operations of the company but only becomes involved in regulation if the IJC Orders are not or cannot be followed.

2.4 Information Services

In April 1984 the IRLBC held its 19th annual public meeting in the Rainy Lake watershed. These meetings are hosted alternately each year on the Canadian and the United States sides of the basin. Through these meetings the Board has attempted to maintain a presence in the basin and to continue the sense of public participation initiated by the Commission with its public hearings held during the Rainy Lake Reference and prior to each of its Orders. At these meetings watershed conditions over the past year are reviewed, prospects for the upcoming inflow season are discussed, and the public are given a chance to make known their concerns to the Board. At this year's meeting two presentations were also made of a more educational nature; one concerning the impact of climatic variations on watershed hydrology and management, and one on the relative importance of snowpack and spring rains on spring runoff. Both of these presentations were well received. Summaries of the past two annual meetings are available.

Similar annual meetings have also been held for some time by the ILWCB. However, in the past two years the meetings were not held as no one from the public attended at the scheduled time. Consequently the ILWCB has discontinued these meetings until warranted by renewed public interest or extreme lake conditions.

In addition to the public meetings, both International Boards prepare Annual Reports to the IJC each spring. These traditionally review basin conditions over the past year but also draw issues of concern to the attention of the Commission whenever warranted.

As the only full-time operational Board in the basin, the Canadian LWCB attempts to maintain a somewhat higher profile. Public meetings are held each spring at one or more sites in the basin and, if conditions warrant, may be held in the fall also. By Board by-law a minimum of three Regulation Meetings are held in the basin each year. This facilitates the attendance of a number of Representatives of Specific Interest Groups recognized by the Board in this area. These include camp owners and cottage owners associations, pulp and paper and hydroelectric interests and native peoples.

To make the public more aware of regulation in the basin, the LWCB has produced a public information brochure entitled “Managing the Water Resources of the Winnipeg River Drainage Basin”. A copy is attached. Through its Secretariat, the Board also releases regular summaries of basin conditions. Recorded messages giving lake levels and flows are updated weekly and are available locally by telephone in Kenora and Winnipeg. A Water Level and Flow Bulletin is produced bimonthly and mailed to interested members of the public. A more technical Provisional Report, which summarizes levels, flows and precipitation throughout the entire Winnipeg River basin, is produced weekly and mailed to a limited distribution list. The Canadian Section of the IJC is a recipient of this report. This report is also available by direct computer access to Board Members and has been offered by this means to other parties such as Boise Cascade in Fort Frances. Recent examples of the Bulletin and the Provisional Report are shown in Figures 4 and 5 respectively. The LWCB also produces an Annual Report.

3. BASIN DESCRIPTION

3.1 Topography, Hydrology and Climate

The Lake of the Woods basin forms part of the headwaters of the Hudson Bay watershed, draining an area of 27,200 square miles (70,400 square kilometres), of which 42 percent is in the United States and 58 percent is in Canada. Approximately 18 percent of the total drainage area consists of an intricate network of lakes, largely rockbound, and connecting streams, of which 70 percent lie within Canada and 30 percent within the United States. This vast area may be conveniently divided into two sub-basins, namely: the Rainy Lake watershed with its outlet at Fort Frances/International Falls, draining an area of 14,900 square miles (38,600 square kilometres); and the remainder of the Lake of the Woods watershed below International Falls, draining an area of 12,300 square miles (31,800 square kilometres) and having 2 outlets near Kenora, Ontario. The Rainy Lake watershed provides nearly 70 percent of the total inflow to Lake of the Woods. Rainy Lake, at the foot of this watershed, is the largest of the principal lakes in the basin, which include Rainy, Namakan, Kabetogama, Crane, Vermillion, Lac La Croix, Basswood, Pickeral and Saganaga.

The principal drainage course of the water, tributary to the Lake of the Woods, commences in North Lake on the International Boundary, some 210 miles (338 kilometres) to the east of Rainy Lake. Flow is generally in a northwesterly direction along the International Boundary until reaching Lake of the Woods. After leaving Lake of the Woods, the waters flow down the Winnipeg River into Lake Winnipeg and ultimately into Hudson Bay by way of Nelson River.

In general, the entire Lake of the Woods watershed is forested and characterized by frequent outcrops of Precambrian igneous, metamorphic and sedimentary rocks, thin soil cover, numerous lakes, ponds and connecting channels. The watershed between Rainy Lake and Lake of the Woods is generally rather flat and swampy with a vertical fall of only 50 feet (15 m), on average, from Rainy Lake to Lake of the Woods. By comparison, the vertical fall from the headwaters of the Rainy watershed to Rainy Lake is approximately 440 feet (135 m).

The climate of the Lake of the Woods watershed is characterized by long severe winters with snow typically on the ground from November through April. Mean annual precipitation is about 27 inches (680 mm) with 30 percent of this amount in the form of snowfall. Mean annual lake evaporation in the watershed is approximately 25 inches (635 mm), while mean annual evapotranspiration (total evaporation loss to the atmosphere from all sources) averages 19 inches (490 mm) over the basin or about 72 percent of the mean annual precipitation.

Normally the winter months, December through March, are the driest, while June, July and August are the months with the greatest amount of precipitation. Extreme temperatures range from about -50 °F to +100 °F (-45 °C to 38 °C) with January being the coldest month and July the warmest. River and lake freeze-up occur by December 1 on the average. In the spring, river breakup normally occurs by April 15 with lake breakup following about 2 weeks later. Major rivers in the watershed normally reach their highest flows during the spring melting season of April, May and June.

The Winnipeg River basin is shown in detail on the basin map in the Appendix. The Lake of the Woods sub-basin and the Rainy-Namakan sub-basin are highlighted in green. In addition, the basin is shown in schematic form in Figure 6. The lakes are scaled to show their relative areas, storage factors and mean flows are given, and drainage areas above certain points are given in both absolute terms and as a percentage of the total area to the main lakes (Lake of the Woods and Lac Seul).

3.2 Hydraulic Structures and Features

Hydraulic structures of major importance in the Lake of the Woods watershed are located at Kenora, Ontario, at the outlets of Lake of the Woods; at Fort Frances/International Falls, at the outlet of Rainy Lake; at Kettle Falls, Minnesota, at the outlets of Namakan Lake, and at Prairie Portage at the inlet to Basswood Lake. All of these structures with the exception of Prairie Portage Dam are owned and operated by Boise Cascade Corporation for the generation of electricity used in plant operations. Prairie Portage dam is an uncontrolled concrete weir, whose purpose is to maintain a stable connecting waterway on Sucker, Birch, Moose, and Newfound Lakes in the upper Rainy watershed. The dam is owned and operated by the United States Forest Service. In addition, natural outflows at Gold Portage at the northwest end of Kabetogama Lake, and Bear Portage on the northern shore of Namakan Lake are also of importance.

Lake of the Woods has 2 major outlets at Kenora; the western outlet which carries well over half the outflow from Lake of the Woods, controlled by Norman Dam, and the eastern outlet, controlled by the Kenora generating station. Norman Dam was put into service in 1898 for the benefit of navigation. In 1925, the centre rockfill section was removed for construction of the Norman powerhouse in order to produce electricity for paper production. The dam is a stone-masonry structure with 20 stop-log controlled sluices, 9 on one side and 11 on the other side of the powerhouse. Stop-log movement is still by the original equipment provided for this purpose, an electrically powered spud winch mounted on rails over the sluices. In 1966 the pier noses were rebuilt with concrete and faced with steel. The Kenora generating station was built in 1906 and later rebuilt to its present configuration in 1923. All water flowing out the eastern outlet is used for power generation or log flume operations, although this latter use is expected to cease in 1985. In addition to these major outlets there is a minor diversion of water from Lake of the Woods via Shoal Lake. In 1914 the City of Winnipeg was authorized by the IJC (Docket 7) to withdraw up to 100 MIGD (186 ft^3/s) (5.27 m^3/s) for domestic and sanitary purposes.

The outlet of Rainy Lake has been controlled since 1909 by an international dam extending between Fort Frances, Ontario, and International Falls, Minnesota, at the site of the former Koochiching Falls. The dam is of stone-masonry construction and is U-shaped, with the apex pointing upstream. Ten gate-controlled arched sluiceways are on the Canadian side, while the apex and American side are designed as a free spillway section. An additional 5 gate-controlled sluiceways discharge into a never-used navigation canal on the Canadian side. In the mid-1970's concrete repair work was done to the piers and gate slots of all sluices. Two powerhouses also exist at this site, one on each side of the river, each between the main dam and the shore. The Canadian powerhouse was extensively rebuilt in the 1950's. The American powerhouse is still original but plans exist to upgrade its equipment.

Above Rainy Lake at Kettle Falls, the outlet of Namakan Lake, flow has been controlled since 1914 by two small dams. One, entirely located within Canada (at the former Squirrel Falls) is known as the Canadian Dam, and the other, straddling the international border, is known as the International Dam. No power is generated (or available) at this site and access is still only by boat or plane. Both structures consist of 5 stop-log controlled sluices; one of these in each dam was constructed as a fishway but neither one has been used as such. These structures were originally of stone-masonry construction but, due to severe deterioration, were rehabilitated between 1962 and 1969. All piers and wing walls were completely encased in concrete and some pier noses were reshaped with steel facing. No improvements have been made to stop-log handling equipment. At the International Dam a diesel powered winch is available but at the Canadian Dam only manual chain hoists are used.

In addition to the aforementioned structures, the two natural overflows at Gold Portage and Bear Portage are significant because they provide flow paths from Namakan Lake to Rainy Lake which bypass the regulatory dams at Kettle Falls. Control of Namakan reservoir is thus diminished in proportion to the capacity of these overflows. Historically Bear Portage overflow was probably more significant than Gold Portage. Although both appear on maps accompanying the Rainy Lake Reference, a timber and stone crib was constructed to inhibit flows at Bear Portage and the 1949 IJC Orders specified that this was not to be altered or maintained. More recently Gold Portage has become the more significant overflow. The overflow was stable until the mid-1950's when apparently it was enlarged by local residents. Since that time it has enlarged further through erosion, the removal of a logging road which acted as a partial dam across the channel, and possible further tampering. In 1958 the flow through Gold Portage with Namakan Lake at elevation 1118.0 ft (340.77 m) was 45 ft^3/s (1.3 m^3/s); by 1981 it had increased to 490 ft^3/s (13.9 m^3/s) and is currently rated at 510 ft^3/s (14.4 m^3/s) at this elevation. In contrast, the Bear Portage flow at this elevation is 60 ft^3/s (1.7 m^3/s). Flows commence at Gold Portage when Namakan Lake elevation reaches 1113.5 ft. (339.39 m) and at Bear Portage at an elevation of 1116.8 ft. (340.40 m).

3.3 Data Collection

Monitoring of basin conditions is carried out on a continual basis by the Water Control Center in St. Paul and by the Lake of the Woods Secretariat in Ottawa. Throughout the year water level, flow and precipitation data are collected on either a daily, twice-weekly or weekly basis, depending on the site and the type of data. As well, during the winter, snow cover is monitored and during the first week of March each year a cooperative Canada-U.S. snow survey is carried out on behalf of the International and Canadian Boards.

Currently about 75% of the hydrometric gauging sites in the Lake of the Woods and Rainy-Namakan Basins are equipped with either landline or satellite telemetering equipment. The installation of this type of equipment in recent years has led to vastly improved capability of monitoring current conditions within the basin and has enabled the computation of 24-hour mean levels and flows on a real-time basis. The density of the total network has been increased gradually as well. Currently, there are 9 near real-time hydrometric stations in the Lake of the Woods basin (5 in Canada, 4 in the U.S.) and 14 in the Rainy-Namakan basin (8 in Canada, 6 in the U.S.). As well as receiving this data directly from site-based microprocessors by landline or through access to satellite receive sites, some of this data is also retrieved through personal communication, including twice-weekly contact with Boise Cascade personnel in Fort Frances.

Precipitation data is currently collected on at least a weekly basis from approximately 9 sites in the Lake of the Woods basin (6 in Canada, 3 in the U.S.) and 7 in the Rainy-Namakan basin (4 in Canada, 3 in the U.S.). Some of this data is available daily from the Canadian Atmospheric Environment Service or from the U.S. National Weather Service. The remainder of the data is retrieved through communication with volunteer meteorologic observers in both Canada and the United States. Currently, plans are underway to expand the collection of near real-time precipitation data, especially from Manitoba and Minnesota.

The March 1 snow survey carried out annually for the Boards includes 13 snow courses in the United States sampled by the U.S. Army Corps of Engineers and 14 in Canada sampled by the Water Resources Branch of Environment Canada. Other snowpack accumulation data from the basin is also monitored at frequent intervals throughout the winter. Sources of this data include Ontario Hydro, the Atmospheric Environment Service, Manitoba Department of Natural Resources, the Ontario Ministry of Natural Resources, and the Minnesota State Department of Natural Resources.

The main data collection sites are shown on the basin map in the Appendix.

3.4 Regional Economy and Water Interests

The Lake of the Woods watershed encompasses portions of five northern Minnesota counties as well as parts of two Canadian provinces, Ontario and Manitoba. This region is sparsely populated and recent trends indicate this situation is not likely to change in the near future. A population growth of only eight percent occurred between 1970 and 1980 in the United States portions of the region, while Canadian portions have experienced a general decline during the period. Cities and towns in the region are few and scattered with the major population centres being Kenora and Fort Frances in Ontario, and International Falls, Baudette, and Warroad in Minnesota.

The economy of the region relies heavily on the pulp and paper industry. Boise Cascade Corporation owns and operates several large mills in Kenora and Fort Frances. Tourism ranks as the area's second most important industry with excellent fishing, many resorts, outfitters, national and provincial parks, and recreational opportunities available. The Namakan chain of lakes has been the focus of tourism development, but has shown no growth or modest decline, in recent years. Other industries of importance include hydroelectric power generation, commercial fishing, agriculture and, to a limited degree, the mining of iron ore.

Important water interests in the watershed include: Boise Cascade Corporation which utilizes a portion of the hydroelectric potential of the region to support its paper production operations; resort owners and outfitters, who rely on stable summer lake levels and good fishing conditions for recreational activities which provide their livelihood; United States National Park Service represented by Voyageurs National Park, which is interested in “improving” levels on the Namakan chain of lakes to enhance fish and wildlife habitats and production within the park; naturalists representing Superior National Forest and Quetico Provincial Park, who maintain large portions of the headwaters area as a natural wilderness area, part of which is designated as the Boundary Waters Canoe Area; domestic and industrial water users as represented by municipalities within the watershed.

In addition, the lower portion of the watershed is the homeland to over 7,500 Ojibway Indians. The Ojibway depend upon the waters of the area for travel, fishing, trapping and, most important, wild rice production. Because of the close relationship of the watershed to the Indian's spiritual and physical lives, the Ojibway are keenly interested in factors affecting their usage of the waters.

4. REGULATION

4.1 Historic Background

(1) Early Years

The history of regulation in the Lake of the Woods watershed dates back to about 1887 when the Canadian government authorized construction of what was known as the Rollerway Dam in the western outlet of Lake of the Woods near Kenora, Ontario, to improve navigation conditions. Between 1893 and 1895 the Keewatin Power Company, under authority of the Ontario government, constructed Norman Dam in the Winnipeg River about one mile (1.6 km) below the Rollerway Dam, which was removed in 1899. In 1906, the Kenora, Ontario, municipal power station was constructed across the eastern outlet of Lake of the Woods at Kenora.

In 1909, the Ontario and Minnesota Paper Company completed construction on the dam spanning the Rainy River between International Falls, Minnesota, and Fort Frances, Ontario. The last structures, of significance to regulation, constructed in the watershed were the Kettle Falls Dams, completed by the Rainy River Improvement Company in 1914.

(2) Lake of the Woods Reference

Norman Dam had a marked effect on Lake of the Woods levels, maintaining them about 3.5 ft. (1.07 m) above natural conditions. As a result of this, there were numerous complaints of high water from south shore settlers in Minnesota. As well, United States Engineers, involved in the Warroad, Minnesota, harbor project, felt that the dams could be operated to maintain more satisfactory (higher) levels during the navigation season. These problems were magnified by the low water conditions of 1910 and 1911 and attempts by certain United States interests to direct some of the water from Lake of the Woods watershed into Lake Superior, via Birch Lake. In an effort to resolve these problems, the Lake of the Woods Reference was transmitted to the International Joint Commission on June 27, 1912, by the governments of Canada and the United States.

The reference sought the answer to questions regarding the most advantageous use of the waters of the Lake of the Woods and sought recommendations on lake regulation. The Commission held public hearings on the matter at International Falls and Warroad in 1914; at International Falls, Warroad, and Kenora in 1915; at International Falls and Winnipeg in 1916; and final arguments the same year in Washington, D.C. Consulting engineers completed field investigations in 1917 and, supplemented by its own studies of the various water interests in the region, the Commission submitted its “Final Report” to the two governments in May, 1917. Briefly, the conclusions and recommendations of the report were as follows:

(a) The ordinary maximum stage on Lake of the Woods should be elevation 1061.25 ft. (323.47 m) m.s.l. with extreme low level at elevation 1056.0 ft. (321.87 m) m.s.l., and extreme high level at elevation 1062.5 ft. (323.85 m) m.s.l.

(b) The ordinary maximum stage may be slightly increased after regulation experience is gained.

(c) The governments should acquire flowage easements to elevation 1064.0 ft. (324.31 m) m.s.l.

(d) It was both advisable and possible to regulate volume, use, and outflow of the water of Lake of the Woods.

(e) The outflow capacity of Lake of the Woods at elevation 1061.0 ft. (323.39 m) m.s.l. should be increased to 47,000 ft^3/s (1330 m^3/s) and Norman Dam should be utilized for regulation purposes.

(f) Advantage should be taken of existing reservoir capacity on Rainy Lake and the lakes immediately above Kettle Falls.

(g) The reservoirs should be enlarged when demands for power warrant.

(h) There should be international control of all dams and works extending across the international boundary, the Canadian Dam at Kettle Falls, and the regulating works and dams at the outlet of Lake of the Woods, when the level rises above elevation 1061.0 ft. (323.39 m) m.s.l. or falls below elevation 1056.0 ft. (321.87 m) m.s.l.

(3) 1925 Convention and Protocol

On February 24, 1925, in Washington, D.C., a Convention and Protocol between governments was signed with ratifications later exchanged on July 17, 1925. The Convention and Protocol, basically, adopted the recommendations of the Lake of the Woods Reference as the basis for regulation of Lake of the Woods. In addition, the Convention provided for the following:

(a) The establishment of the Canadian and International Lake of the Woods Control Boards.

(b) Regulation to provide the highest continuous uniform discharge from the lake between elevations 1056.0 ft. (321.87 m) m.s.l. and 1061.25 ft. (323.47 m) m.s.l.

(c) No waters were to be diverted from Lake of the Woods to any other watershed without approval of governments.

(4) Rainy Lake Reference

At the moment the Convention and Protocol was signed, identical letters of reference from the governments were transmitted to the Commission, submitting questions as to the regulation of the levels of Rainy Lake and other upper boundary waters.

During September, 1925, an initial public hearing to gather information on the matter was held at International Falls, Minnesota. Numerous written protests were recorded from towns, municipal organizations, conservation and other societies, and individuals against any change in levels in the Rainy Lake watershed. Oral statements were made on behalf of state, provincial, and municipal governments as well as various industrial interests on both sides of the boundary.

The scope of the investigation was of such a complex nature that the Final Report of the engineers to the Commission was not submitted until April, 1932. Following public disclosure of this report, the Commission met twice, in Ottawa in October 1932, at the regular meeting of the Commission, and in Washington, D.C., in April 1933, at a special meeting, with representatives of the Receivers of the Minnesota and Ontario Paper Company. Discussions were held regarding the merits of alternatives, proposed by a separate study commissioned by the company, to the recommendations of the Final Report of the engineers.

Final hearings were held in Winnipeg and in Minneapolis in October 1933. Briefs and other statements were filed and oral testimony given on behalf of Canadian and United States interests. The "Final Report" of the International Joint Commission on the Rainy Lake Reference was submitted to governments in May 1934. The conclusions and recommendations reached by the Commission were as follows:

(a) The upper limit of the ordinary range of levels on Rainy and Namakan Lakes should remain, respectively, elevation 1108.61 ft. (337.90 m) m.s.l. and elevation 1120.11 ft. (341.41 m) m.s.l., with the need to exceed these levels at some point in the future, unlikely.

(b) Limited development of boundary waters above Namakan Lake could be warranted in the future, but decisions regarding this development should be left until that time.

(c) No interests, other than the owners and operators, were benefitted by the storage in Rainy and Namakan Lakes, provided by the dams at Fort Frances/International Falls and Kettle Falls. Therefore, no apportionment of cost among the various interests for this storage was required.

(d) It would be wise and in the public interest that the Commission be empowered to determine when emergency conditions exist in the Rainy watershed, whether by reasons of high or low water, and to adopt such measures of control deemed necessary with respect to the existing dams at Kettle Falls and International Falls and any future works in the watershed.

(5) Rainy Lake Convention

The recommendations of the Commission's "Final Report" on the Rainy Lake Reference were accepted as a basis of agreement for a Convention between governments, which came in force, upon exchange of ratifications by governments, in October 1940. The 1940 Convention did not define any specifics for the regulation of the upper boundary waters but clothed the IJC with the power to determine when emergency conditions exist in the Rainy Lake watershed and to adopt control measures as necessary with respect to the existing or any future dams in the watershed, in the event the Commission determines that emergency conditions exist. In 1941 the IJC created the International Rainy Lake Board of Control and directed it to examine and report on the issue of emergency conditions.

(6) 1949 Regulation Order

After detailed study and recommendations by the International Rainy Lake Board of Control and public hearings held in 1941 and 1946, the Commission issued its Order of June 8, 1949, which provided that:

(a) The International Rainy Lake Board of Control would have general supervision over regulation of Rainy and Namakan Lakes at all times.

(b) Emergency conditions existed on Namakan Lake when its level was higher than 1118.61 ft. (340.95 m) m.s.l. or fell below 1108.61 ft. (337.90 m) m.s.l. Emergency conditions existed on Rainy Lake at levels above 1108.11 ft. (337.75 m) m.s.l. or below 1104.61 ft. (336.69 m) m.s.l.

(c) The levels of Rainy and Namakan Lakes would be regulated, to the extent existing facilities permitted, according to rule curves (see Figures 7 and 8) with any wide variations subject to Board and Commission approval.

(d) Whenever the level of Rainy Lake was below its rule curve, an average 6,000 ft^3/s (170 m^3/s) discharge would be in effect except: when the level was below the rule curve on 1 July and average inflow was less than 10,000 ft^3/s (283 m^3/s), the outflow would then be 4,000 ft^3/s (113 m^3/s) until levels returned to the rule curve; or when the level was at any time more than 2 ft. (0.6 m) lower than the rule curve and inflow since the first of the month under consideration was less than 10,000 ft^3/s (283 m^3/s), the outflow would then be reduced to 4,000 ft^3/s (113 m^3/s) until "rule" levels were reached and/or inflow rose above 10,000 ft^3/s (283 m^3/s), since the first of the month being considered.

(e) The man-made barrier which obstructed the Bear Portage overflow was not to be altered in any way by anyone without permission of the Commission.

The rule curve approach to the regulation of Rainy and Namakan Lakes, provided by the 1949 Order, seemed a good compromise between the desires of riparian interests for uniform levels year-round and the desires of the power interests for fluctuating levels to obtain outflows when required.

It is noteworthy that the emergency levels defined by the IJC reduced on both lakes the operating ranges approved at the time of dam construction. On Rainy Lake the upper limit was lowered by 0.5 ft. (0.15 m) and the lower limit was raised by 3 ft. (0.91 m). On Namakan Lake the upper limit was lowered by 1.5 ft. (0.46 m).

Also, while the 1949 Regulation Order was based for the most part on the IRLBC Report to the IJC of March 1948, there was one major deviation from the Board's report. This dealt with the definition of "emergency conditions". In the 1940 Convention, the IJC was "...empowered to adopt such measures of control as to it may seem proper... in the event, the Commission shall determine that such emergency conditions exist." The Board proposed that emergency conditions be defined "whenever the relation between inflow and outflow is such that immediate action must be taken to increase (or decrease) the rate of outflow in order to prevent the water level of the reservoir from rising above (or falling below)..." specified elevations. According to the wording of the Treaty, this definition would have given the IJC explicit power throughout the entire operating range of Rainy and Namakan Lakes, depending on inflows. However, the IJC took a different approach. It stated that, in order to prevent the occurrence of emergency conditions, it is necessary to anticipate high and low inflows and to regulate outflows so as to preclude the occurrence of emergency conditions. The IJC then defined the emergency conditions in terms of absolute levels as given in (b) above. Consequently the Commission interpreted that it was empowered to act not only "in the event" of emergency conditions but also "to preclude the occurrence" of such conditions.

(7) 1957 Supplementary Order

Excessive spring runoff during the years 1950 and 1954 caused both Rainy and Namakan Lakes to exceed their respective summer rule curve elevations by 1.4 feet (.43 m) to 4.9 feet (1.5 m). Numerous complaints, primarily from recreational interests in the Namakan chain of lakes area, were lodged with the Commission regarding the adverse impacts of the high water levels. The International Rainy Lake Board of Control held a public meeting at International Falls, Minnesota, in April 1955 during which a number of points of misunderstanding regarding the Board's involvement in the regulation process were clarified.

As a result of the complaints over the high water levels in 1950 and 1954, the Commission, in a directive issued in April 1956, requested the Board to prepare a report covering the possibilities of formulating and putting into effect a revised method of regulation for Rainy Lake and the Namakan chain of lakes. The Board submitted its report to the Commission in July 1956. The findings of the report responded to four questions set forth in the April 1956 directive and were essentially as follows:

(a) The Commission’s Order of June 8, 1949, was generally satisfactory.

(b) The Terms of the Order were essentially met, except for the extreme high water years of 1950 and 1954.

(c) The Board should be authorized to vary from the rule curve elevations at its discretion.

(d) No change was suggested in the Rainy Lake rule curve. However, a maximum rule curve to be used in conjunction with the existing rule curve was suggested for Namakan Lake as beneficial to the various interests by providing greater flexibility of operation. Maximum allowable elevations on the lake would be increased from 1 October to 1 June with the lake being operated between the two rule curves.

(e) No change was required in the existing control works. However, it should be mandatory for the owners to maintain the existing works in good operating condition.

The recommendations of the Board were considered by the Commission, while public hearings on the matter were held in August, 1956, at International Falls, Minnesota. They were adopted when the Commission issued a Supplementary Order dated October 1, 1957, amending the 1949 Order. The Supplementary Order was to be in force until September 30, 1962. The Commission, after holding public hearings, extended the termination date of the 1957 amendment on two occasions, October 2, 1962, and April 5, 1967, for additional five year periods. The last extension was to have expired on October 3, 1972.

(8) 1970 Supplementary Order

Because of high and low water conditions on Rainy and the Namakan chain of lakes from 1957 through 1968, the rule elevations were violated on many occasions, culminating in the extreme high levels during July 1968 of 1110.16 feet (338.38 m) m.s.l. on Rainy and 1121.09 feet (341.71 m) m.s.l. on Namakan Lake. The levels of 1968 resulted in reports of damage to tourist resorts on Crane and Kabetogama Lakes, part of the Namakan chain of lakes.

In August 1968, the Commission directed the International Rainy Lake Board of Control to consider and report to the Commission upon the advisability of an early examination of further regulatory measures in the Rainy Lake watershed. Experience had demonstrated the difficulties of trying to regulate Rainy and Namakan Lakes to precise elevations on certain dates, under all conditions of supply and also the desirability of further qualifications of the Commission’s determination of “emergency conditions” within the meaning of the Rainy Lake Convention.

The Board presented its proposals before the Commission in October, 1968, at which time the proposals were approved and the Board was requested to carry out a review of regulation on the lakes. The Board's report to the Commission, dated March 1969, was made public at once to all interested persons. A public hearing on the matter was held at International Falls, Minnesota, in June 1969.

At the hearing testimony was made on behalf of the Province of Ontario and the State of Minnesota, the Manitoba Hydro-Electric Board, the City of Winnipeg Hydro-Electric System, the Hydro-Electric Power Commission of Ontario, the Ontario-Minnesota Pulp and Paper Company Limited, the operators of tourist, fishing and hunting camps, resorts and various individuals.

The International Rainy River Pollution Advisory Board reported to the Commission in April 1970 that when the outflow from Rainy Lake is low, unsightly fibrous sludge deposits on the bed of Rainy River are exposed; that this condition becomes increasing ly offensive when the outflow is less than 4,000 ft^3/s (113 m^3/s); and that at a streamflow of 3,300 ft^3/s (93.4 m^3/s) dissolved oxygen in Rainy River is below the objective of 5 milligrams per litre.

On July 29, 1970, the Commission issued a Supplementary Order amending the previous Orders. The key provisions of the 1970 Order were as follows:

(a) Emergency conditions exist in and along the shores of Rainy Lake and the Namakan chain of lakes when the level of Rainy Lake is above elevation 1108.1 ft. (337.75 m) and the level of Namakan Lake is above elevation 1118.6 ft. (340.95 m) m.s.l., excluding wind and current effects, and the inflow is in excess of the outflow capacity of the existing structures at International Falls and Kettle Falls.

(b) Emergency conditions also exist when the levels of Rainy and Namakan Lakes are lower than elevations 1104.6 feet (336.68 m) m.s.l. and 1108.6 feet (337.90 m) m.s.l., respectively, and outflows are reduced to the minimum values prescribed by the Commission.

(c) Insofar as possible, high and low inflows to Rainy and Namakan Lakes should be anticipated so that the discharge capacities of the dams at International Falls and Kettle Falls are used to best advantage to prevent the occurrence of emergency conditions.

(d) The companies, their successors or assigns should operate the discharge facilities at International Falls and Kettle Falls, as authorized by the International Rainy Lake Board of Control, in such a manner that the levels of Rainy and Namakan Lakes would be between their maximum and minimum rule band values on certain dates as shown in Figures 7 and 8.

(e) When the level of Rainy Lake is above elevation 1108.6 ft. (337.90 m) m.s.l., the dam at International Falls is to be discharging at full capacity. Similarly, when the level of Namakan Lake is above 1119.1 ft (341.10 m) m.s.l., the Kettle Falls Dams are to be discharging at full capacity.

(f) When the level of Rainy Lake falls below the specified minimum rule curve elevation, the outflow from the International Falls dam is to be reduced to 4,000 ft^3/s (113 m^3/s) between sunrise and sunset in the months of May to October and to 3,300 ft^3/s (93.4 m^3/s) at all other times. The outflow at Kettle Falls is to be reduced to 1,000 ft^3/s (28.3 m^3/s) whenever its level is below the minimum rule curve.

(g) The International Rainy Lake Board of Control, upon obtaining Commission approval, was empowered to authorize Rainy and/or Namakan Lake levels to be temporarily raised above or lowered below their respective rule bands.

(h) All obligations of the June 8, 1949 Order, as amended by the October 1, 1957 Supplementary Order and by the July 29, 1970 Supplementary Order, upon the Companies, their successors or assigns, applied jointly and severally to Boise Cascade Corporation, Minnesota and Ontario Paper Company (merged into Boise-Cascade Corporation in 1965), Rainy River Improvement Company and the Ontario-Minnesota Pulp and Paper Company Limited.

(i) The man-made barrier which existed for many years at the Bear Portage natural overflow outlet, and which had deteriorated by natural process, was not to be modified in any way by anyone without permission of the Commission.

(9) Supplementary Orders since 1970

To date six Supplementary Orders have been issued by the Commission, primarily to authorize minimum flow deviations during periods of low levels on Rainy and Namakan Lakes. These Supplementary Orders, which have all expired, are dated October 20 and 28, 1976, November 19, 1976, May 4, 1977, June 14, 1977, and May 7, 1980. Currently, only the Commission's Order of June 8, 1949, as amended by the Supplementary Orders of October 1, 1957 and July 29, 1970, remains in effect as the basis for regulation of Rainy Lake and Namakan Lake.

The regulation criteria currently in place for Lake of the Woods, Rainy and Namakan Lakes are summarized in Figure 9.

4.2 Constraints to Regulation

Regulation operations in Rainy-Namakan and Lake of the Woods basins are constrained by imperfect foreknowledge and physical or hydrologic limitations. These are discussed below.

(1) Imperfect Foreknowledge

In order to regulate these lakes within their prescribed limits, it is necessary to anticipate future inflows. If it were possible to have perfect foreknowledge of inflows, regulation would be a simple task. However, this is not the case. Because of the size of these lakes, the amount of precipitation that occurs over a period of hours to a few days is not normally of concern. It is true that sustained heavy rain for several days can have a temporary effect on lake levels, especially with Rainy and Namakan Lakes. However, it is generally the average amount of precipitation that persists over several weeks to over a season that will have an impact on levels. Unfortunately, the current state of precipitation forecasts is such that quantity estimates for even a few days are unreliable and no useful longer-term forecasts are available. Further, even if precipitation is known, the amount lost to evapotranspiration, infiltration and other factors is highly variable. Consequently it is impossible to have full knowledge of inflows to the system.

It is often felt that forecasts should be possible at least at some times of the year. For example, it should be possible to use winter snowpack to predict spring runoff. However, as shown on the left side of Figure 10, snowpack in the Rainy River basin on average contributes only about one-third of the water available for runoff - spring rains are a more significant factor. This is also illustrated by the top two correlation graphs on the right side of Figure 10. Further, as shown by the bottom graph, even when both inputs are known, a wide variation in runoff is possible. This may be due to:

- inaccurate estimates of mean areal snowpack and rainfall due to extrapolation from a limited number of point measurements;
- temperature, solar radiation, wind, ground frost, antecedent basin storage and other factors affecting melt and runoff rates.

Attempts are made to take advantage of basin streamflow travel times to predict inflows at downstream sites. However, increased forecast time (travel time) is gained at the cost of reduced contributing drainage area. For example, Lac La Croix outflows may take one week or more to reach Rainy Lake but they contribute only 39 percent of average Rainy Lake inflows. Further, travel times are highly variable in the headwaters area due to the storage effects of innumerable lakes.

Today it is possible to have a much better picture of current conditions throughout the basin than was possible in the past, due to the number of stations providing precipitation and streamflow data on a real-time basis. It is doubtful that major inputs to the system would go completely undetected as happened in the past. However, spatial coverage is still limited, inhibiting the estimation of areal extent and magnitude of events. Also, due to access problems, gauge and telemetry malfunctions may result in missing data for extended periods.

All of the aforementioned factors combine to create an imperfect foreknowledge of future inflows on which to base regulation decisions. Because of this imperfect foreknowledge, release decisions must of necessity consider the risks of not filling or overfilling the lakes.

(2) Physical and Hydrologic Limitations

In any system the ability to regulate levels is a function of the variability and magnitude of the inflows and the physical characteristics of the system. With Rainy and Namakan Lakes and Lake of the Woods, the ability to not exceed upper level limits is constrained by the outflow capacity of the structures and the machinery available to open sluiceways. The ability to maintain lower level limits is constrained by the net available inflows, the machinery available to close sluiceways, structural leakages and the Gold and Bear Portage uncontrolled overflows.

The benefits of any increase in outflow capacity from a reservoir must be carefully weighed against the disbenefit of higher inflows to downstream sites. Nevertheless, it could be argued that the outflow capacity of the dams on Namakan Lake and Lake of the Woods is inadequate in that inflows which exceed outflow capacity occur at some point in most years. This is also true to a lesser degree for the Rainy Lake dam. The situation is most severe in Namakan Lake. The situation occurs more frequently during spring freshet but also occurs during prolonged periods of summer or fall rainfall. During these periods lake levels are out of control. If heavy runoff is anticipated in the spring, the only course of action available is to draw the lake level lower prior to the event commencing. This may require the spilling of water and the loss of valuable storage. In spite of this, inflows may be such that specified limits are exceeded. However, if inflows are less than anticipated, it may then be difficult or impossible to reach adequate summer levels. As to the summer and fall, when lake levels are normally near their upper limit, the occurrence of inflows greater than outflow capacity may well result in storage limits being exceeded, with no possible recourse. Figure 11 shows the effect of various inflows on the levels of Rainy and Namakan Lakes which existed in April of this year. As shown by the graphs on the left side, it is possible to maintain both lakes within their operating bands with a normal or 50 percentile inflow. However, as shown by the graphs on the right side, inflows of 75 percentile or greater would cause Namakan Lake to exceed its band, while Rainy Lake exceeds its band with inflows greater than 90 percentile.

The same graphs also give examples of inflows being inadequate to maintain minimum level requirements. With 10 percentile inflows, it is impossible for Rainy and Namakan Lakes to be maintained in their bands even with the outflows reduced to the minimum specified. If the end of winter levels had been lower, the results would be even more severe. Inadequate inflows may also occur in the summer and fall, as they did this year, when inflows less than the total of evaporation losses and the minimum outflow caused the level to decline.

The machinery available to open/close sluiceways was noted as a constraint to observing both upper and lower limits. The Lake of the Woods and Namakan Lake dams are stop-log structures. As described in Section 3.2, the equipment is primitive at all sites, but is the worst at the Canadian Dam on Namakan Lake. Stop-log movements are very cumbersome and time consuming and may be dangerous or impossible under high flow or winter conditions. Further, work crews must be transported from Fort Frances by boat or plane to the Namakan Lake dams. Consequently it is not possible to respond immediately to changing inflow conditions and considerable delay may occur. Also, stop-log control mechanisms are conducive to errors in flow changes, due to the potential for confusion over the number of stop-logs to remove from a particular sluiceway. This is particularly true when varying numbers of stop-logs are being removed from or installed in a large number of sluiceways.

In addition, the stop-logs at the above structures, and also the gates at the Rainy Lake dam, do not seal tightly. This results in uncontrolled flow leakage which, ordinarily, is a small percentage of the total outflow and causes no problem for regulation. However, during periods of low inflows, these uncontrolled leakages can represent a significant loss. Leakage has probably been the worst at the Namakan Lake dams, followed by the Lake of the Woods dam.

Finally, the natural overflows at Gold Portage and Bear Portage represent an uncontrolled loss from Namakan Lake into Rainy Lake. These overflows provide additional outflow capacity from Namakan Lake during high water periods, helping to reduce peak levels on Namakan Lake. Problems arise during periods of low inflows. At these times the overflows aggravate the problem of maintaining minimum levels on the lake by providing undesired releases.

4.3 Current Regulation

This section will consider the effectiveness of current regulation practices in achieving the level criteria specified for each lake. Lake of the Woods will be considered separately from Rainy and Namakan Lakes. For reference, the regulation criteria were summarized previously in Figure 9.

(1) Lake of the Woods

The ILWCB only becomes involved in the regulation of Lake of the Woods when levels exceed elevation 1061.0 ft. (323.39 m) or drop below elevation 1056 ft. (321.87 m). The normal operating range is 1056.0-1061.25 ft. (321.87-323.47 m) while elevation 1062.5 ft. (323.85 m) is not to be exceeded if at all possible.

A review has been made of the frequency with which these levels have been encountered. The period of record considered was 1927 through 1983 inclusive, 1927 being the first year that the lake's enlarged outflow capacity as called for in the 1925 Convention and Protocol was available. Considering mean daily levels, the following level frequencies have occurred in this 57 year period:

	Percent of Time
Below 1056.0 ft. (321.87 m)	1.36
Above 1061.0 ft. (323.39 m)	8.79
Above 1061.25 ft. (323.47 m)	4.32
Above 1062.5 ft. (323.85 m)	0.85

Levels have only fallen below elevation 1056.0 ft. (321.87 m) in March-May of 1930 and from September 1930 to April of 1931. Inflows during this period were the lowest on record (since 1893). Levels have risen above the operating band in a total of 18 out of the 57 years, for deviations ranging from 3 days to 178 days, the latter duration resulting from the flood of 1950. However, levels rose above the flood level of 1062.5 ft. (323.85 m) in only 2 years, 1927 and 1950, for periods of 68 and 109 days respectively. These years represent respectively the third largest and the largest floods on record.

Based on the above frequencies, there appears to be no cause for concern regarding Lake of the Woods regulation practices. Based on the first two frequencies in the above table, the mandate of the ILWCB has been exercised about 10 percent of time, the last occasion being in 1974. Figure 12 shows levels and flows to date in 1984.

(2) Rainy-Namakan Lakes

The current set of operating criteria for these lakes was issued in July 1970. Consequently only regulation under these criteria and since this time is considered herein. However, a full set of graphs of Rainy and Namakan Lakes levels for the period 1912-1983 is included in the Appendix. These graphs clearly show how the range of storage has been diminished and how levels have become much more regular and cyclical on these lakes under the IJC Orders. The graph of each year shows the IJC rule curve or band that was in place at that time, if any. In addition, level plots for Lac la Croix are provided. As this lake is naturally regulated, its level illustrates the magnitude and timing of inflows to the basin above Namakan Lake.

Level criteria on Rainy and Namakan Lakes are much more tightly defined than on Lake of the Woods. In addition, the variability of inflows relative to storage and outflow capacity is greater. Consequently deviations from the specified bands are more frequent. Figure 13 summarizes the frequency of deviations of Rainy Lake levels from its specified band for the 13-year period from 1971 to 1983 inclusive. The frequency of levels in excess of the specified flood level are also indicated. Figure 14 is similar to Figure 13 except that it summarizes the frequency of deviations greater than 2 in. (5 cm) from the specified operating band. Figures 15 and 16 provide similar summaries for Namakan Lake.

The frequencies of deviations shown in these figures appear high. However, a significant number of the deviations are relatively small deviations. Considering only deviations greater than 2 in. (5 cm) reduces the total percent of deviation time to about 20 percent from 31 percent in the case of Rainy Lake, and from about 25 percent to 17 percent for Namakan Lake. Also, the percent of time above the flood level, 1.4 percent for Rainy Lake and 0.6 percent for Namakan Lake, is quite small. In discussing constraints to regulation in Section 4.2, it was noted that it appears to be difficult or impossible to maintain levels in the operating bands with inflows over 90 percentile or under 10 percentile. If this is the case, deviations are to be expected about 20 percent of time, a number not too different from the frequency of deviations greater than 2 in. (5 cm). More work would be required to establish at what point deviations are impossible to avoid and what percentage of current deviations might be avoidable through better operation practices and more readily adjustable structures.

The relation between deviations and periods of high or low inflows is shown for Rainy Lake by Figure 17 and for Namakan Lake by Figure 18. On these graphs, the shaded bars for the inflow histogram indicate percentile inflows in the April-July period. This period accounts for about 50 percent of the total annual inflow to both lakes. The August-November and December-March periods account for the remaining 50 percent, with the fall period normally wetter than the winter. These graphs show that significant deviations from the operating bands generally occur when inflows exceed 90 percentile or are less than 10 percentile.

Figures 19 and 20 show the levels and flows for Rainy and Namakan Lakes for 1984 to date. Levels on these graphs are weekly rather than daily values and so tend to obscure deviations. However, deviations did occur above the Rainy Lake band in mid-June, at June month-end, and in mid-July. Also, deviations below the bands of both lakes occurred in late summer to fall. Namakan Lake levels dipped below its band from early September to mid-October, whereas the Rainy Lake deviation was greater and lasted from late August to early November.

Several comments can be made concerning these deviations. The deviation above the Rainy Lake band in June was supported by the IRLBC. When the level first exceeded the band, less than 3 weeks remained before the point of maximum band elevations would be reached. Based on an assessment of current basin conditions, the Board felt that advantage should be taken at that time of the available water to complete the lake refill. However, levels were not permitted to exceed the summer band level. Similar situations have occurred in other years. For example, the plots in the Appendix show both Rainy and Namakan Lakes deviating above the rising limbs of their operating bands in 1981 and 1982. In both these years the freshet arrived early and the Board was concerned that the spillage necessary to maintain levels within the bands might result in deficient levels later in the year.

Regarding the deviation at the end of June, it is the Board's opinion that operation by Boise exacerbated the situation. Levels were within the band and falling. To stabilize levels Boise began closing sluices. However, they apparently overreacted and reduced the outflow to about 7,000 ft^3/s (200 m^3/s) less than the current rate of inflow. This resulted in rapidly rising levels, a situation which was further compounded by moderate to heavy rainfall over several days directly on the lake. A less dramatic closure and a quicker opening would have prevented or diminished this event.

Regarding the deviations below the bands this fall, inflows to the Rainy Lake basin were far below normal and were less than the total of evaporation losses plus the minimum required outflow. The outflow was reduced to the minimum specified but levels clearly could not be maintained on Rainy Lake. In the Namakan Lake basin inflows were also low but levels within the band probably could have been maintained. Nevertheless they also were permitted to drop below the band, with the Board's approval, in order to ease the situation on Rainy Lake. A reduction in Namakan Lake outflows to their specified minimum in order to maintain Namakan Lake levels would have further reduced the inflows to Rainy Lake and caused its level to decline even further below its band. When the Namakan Lake level first dropped below its band, Rainy Lake levels had already declined to levels that would not be reached by the declining portion of its band for another month and a half. In contrast, as the Namakan band declines earlier, actual Namakan levels were only leading its declining minimum band levels by less than two weeks. Conversation with several interests on the lake revealed that this was not causing any problems. Consequently Namakan outflows were not reduced to minimum. The drought period ended in mid-October with several weeks of heavy rains. Namakan Lake levels quickly returned to within its operating band. However, in the case of Rainy Lake, Boise immediately increased its powerplant flows with the result that Rainy Lake levels hovered just under its operating band for another two weeks before finally entering the band in early November.

The above examples from the current year show several instances of lake level regulation by Boise Cascade being less than might be expected. This is not totally a function of Boise operating practices but also of the poor equipment at these sites. The examples also show that the current Board members view the operating bands, to a certain degree, as guides to regulation rather than as rules to be rigidly followed. The bands provide a general framework but may not give the best policy for any specific year. The Board believes that some variation to better suit the timing of individual freshets or to better balance the impacts of events such as droughts is appropriate. This view was apparently shared by the previous Board members who prepared the 1956 Report to the IJC prior to the 1957 IJC Order. They stated that the rules of the time should be targets, not requirements. However, the Board members who prepared the 1969 Report of the Board prior to the 1970 Orders stated that the bands, in particular the rising upper limbs, should be rigidly observed. The question of how the operating bands should be interpreted by the Board and of how tightly the operations of Boise Cascade should be controlled may be one requiring further study or direction from the IJC. In any case, the visual impression given by the graphs of levels in the Appendix is that the overall objectives of regulation are being met, even though absolute criteria may not be satisfied.

5. HYDROCLIMATOLOGY

Future availability of water is one of the primary uncertainties in the planning and regulation of water resource projects. Traditionally, hydrologists have relied upon classical statistical analyses and assumed that the past hydrologic record is representative of the events likely to occur in the future. However, this approach does not account for long-term climatic variation or change. Reconstruction of climatic history provides sufficient evidence to document that climate is not stationary. In the last 1,000 years, no two centuries were anything alike. The climate of the last 100 years is not typical of the previous 1,000 years. In the perspective of the last one million years, it is very abnormal. Although it is unlikely that catastrophic climatic changes will occur in the near future, significant variations in climate are expected to occur because of natural variations and/or perhaps man-induced variations in the chemistry of the atmosphere. Therefore, the consequences to water resource management, planning, and project operation, of projecting the statistical properties of the past record to the next 50 to 100 years, could be quite adverse and this underscores the compelling need for water resource managers to anticipate future climatic conditions.

In the upper Mississippi River watershed, there is a definite pattern and link between climate and water levels in the lakes and streams of this region. This pattern is not merely a within-basin process, but rather it is a basin response to a major anomaly in the atmospheric circulation; an anomaly that is often near hemispherical in areal magnitude. This pattern of variation in runoff is also found in the lower Rainy Lake watershed as manifested by the Rainy River at Manitou Rapids, and is a classic example of hydrologic persistence in the flow records. Hydrologic persistence is defined as the tendency for high flows to follow high flows and low flows to follow low flows, and is attributed to storage processes in the atmosphere and in the drainage basin, either surface or subsurface.

Historically, the Lake of the Woods watershed has experienced periods of extreme high and low lake levels, which have caused hardship for the various water interests in the region. It is prudent to consider the effects of long-term climatic variations and their impacts on water requirements as a risk management procedure, in planning for the watershed's future socio-economic growth. By developing possible future hydroclimatic scenarios, water resource managers may be able to anticipate future climatic variation, thereby improving regulation, planning, and management of the water resources of the Lake of the Woods watershed.

At the IRLBC Public Meeting in Fort Frances this spring, a presentation was made describing the impact of climatic trends on water levels and flows. The need to plan for and adjust to future changes was noted. The Board stated that basin residents should define their requirements, desires and constraints and present these to the policy makers.

6. CONCERNS

The International Board members are aware of a number of concerns regarding lake regulation held by different interests in the Winnipeg River basin boundary waters. The members also have a number of their own concerns. These are dealt with in the following two sections.

6.1 Groups in the Basin

Concerns of groups in the Rainy-Namakan basin are summarized below. In general most input comes from the United States portion of the basin.

(1) Resorts/Outfitters

- Although the current regulation scheme has greatly extended and stabilized the period of high summer levels compared to natural conditions, it appears that those in the tourist industry would prefer a longer season, primarily through high levels being achieved earlier in the spring but also through some extension into the fall. Most of the interest in this regard pertains to Namakan Lake. A main concern is adequate navigation levels by the start of fishing season in mid-May. Several outfitters in the Ash River area who rent houseboats require levels close to the summer range in order to navigate the river and are quite vocal on this issue.

- There is some concern that early-May levels on Rainy and Namakan Lakes are typically too low for good fish spawning conditions. Some claim that minimum water levels suitable for spawning are above the upper limits of the current operating bands in the first two weeks of May. However, this view is not supported by a 1981 report by the Minnesota Department of Natural Resources on the effects of water levels on Walleye and Northern Pike reproduction. This report states that levels lower than the operating band are still adequate for spawning in Namakan Lake. The report was less definite regarding Rainy Lake, noting that there was no evidence of water levels being detrimental but stating that conditions might be better with higher levels. Although the mean level during spawning has actually been lower in both lakes since the 1970 IJC Orders came into effect, fish stocks have increased, presumably due to factors such as reduced fishing pressure.

- There is a general awareness that flows through Gold Portage are increasing. There is concern that continued erosion will lead to lower Namakan Lake levels.

- There is growing concern about the impact of Voyageurs National Park (U.S.A.) on the area. With the expropriation and closing of resorts in the area by the Park Service, it is felt that access to the area has been reduced and has been restricted to only people capable of outdoors camping. Many claim a decline in business due to the Park. Further upstream in the basin, in the Superior National Forest in the United States and Quetico Provincial Park in Canada, motorized access of any kind is banned in some areas and the land is preserved as wilderness.

There appears to be a growing reaction by tourist operators in the United States. One claim being made is that such restrictive practices may violate the "free access" clause of the Boundary Waters Treaty.

- There is a general feeling that regulation of lake levels still favours power production by Boise Cascade in Fort Frances-International Falls, to the detriment of other interests. At public meetings it is often stated that the IRLBC should exercise more control over Boise Cascade, particularly in the spring when levels are low and inflow prospects seem poor. It is felt that reacting only when the operating band limit is reached is too late.

(2) U.S. Forest Service/Quetico Park

- Both Services intend to continue their policy of non-motorized access and the restriction of any development that impacts on the wilderness experience. Hydrometeorological monitoring stations and associated equipment are viewed as undesirable.

(3) Voyageurs National Park (VNP)

- While U.S. Park Service policy does not favour artificial regulation, the Park Service recognizes that a return to natural conditions on Rainy and Namakan Lakes would not be appropriate. However, it does believe that changes might be made to the current operating bands to improve conditions for fish and wildlife. A study has been mounted toward this end. To date it includes the development of a computer model to simulate reservoir operations and the initiation of research to determine water level criteria for fish, marine life, shore nesting bird species and others. A paper on the computer model was presented at the Annual Conference of the American Water Resources Association in August of this year. Runs of the model to date have focussed on higher water levels earlier in the spring since the Park Service believes that this would be better for the fishery and certain bird species.

(4) Boise Cascade Corporation

- Those involved with water level regulation at Boise Cascade believe that strict adherence to the IJC operating bands leads to wastage of water. In particular they would prefer to allow levels to rise above the band when the spring runoff starts early.

- The company still harbours some resentment for the loss of storage and the loss of operating freedom when the IJC Orders were imposed.

- Although the company tried to sell the Namakan and Rainy Lake dams several years ago, it now apparently has decided that it should retain ownership. There is concern that the dams may be expropriated and this is reflected in a reluctance to make expenditures toward their maintenance or rehabilitation. If a long-term guarantee of continued ownership and continued benefit to the company was possible, expenditures might be more readily made. Plans currently exist for turbine upgrades in the American powerhouse at International Falls, but apparently no expansion is planned, as was once the case.

- There is apparently some feeling within Boise Cascade that the lakes could be regulated more effectively for power production within the operating bands. To this end the company has tentatively approached the IRLBC concerning the possible funding of additional gauging which might lead to better inflow forecasts.

Concerns of groups in the Lake of the Woods basin will be considered next. Basically, all interests are displeased with levels corresponding to the mandate of the ILWCB; that is, levels above 1061.0 ft. (323.39 m) or below 1056.0 ft. (321.87 m). The degree of dissatisfaction is probably greater with low water than with high water. However, most specific concerns lie within the range managed solely by the Canadian LWCB.

(1) Native People

- The main concern of the Ojibway Indians is the impact of water levels on the growth of wild rice. Generally water levels in the 1058-1059 ft. (322.48-322.78 m) range during the growing season from April through September are believed best, with the further restriction that the rate of rise of level should be limited during the plant's floating leaf stage, usually in June. Unfortunately June is typically the largest inflow month for Lake of the Woods and in many years it is not possible to restrict the rate of rise to tolerable limits. Further, full advantage must usually be taken of these inflows if adequate levels are to be reached for summer uses and winter storage needs. Usually the best wild rice crops coincide with drought years.

(2) Outfitters/Cottages

- Good summer recreational levels for boating are important to both Outfitters and Cottagers. Levels in the 1059-1060 ft. (322.78-323.09 m) are considered desirable.

- The fishery is very important to Outfitters and to most Cottagers. Concern has been very high in recent years due to declining fish stocks and consequently good spring spawning conditions have been considered to be crucial. For this purpose levels of at least 1058.0 ft. (322.48 m) by mid to end-April are desired.

(3) Hydropower

- Lake of the Woods is an important storage reservoir for Boise Cascade's powerplants at the outlets and for Ontario Hydro and Manitoba Hydro powerplants down the Winnipeg River. Full use of the available storage is a prime objective, with winter flows being the most important. Deeper winter drawdown might further this objective but would make the refill to levels needed for other users less certain.

6.2 Board

The concerns of the International Board members are outlined in turn under the following headings. The concerns are not ranked.

(1) Structures

The issue of structural condition and limitations of the dams controlling the outlets of Lake of the Woods, Rainy Lake and Namakan Lake have been discussed in Sections 3.2 and 4.2 of this report. The effect of these limitations on regulation of the lakes is of some concern, particularly at International Falls and Kettle Falls. Further, if these dams were being built today, their design would include consideration of the Probable Maximum Flood. Based on the frequency with which the outflow capacities of the structures is exceeded, it is doubtful whether these structures could withstand such an event. Consequently there is also some concern over the ultimate safety of these structures. As the Canadian LWCB and the IJC have a responsibility for regulation in this system, it is felt that they also have some responsibility for assuring themselves as to the adequacy of the structures by which regulation is achieved.

The age of these dams ranges from 70 to 86 years. The useful economic life of new concrete structures is normally considered to be 50 years without major rehabilitation. The overall condition of the dams is generally satisfactory at present, due in part to recent structural repairs. However, they have reached the point where major rehabilitation or replacement must be given some consideration, due to age and the vast amount of time that would be required to accomplish an international undertaking of this scope.

Major rehabilitation of these dams would remove existing structural limitations, could provide greater hydraulic efficiency for hydroelectric power generation and flood control, and would insure reliable control of lake levels in the Lake of the Woods watershed well beyond the year 2000.

(2) Data Quality

The recent hydrologic model study, undertaken by Voyageurs National Park, and efforts by the Lake of the Woods Secretariat to model the Lake of the Woods watershed, have underscored deficiencies in the historic record of outflows from Lake of the Woods, Rainy Lake and Namakan Lake. These deficiencies have resulted from use of inaccurate flow ratings in computing outflows, unmeasured flow leakages through the dams, and the natural overflows at Gold and Bear Portages. It is felt that the effects of these deficiencies on the historic outflow records should be assessed to determine their significance and efforts should be made to correct them. For the current VNP study, and for any future study on regulation that may be required by the IJC, it is important to have as accurate records as possible and, further, to know how data errors may influence the study results.

Some of the data problems are listed below:

- Namakan Lake
    - flow records are only for the Kettle Falls structures and do not include the two overflows. If the lake level falls below the lower limit in the summer period and structural outflows are reduced to the minimum, the error in the historic record due to unrecorded Gold Portage flows would be 43 percent. With the average levels and outflows recorded for September, the error is 14 percent.
    - one overflow, Gold Portage, has enlarged tenfold since 1958.
    - the Kettle Falls rating curve still in use has not been applicable since 1962-69 when the structures were rehabilitated.
    - leakage has at times been significant but has mostly been undocumented.
- Rainy Lake
    - theoretical ratings are used but the approach conditions and the location of the headpond gauges severely violate the assumptions made.
    - the spillway discharge coefficient was arbitrarily changed from 0.68 to 0.60.

- uncertainty exists over whether the removal of pulpwood grinders from the U.S. side rendered the ratings invalid.

- Lake of the Woods

    - periodic leakage problems.

    - new rating adopted in 1971 - comparison shows that the new rating yields on average 7 percent greater outflow for the same conditions. Previous records have not been adjusted, yet, since no structural changes have occurred, the new rating should be just as applicable right back to 1927 as since 1971.

    - outflows are generally believed to be incompatible with flows recorded just downstream at the Whitedog powerplant. Some say that the situation is worse with the new rating.

(3) Boise Cascade Operations

Boise Cascade Corporation is responsible for the operation of the structures controlling Rainy and Namakan Lakes. Basically this operation has been adequate. The historical water level graphs in the Appendix show that the IJC level objectives have generally been followed. Further, from the analysis in Section 4, it is clear that the major periods of deviation from the operating bands could not have been prevented. However, the Board believes that improved regulation practices might have reduced the severity of these periods and might have eliminated some of the more minor deviations. Currently, regulation decisions are made by Boise Cascade personnel who have not had the benefit of formal hydrologic training and who have little time amid their other duties to devote to this task. Decisions do not always utilize all available basin information and data analysis is limited. Regulation operations could improve if given a higher priority within Boise Cascade and if based on a more comprehensive program of data collection and analysis. Ideally, trained hydrologists should be involved.

(4) Gold Portage Overflow

Details on this overflow were given in Section 3.2. As outlined in recent IRLBC annual reports to the IJC, a discharge rating has been developed for the overflow and is being continually updated, gauging has been installed to monitor daily flows and erosion is being monitored annually at several sections. Current indications are that the erosion has slowed down or stopped. However, the site must be watched closely in the future since continued erosion could further diminish the ability to control the levels of Namakan Lake. If further enlargement occurs, it will be necessary to consider a structure at this site. As it is, its capacity at the lower limit of summer levels is approximately half of the minimum outflow specified in the IJC Orders. In this context it is important to note that the IJC Orders specify the minimum outflow as "...the total outflow from the dams at Kettle Falls...". Thus the actual minimum outflow at such times could be up to 1.5 times the minimum specified.

(5) Gauge Access

Streamflow gauges at the outlets of Lac la Croix and Basswood Lake, upstream of Namakan Lake, are important indicators of inflows for the IRLBC and for Boise Cascade. However, the area in which the Basswood gauge is located has recently been declared a non-motorized area of Superior National Forest and a similar policy, though unlikely, has been discussed for Lac la Croix. With no motors permitted, it is now a long and difficult journey by canoe in summer or snowshoe in winter to service the Basswood gauge. This may result in degraded data quality and in periods of missing records when malfunctions occur. Further, any additional gauging desirable in the future is likely to involve sites in Superior National Forest or Quetico Provincial Park. Under current policy it would be very difficult to gain permission for a gauge installation in such an area and, if installed, access would be an ongoing problem. The IRLBC intends to ask the U.S. Geological Survey and the Water Survey of Canada to negotiate a solution to this problem with the agencies involved. If no solution is forthcoming, it may be necessary for the IJC to become involved.

(6) Study by Voyageurs National Park

As outlined in Section 6.1, a study is underway by Voyageurs National Park concerning the current IJC operating bands for Rainy and Namakan Lakes. The IRLBC understands that this study will not be completed for some time yet but fully anticipates that, once the study is complete, the Board and/or the IJC will need to address the conclusions of the study and whether or not the operating bands should be adjusted. The Board met with the Park Service in April of this year to learn more of the study. In the ensuing discussion, several recommendations were made by Board staff regarding the simulation model. These centred on the need to perform sensitivity tests to determine the impact of potential data errors on model results, the need to use various periods of historic inflow record to ensure that any modified operating bands could accommodate the variation and trends in inflow which the record displays, and the need to account for the fact that the model has perfect foreknowledge of inflows one month in advance whereas, in reality, water level managers must cope with much more uncertainty. In addition, the Board strongly recommended that the Park Service should attempt to consider in the study the concerns of all affected interest groups on the lakes as a better, more complete report would result and, in any case, all interests would have to be considered at some point before any action could be taken. The Park Service subsequently requested the Board to assist in assembling a forum of affected parties to discuss concerns to be addressed by the study. However, as directed by the Commission, the Board responded that while its support staff could provide some assistance in proposing attendees and providing encouragement and advice, the Board could not become directly involved as this would compromise its ability to impartially assess any resultant proposal. No further follow-up in this regard has taken place. However, the Board support staff has complied with a number of requests for hydrologic and hydraulic data and other information and the Park Service has been very open about its work in return. In addition, the support staff, as well as Boise Cascade representatives, attended a workshop held by Park Service researchers on the project. Based on these contacts, the Board understands that environmental issues are being addressed in a very comprehensive manner. However, without input from other groups, other interests are not likely to be similarly considered. Also, as any modelling work is of necessity dependent on simplifying assumptions and the data available, the results are subject to interpretation. Consequently, the Board is concerned that the study may not result in any clear solutions. An IJC-sponsored investigation may ultimately be required.

(7) Support for Board Activities

In recent years the amount of public pressure on Control Boards and other agencies involved in water resource management has been increasing. Unfortunately, at the same time, restraint programs in both countries have limited the resources available to respond to the new requirements. It is felt that IJC Boards in particular may be affected by this situation. Resources are not provided directly by the IJC. Board members and their support staff serve the IJC on a part-time basis, using to a certain extent the resources available to them through their main programs. With restraint, it is more difficult to divert the resources, in particular manpower, from main programs to support needed IJC activities. In the case of the IRLBC, resources are not available to address the data problems mentioned under item 2 nor to thoroughly address the questions likely to result from the study mentioned under item 6. The IRLBC is most likely not unique in this regard. The IJC may need to consider the means by which its work is to be conducted in the future.

(8) Board Role

The role of the IRLBC needs to be clarified in several regards. For example, the Board has held public meetings for many years. The public attends in the belief that their concerns will be listened to and responded to. They expect the Board to be proactive in addressing their regulation concerns and to anticipate water shortages or surpluses. In fact, the Board has no such mandate. It can only be reactive to the directives of the IJC and to violations of the operating bands. What is the duty of the Board regarding the concerns of the public? Might not a proactive approach at times better serve the community? Is the initiative mentioned in the last paragraph of Section 5 acceptable?

Regarding the study by Voyageurs National Park, the IRLBC sees a lack of leadership in bringing together the parties concerned over regulation issues and progressing to an amenable solution. The Board seems to be a logical vehicle for addressing such concerns but does not have the resources to become involved and has been directed by the IJC not to become involved. How should these issues be resolved?

Regarding regulation of Rainy and Namakan Lakes, the 1970 IJC Order states that “The Companies .... shall operate the discharge facilities .... as authorized by the IRLBC .... that insofar as possible the level .... will be between the following maximum and minimum elevations....”. This could be interpreted that the IRLBC may direct Boise Cascade operations. However, the Directive to the Board sounds much weaker, stating that “Whenever, in the opinion of the Board, the terms of the Order are not being complied with, the Board shall so inform Boise .... and make such recommendations as ....”. What is the extent of IRLBC authority in supervising Boise Cascade operations?

(9) Representativeness of Public Comment

In Section 6.1 the concerns of various interests are summarized as understood by the Board. However, the Board's contact with people in the basin is limited. While public involvement was much greater at the time of the original Reference and the subsequent Orders, there is now much less involvement, which is normal as people become used to and adapt to procedures long in place. Consequently it is unknown if the limited input being received is representative of the community at large or only a vocal few.

(10) Watershed Strategy Plan

The Lake of the Woods watershed encompasses a vast sparsely populated region, having abundant water resources. Questions of proper utilization of these resources by competing water interests have resulted in some polarization and animosity between the various interests. Water resources development in the watershed has been based upon each interest looking out for itself, which has generally hindered effective development and utilization of resources.

The involvement of the International Joint Commission in providing guidance in matters of regulatory function and resource development has been a stabilizing influence in the region. However, if future water resources development in the region is to be proper, fair to all interests, and effective, a cooperative effort among the various interests must be fostered and a sense of direction established. This direction would be provided by a watershed strategy plan for water resources development. Development of this plan would be an international undertaking and specific suggestions are not offered in this report. However, it is quite clear that some movement in this direction is necessary to solve problems such as rehabilitation or replacement of the aging dams at Kenora, International Falls, and Kettle Falls.

7. CONCLUSIONS

A great deal of information has been given in this briefing paper. Even so, much has been glossed over, considering that regulation activities in the basin span more than 80 years. To assist in locating more detail, if required, a reference list of selected documents is given in the Appendix.

It is hoped that this paper will itself be a useful reference document for the Commission. It is expected that it will generate questions by the Commission and perhaps further discussion. This will be welcomed by the International Boards and will indicate that this paper has served its purpose.

In conclusion, the members of the International Boards would like to highlight the following opinions:

- regulation practices for Lake of the Woods are adequate

- in general, the existing IJC Orders for the regulation of Rainy and Namakan Lakes are adequate. In making this statement, the members assume that the operating bands may be interpreted as guides rather than as rigid rules, thus allowing for a component of engineering judgement in their application. However, these bands have not been objectively assessed in over 15 years. The study currently underway by Voyageurs National Park may force such an assessment.

- all structures in the basin by which regulation is made possible are nearing the end of their useful lives. Although the structures are privately owned, it is assumed that some governmental or public input would be involved in their replacement since they regulate multi-use international waters. Considering the lead time required for capital projects, especially in boundary waters, planning for their replacement should start now. Replacement of the structures will involve consideration of outflow capacity and in this regard studies should be performed which will consider the operation of the whole system, not just individual lakes in isolation.

- any consideration of replacement of structures or review of regulation policy should be performed in a broader framework of the overall objectives for the region. There are a number of interests in the basin whose activities related to the water resource are in conflict, to a greater or lesser degree. If future development and use of the resource is to be fair to all interests, a cooperative effort must be fostered among the various interests and an overall basin plan must be developed to provide a clear sense of direction.

- the International Boards could play a useful role in addressing the concerns of citizens regarding regulation and in providing at least an initial focus for discussions concerning dam replacement and basin plans. However, this would require authorization for the Boards to adopt a proactive rather than a reactive posture. Also, current resource levels would not support much involvement.

- a number of the concerns expressed by citizens in the area go beyond the water level regulatory role of the Control Boards. For example, there are concerns that certain jurisdictions may have acted arbitrarily, and perhaps in contravention of international treaties, with regard to means of access to the area and limitations on activities. Some of these concerns may require investigation directly by the IJC under the terms of the Boundary Waters Treaty and some, of a more commercial nature, may require consideration by the governments of the two countries.

FIGURES

FIGURE 1

ADMINISTRATIVE ORIGIN AND STRUCTURE

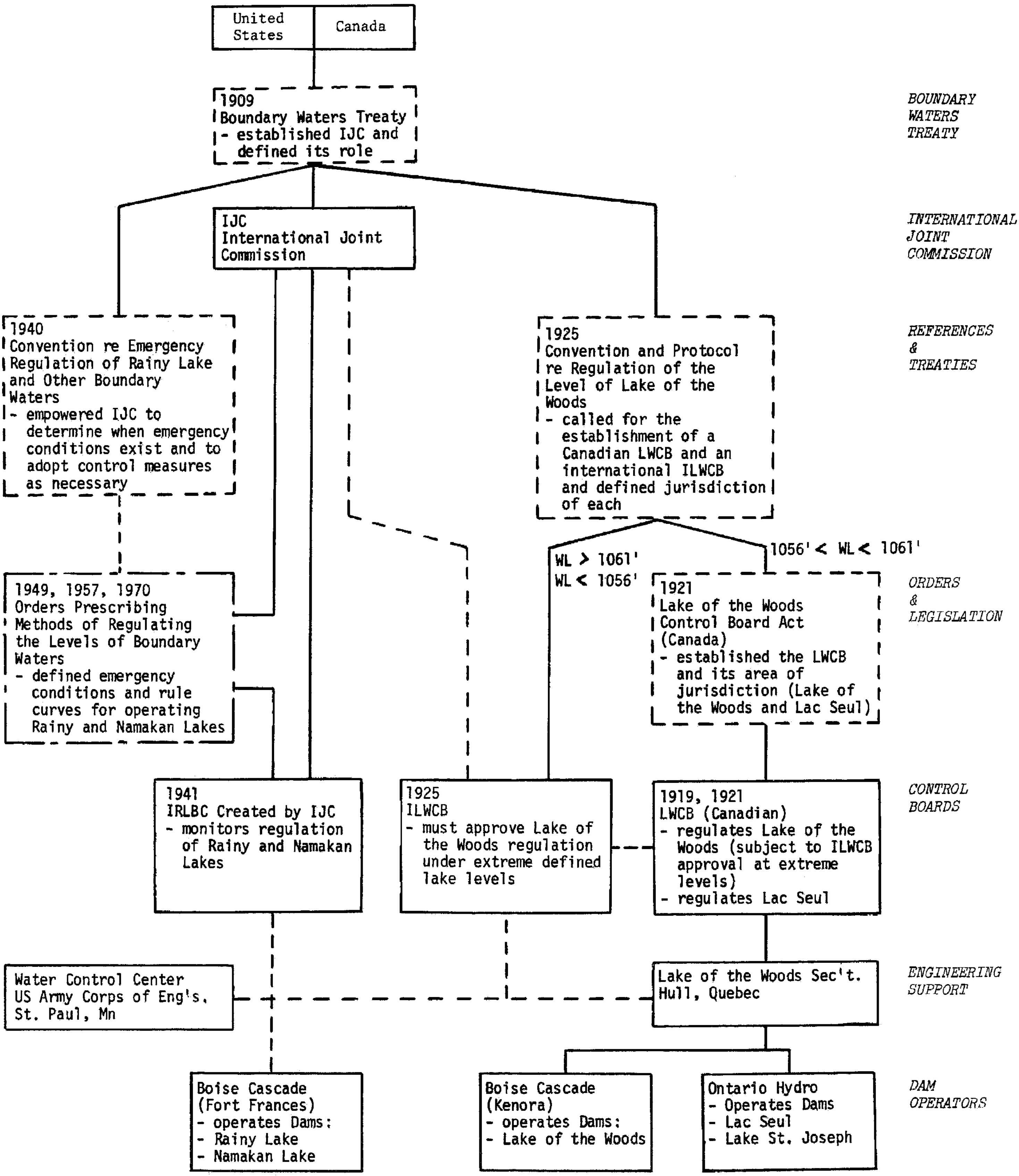


FIGURE 2

BASIN SCHEMATIC AND BOARD JURISDICTIONS

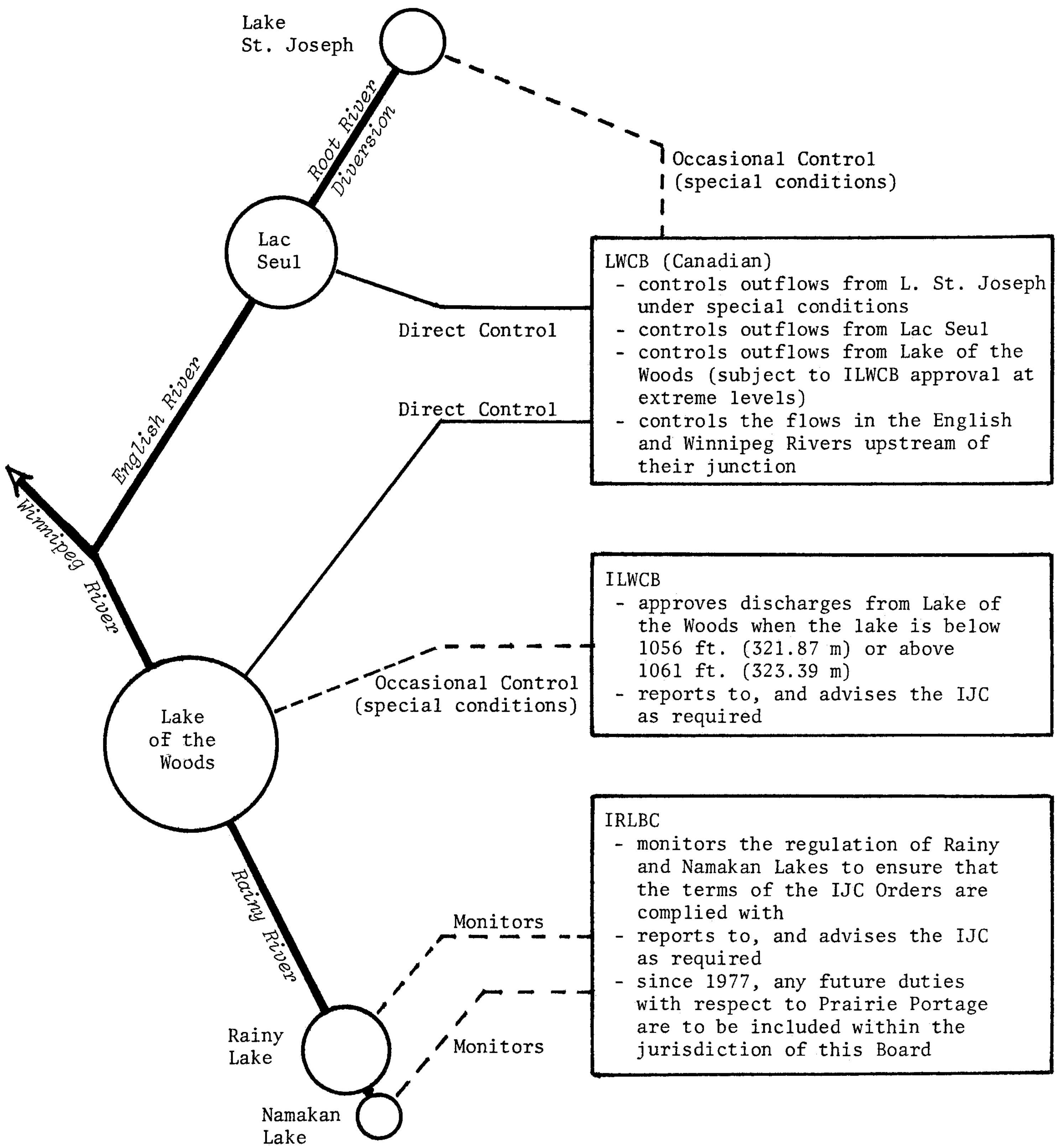


FIGURE 3

Board Origin and Membership

IRLBC - International Rainy Lake Board of Control

- established by the IJC in 1941
- 2 members, one Canadian and one American, are appointed by the IJC
- current members are: - Col. E.G. Rapp, Member for the United States
  - Mr. J.E. Slater, Member for Canada

ILWCB - International Lake of the Woods Control Board

- established by the 1925 Convention and Protocol between Canada and the United States re Regulation of the Level of Lake of the Woods
- 2 members, one Canadian and one American, are appointed by their respective governments
- the Board reports through the IJC for convenience
- current members are: - Mr. J.E. Slater, Member for Canada
  - Col. E.G. Rapp, Member for the United States

LWCB - Lake of the Woods Control Board (Canadian)

- established by Canadian legislation in 1921
- given International Authority by the Convention and Protocol of 1925
- 4 members are appointed by Canadian Federal and Provincial Governments
- current members are: - Mr. J.E. Slater, Member for Federal Gov't
  - Mr. T.E. Falk, Member for Ontario
  - Mr. R.M. Odell, Member for Ontario
  - Mr. N. Mudry, Member for Manitoba
- to ensure coordination with the United States, the federal member on the LWCB is the Canadian member on the ILWCB and the IRLBC.

ENGINEERING SUPPORT

- support to the above Boards for day-to-day duties and other technical activities as required is provided by:

in Canada - Lake of the Woods Secretariat
Executive Engineer - R.F. Walden

in the United States - Water Control Centre
St. Paul District Corps of Engineers
Chief - E.G. Eaton

FIGURE 4

LWCB
Lake of the Woods Control Board

OCTOBER 15, 1984

WATER LEVEL AND FLOW BULLETIN

For current level and flow information, telephone for recorded messages:

KENORA (807) 468-5151
WINNIPEG(204) 949-4130

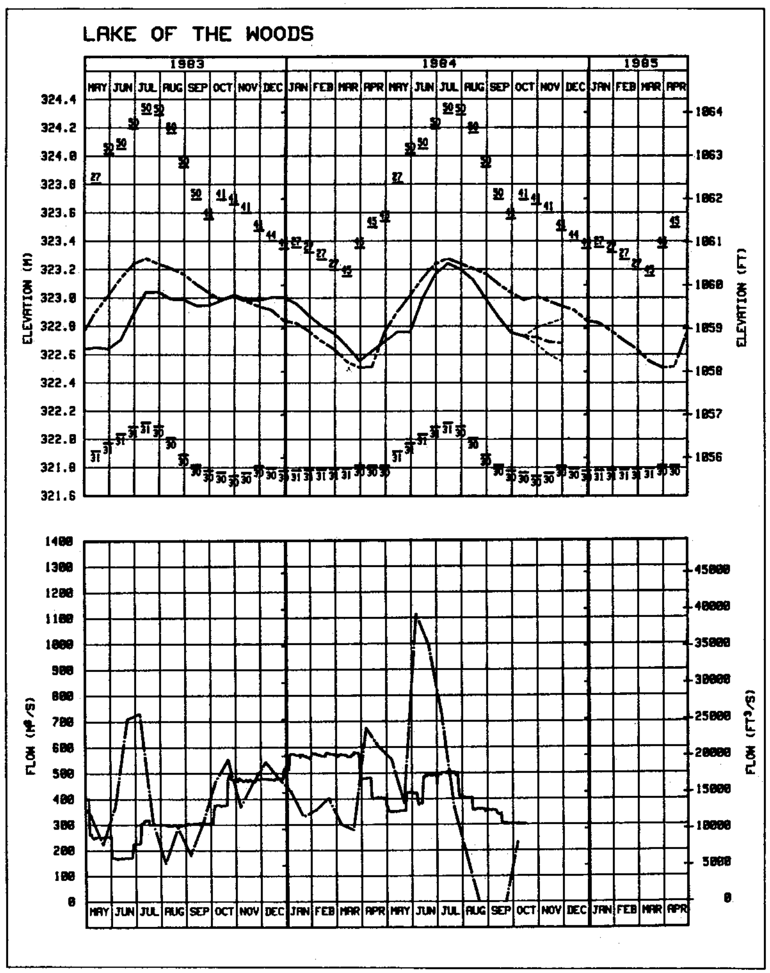
For additional information, contact the Executive Engineer by telephoning (819) 997-2529 or by writing to the address overleaf

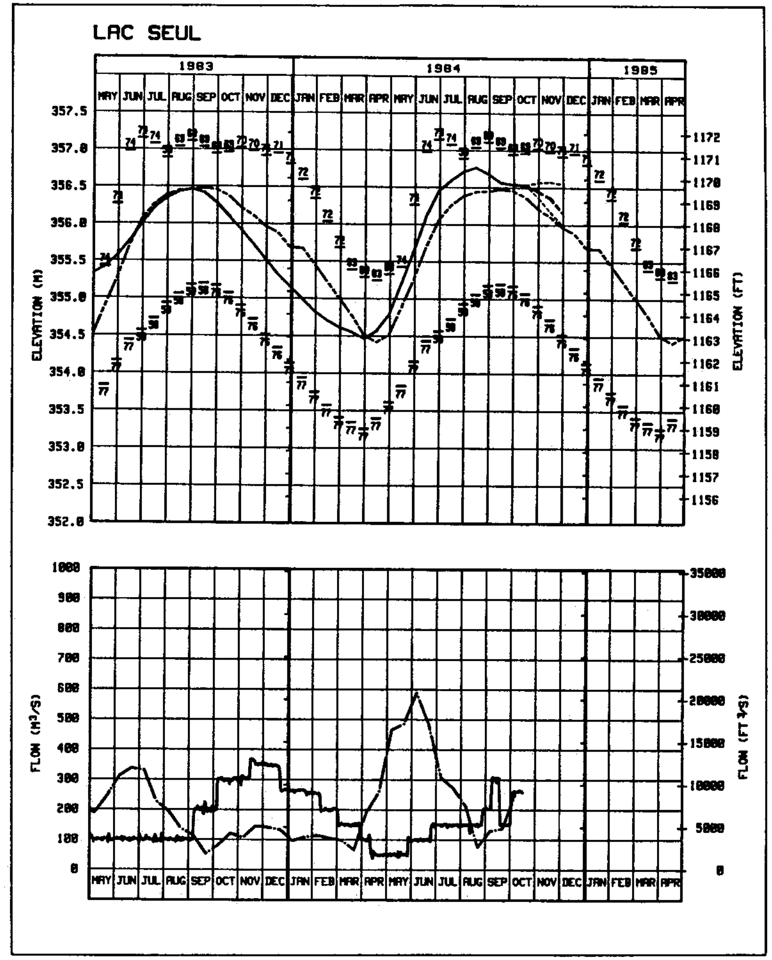
LEGEND

Level	————	Actual
	- - - - -	Median
	74	Maximum (1974)
	61	Minimum (1961)
	- - - -	Forecast
Flow	————	Actual Outflow
	—·—·—	Computed Net Inflow

NOTE: All data are provisional.
Period of record for historic data: Lake of the Woods 1927-1983
Lac Seul 1958-1983

This Bulletin is issued 6 times per year (Feb, Apr, Jun, Aug, Oct, Dec)





LWCB
Lake of the Woods Control Board
8th Floor, Place Vincent Massey
351 St. Joseph Blvd.
Hull, Quebec J8Y 3Z5

FIGURE 5

LAKE OF THE WOODS CONTROL BOARD — ISSUED: 841101

PROVISIONAL REPORT

PERIOD ENDING: 1984 10 30 (Basin Precipitation) | 1984 10 30 (Lake Elevation and Flows)

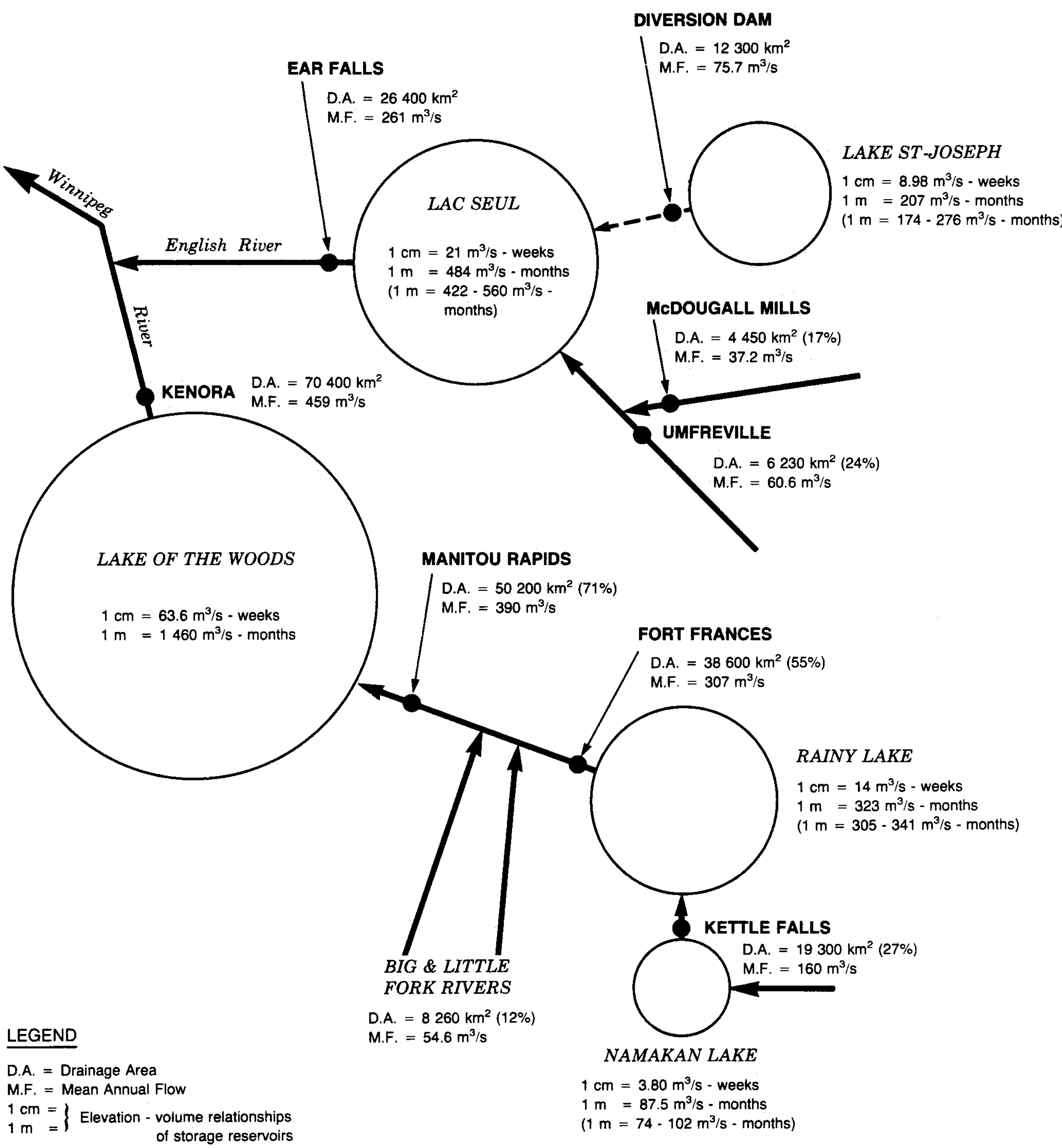
	BASIN PRECIPITATION 7 DAY	30 DAY	30 DAY % OF NORMAL	LAKE ELEVATION END ELEV	CHANGE IN 7 DAYS	STORAGE STATUS	7 DAY FLOWS OUTFLOW	INFLOW	14 DAY FLOWS OUTFLOW	INFLOW	MEDIAN & %'ILE
	MM (IN)	MM (IN)	%	M (FT)	M (FT)	% OR M (FT)	CMS (CFS)	CMS (CFS)	CMS (CFS)	CMS (CFS)	CMS %
ENGLISH SYSTEM											
Cat River							28.6 (1010)		27.6 (974)		49.3 15%
LAKE ST JOSEPH	16 (.6)	73 (2.9)	125%	*	*		100 * (3530)	*	108 * (3530)	*	82.5 I
Sturgeon River Mcdougall Mills							12.6 (446)		12.5 (440)		27.5 LT10%
English River Umfreville							22.2 (783)		21.2 (750)		44.4 20%
LAC SEUL	12 (.5)	80 (3.2)	134%	356.468 (1169.51)	-.013 (-.04)	84%	299 (10600)	269 (9520)	298 (10600)	196 (6940)	259 I 39%
Chukuni River							27.4* (968)		20.8* (732)		28.6 36%
English River Manitou							349 (12300)		378 (13400)		
Wabigoon River Quibell							25 * (883)		20.1* (708)		32.7 LT10%
English River Caribou	19 (.7)	120 (4.7)	254%				373 (13200)		345 (12200)		
WINNIPEG SYSTEM											
Basswood Lake				395.999 (1299.21)	.035 (.11)		6.7 (237)		6.5 (229)		21.2 LT10%
LAC LA CROIX	7 (.3)	72 (2.8)	141%	360.388 (1182.38)	-.02 (-.07)		34.3 (1210)		35.2 (1240)		60.3 16%
Vermilion River							*		*		
NAMAKAN AND KABETOGAMA LAKES				340.388 (1116.76)	-.027 (-.09)	31%	62.1 (2190)	51.1 (1810)	62.2 (2200)	61.6 (2180)	107 I 40%
Seine River Sturgeon Falls							18 (634)		23.1 (816)		43.1 17%
RAINY LAKE	5 (.2)	87 (3.4)	182%	337.477 (1107.21)	-.013 (-.04)	-.009 (-.03)	136 (4810)	118 (4150)	146 (5190)	161 (5690)	193 I 34%
Fork Rivers							92.1* (3250)		82.3* (2910)		26.2 82%
Rainy River Manitou Rapids							340 (12000)		303 (10700)		280 55%
LAKE OF THE WOODS	4 (.2)	116 (4.6)	273%	322.855 (1059.24)	.049 (.16)	62%	304 (10800)	615 (21700)	304 (10800)	649 (22900)	220 I 85%
Winnipeg River Slave Falls	21 (.8)	130 (5.1)	333%				655 (23100)		654 (23100)		692 44%

NOTE: * DENOTES MISSING DATA

COMMENTS:

FIGURE 6

WINNIPEG RIVER WATERSHED BASIN SCHEMATIC



LEGEND

D.A. = Drainage Area
M.F. = Mean Annual Flow
1 cm = } Elevation - volume relationships
1 m = } of storage reservoirs

FIGURE 7

RAINY LAKE OPERATING RULES

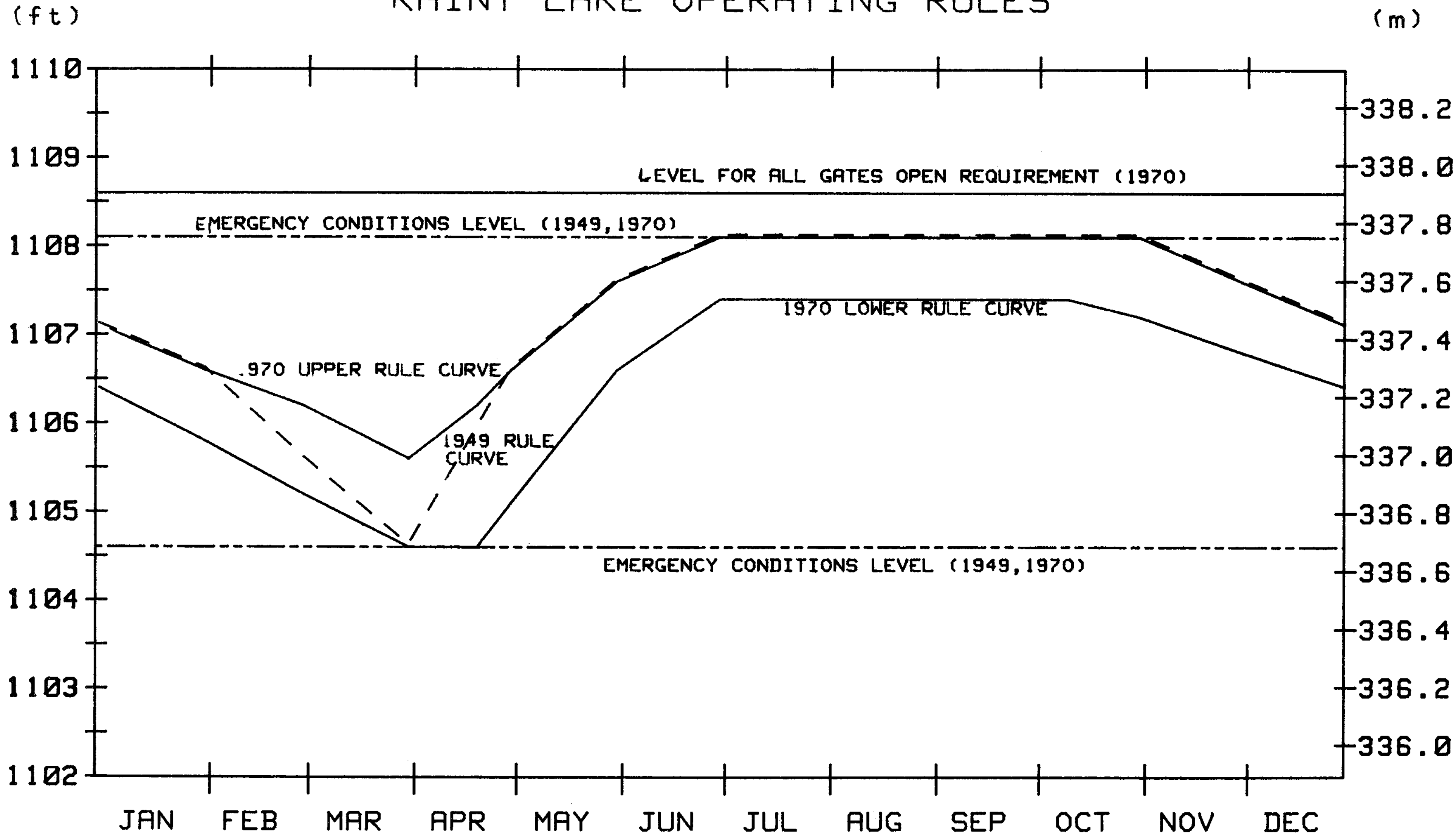


FIGURE 8

NAMAKAN LAKE OPERATING RULES

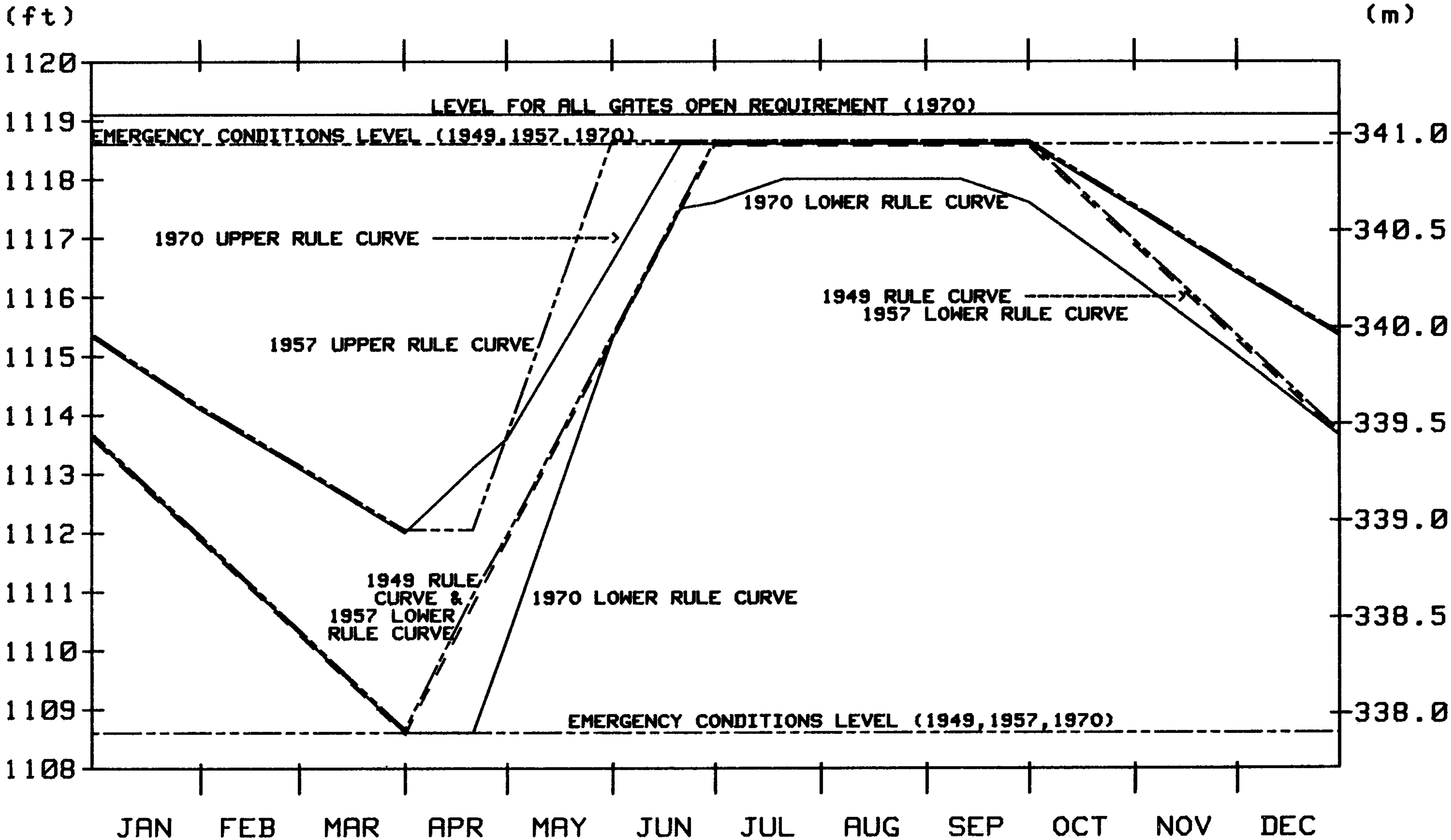


FIGURE 9

Regulation Criteria (Rules)

Lake of the Woods

- normal operating range: 1056 ft. (321.87 m) <WL<1061.25 ft. (323.47 m)
- the lake as a multipurpose reservoir is to be operated within the normal operating range to achieve the highest continuous uniform discharge subject to the requirements of various interests
- when WL ≥ 1061 ft. (323.39 m) the lake is to be regulated to ensure the WL remains less than 1062.5 ft. (323.85 m)
- flood easements exist in the United States up to 1064 ft. (324.31 m)

Rainy Lake

- emergency conditions exist when
    - WL > 1108.1 ft. (337.75 m) and inflow > dam outflow capacity
    - WL < 1104.6 ft. (336.68 m) and outflow = dam minimum discharge
- the WL is to be kept within the rule curve band (see Figure 7) insofar as possible
- all dam gates to be opened fully when WL > 1108.6 ft. (337.90 m)
- when WL < lower rule curve, outflow = 4000 ft^3/s (113 m^3/s) between sunrise and sunset in May to October inclusive and 3300 ft^3/s (93.4 m^3/s) at all other times

Namakan Lake

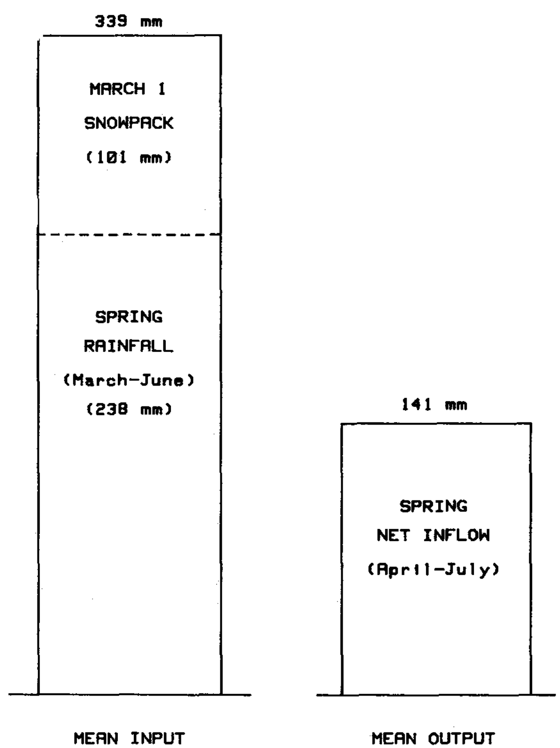
- emergency conditions exist when
    - WL > 1118.6 ft. (340.95 m) and inflow > dams outflow capacity
    - WL < 1108.6 ft. (337.90 m) and outflow = 1000 ft^3/s (28.3 m^3/s)
- the WL is to be kept within the rule curve band (see Figure 8) insofar as possible
- all dam gates and fishways to be opened fully when WL > 1119.1 ft. (341.10 m)
- when WL < lower rule curve, dam outflow = 1000 ft^3/s (28.3 m^3/s)

NOTE: WL = Water level

FIGURE 10

MEAN SPRING BASIN INPUTS
COMPARED TO
MEAN SPRING NET INFLOW

Rainy - Namakan Basin



RAINY LAKE BASIN

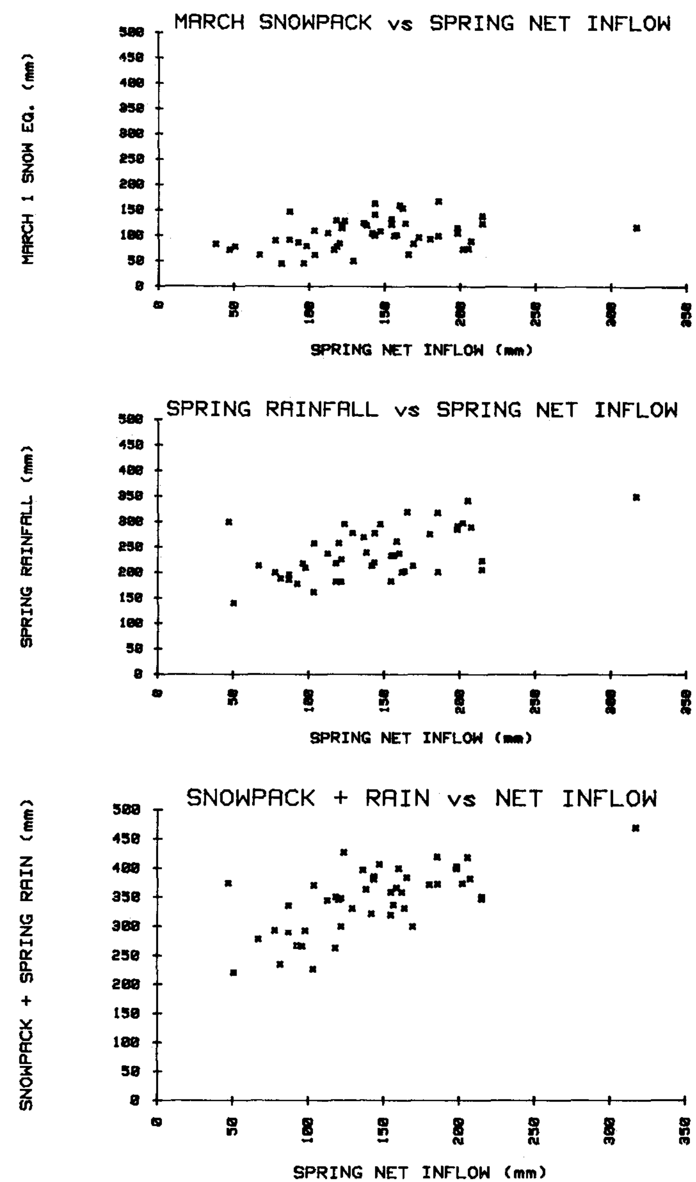
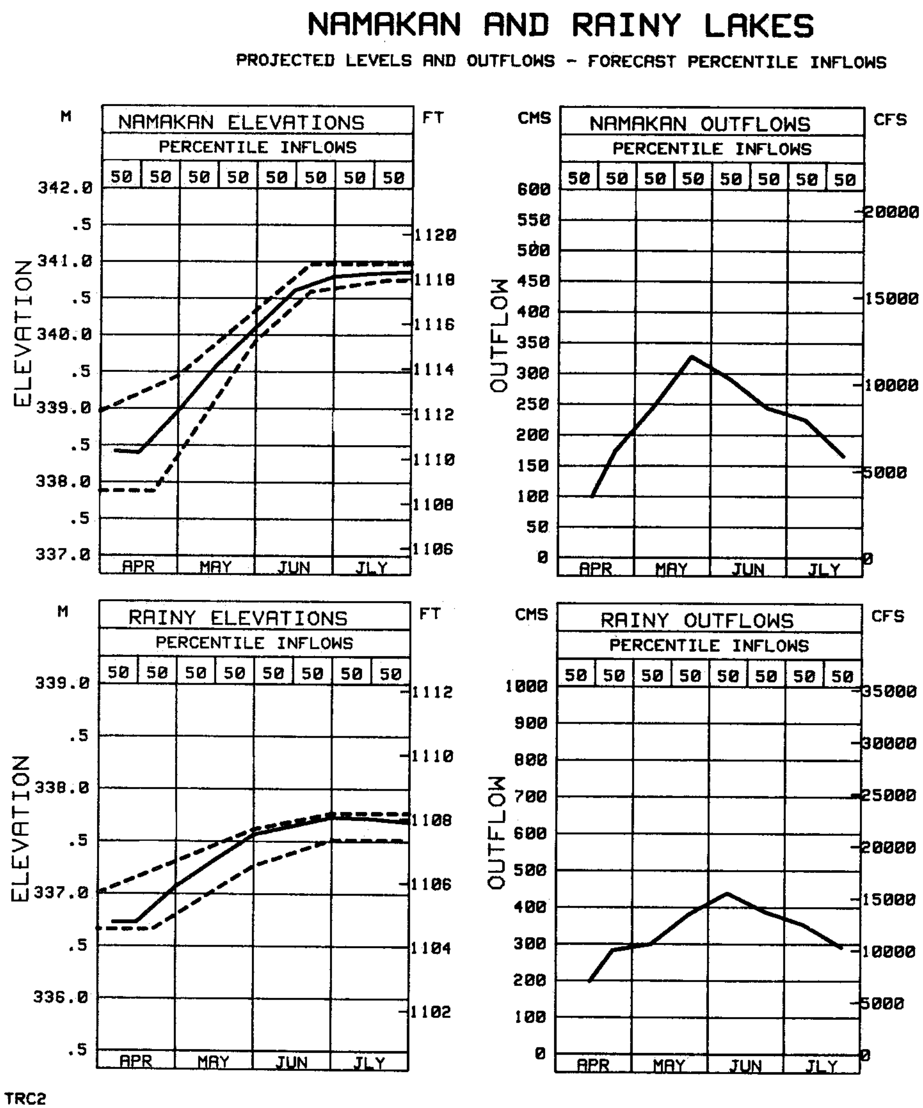


FIGURE 11


NAMAKAN AND RAINY LAKES
PROJECTED LEVELS AND OUTFLOWS - FORECAST PERCENTILE INFLOWS
NAMAKAN ELEVATIONS
PERCENTILE INFLOWS
50 50 50 50 50 50 50 50
ELEVATION
M
FT
NAMAKAN OUTFLOWS
OUTFLOW
CMS
CFS
RAINY ELEVATIONS
RAINY OUTFLOWS
APR MAY JUN JLY
TRC2

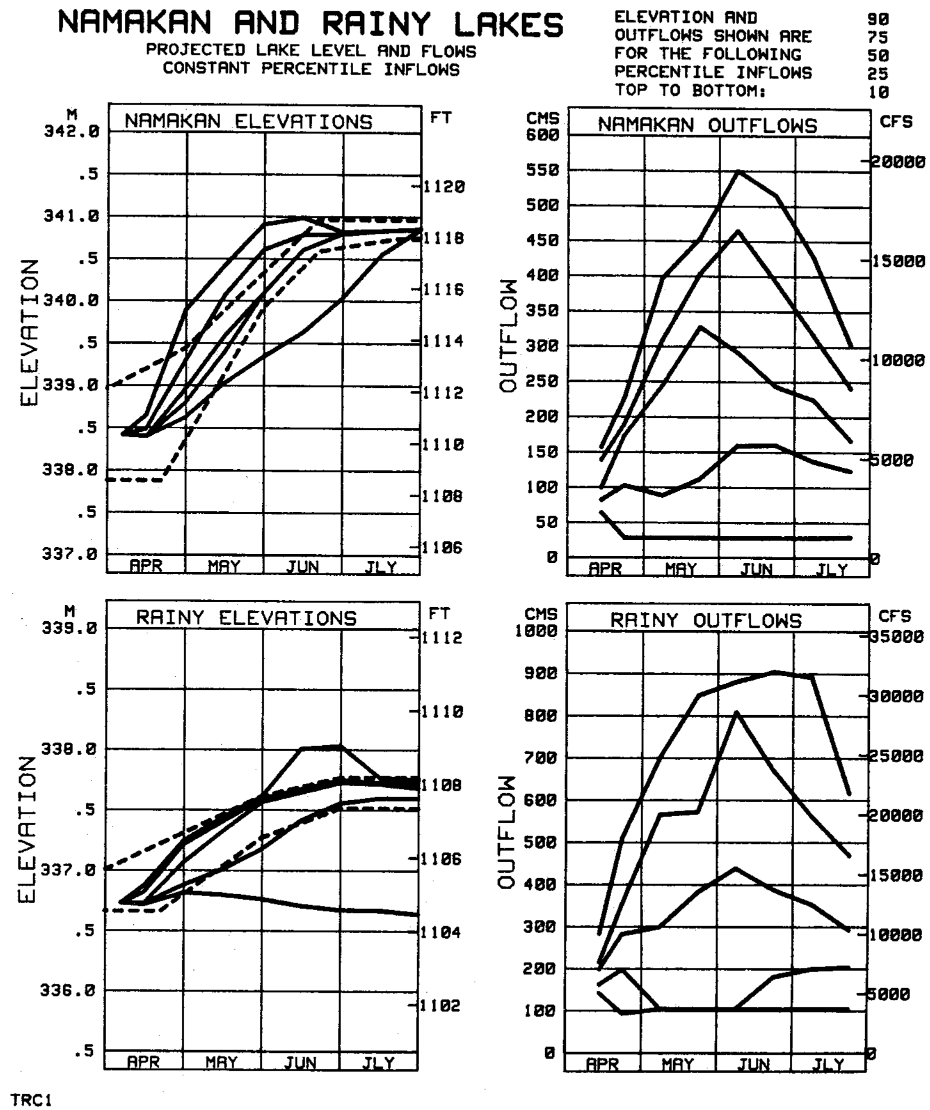

NAMAKAN AND RAINY LAKES
PROJECTED LAKE LEVEL AND FLOWS
CONSTANT PERCENTILE INFLOWS
ELEVATION AND OUTFLOWS SHOWN ARE FOR THE FOLLOWING PERCENTILE INFLOWS TOP TO BOTTOM:
90
75
50
25
10
NAMAKAN ELEVATIONS
NAMAKAN OUTFLOWS
RAINY ELEVATIONS
RAINY OUTFLOWS
ELEVATION
OUTFLOW
APR MAY JUN JLY
TRC1

FIGURE 12

LAKE OF THE WOODS
LEVELS & FLOWS
1984

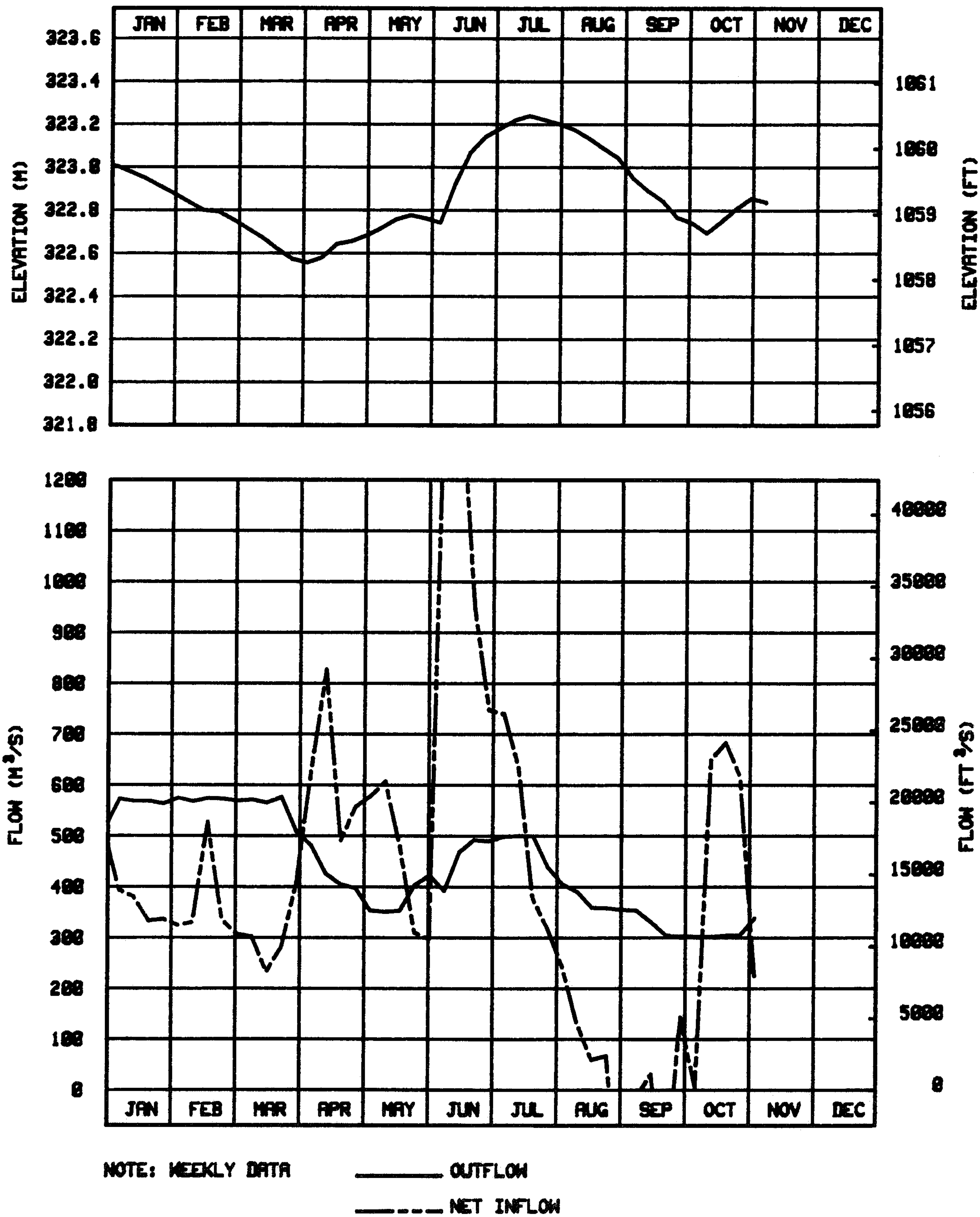


FIGURE 13

RAINY LAKE

FREQUENCY OF DEVIATIONS FROM BAND

ABOVE BAND

NUMBER OF DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	NUMBER OF MNTHS	% OF TIME
1971	0	0	0	0	0	0	0	0	0	6	30	23	3	16.2%
1972	0	0	0	0	0	0	12	1	0	0	0	0	2	3.6%
1973	0	0	0	0	0	0	0	0	0	0	2	0	1	0.6%
1974	0	0	0	0	21	30	15	0	0	0	2	0	4	18.6%
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1976	0	0	0	7	13	0	0	0	0	0	0	0	2	5.5%
1977	0	0	0	0	0	0	0	0	14	31	19	0	3	17.5%
1978	0	0	0	0	1	28	0	0	0	0	0	0	2	8.0%
1979	0	0	0	5	31	15	0	0	0	0	0	26	4	21.1%
1980	18	0	0	0	0	0	0	0	0	0	0	0	1	4.9%
1981	0	0	0	0	23	4	0	0	0	0	0	0	2	7.4%
1982	0	0	0	0	13	17	7	0	0	3	0	0	4	11.0%
1983	0	0	0	0	0	0	16	4	0	0	7	12	4	10.7%
# OF YRS.	1	0	0	2	6	5	4	2	1	3	5	3		
% OF TIME (DAYS)	4.5%	0.0%	0.0%	3.1%	25.3%	24.1%	12.4%	1.2%	3.6%	9.9%	15.4%	15.1%		9.6%

BELOW BAND

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	NUMBER OF MNTHS	% OF TIME
1971	0	0	0	0	0	0	0	4	23	0	0	0	2	7.4%
1972	0	0	6	29	0	0	0	0	10	8	0	0	4	14.5%
1973	0	0	0	0	6	30	11	0	0	0	0	0	3	12.9%
1974	0	0	0	2	0	0	5	12	0	0	0	0	3	5.2%
1975	0	0	0	8	0	0	0	15	30	22	0	0	4	20.6%
1976	0	0	0	0	0	0	0	17	30	31	30	31	5	38.0%
1977	31	28	21	0	31	30	31	31	10	0	0	0	8	58.4%
1978	0	0	13	8	0	0	0	0	0	13	0	0	3	9.3%
1979	0	0	0	0	0	0	0	20	30	31	3	0	4	23.0%
1980	0	0	0	0	26	30	31	31	30	31	5	0	7	50.3%
1981	0	0	0	0	0	0	0	3	30	27	0	0	3	16.4%
1982	0	0	10	8	0	0	0	0	18	0	0	0	3	9.9%
1983	0	0	0	0	25	16	0	0	0	0	0	0	2	11.2%
# OF YRS.	1	1	4	5	4	4	4	8	9	7	3	1		
% OF TIME (DAYS)	7.7%	7.6%	12.4%	14.1%	21.8%	27.2%	19.4%	33.0%	54.1%	40.5%	9.7%	7.7%		21.3%

OUTSIDE BAND

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
# OF YRS.	2	1	4	7	10	9	7	10	9	10	8	4	
% OF TIME (DAYS)	12.2%	7.6%	12.4%	17.2%	47.2%	51.3%	31.8%	34.2%	57.7%	50.4%	25.1%	22.8%	30.9%

ABOVE FLOOD LEVEL

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	NUMBER OF MNTHS	% OF TIME
1971	0	0	0	0	0	0	0	0	0	0	8	0	1	2.2%
1974	0	0	0	0	0	25	11	0	0	0	0	0	2	9.9%
1977	0	0	0	0	0	0	0	0	3	19	0	0	2	6.0%
# OF YRS.	0	0	0	0	0	1	1	0	1	1	1	0		
% OF TIME (DAYS)	0.0%	0.0%	0.0%	0.0%	0.0%	6.4%	2.7%	0.0%	0.8%	4.7%	2.1%	0.0%		1.4%

FIGURE 14

RAINY LAKE

FREQUENCY OF DEVIATIONS GREATER THAN 5 CM FROM BAND

ABOVE BAND

	NUMBER OF DAYS												NUMBER OF MNTHS	% OF TIME
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		
1971	0	0	0	0	0	0	0	0	0	3	30	19	3	14.3%
1972	0	0	0	0	0	0	8	0	0	0	0	0	1	2.2%
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1974	0	0	0	0	18	30	14	0	0	0	0	0	3	17.0%
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1977	0	0	0	0	0	0	0	0	12	30	0	0	2	11.5%
1978	0	0	0	0	0	17	0	0	0	0	0	0	1	4.7%
1979	0	0	0	3	31	9	0	0	0	0	0	0	3	11.8%
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1981	0	0	0	0	9	0	0	0	0	0	0	0	1	2.5%
1982	0	0	0	0	11	14	0	0	0	0	0	0	2	6.9%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
# OF YRS.	0	0	0	1	4	4	2	0	1	2	1	1		
% OF TIME (DAYS)	0.0%	0.0%	0.0%	0.8%	17.1%	18.0%	5.5%	0.0%	3.1%	8.2%	7.7%	4.7%		5.4%

BELOW BAND

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	NUMBER OF MNTHS	% OF TIME
1971	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1972	0	0	0	25	0	0	0	0	0	0	0	0	1	6.8%
1973	0	0	0	0	2	30	6	0	0	0	0	0	3	10.4%
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1975	0	0	0	0	0	0	0	0	18	0	0	0	1	4.9%
1976	0	0	0	0	0	0	0	4	30	31	30	31	5	34.4%
1977	31	28	11	0	28	30	31	31	8	0	0	0	8	54.3%
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1979	0	0	0	0	0	0	0	0	10	31	0	0	2	11.2%
1980	0	0	0	0	23	30	31	31	30	31	3	0	7	48.9%
1981	0	0	0	0	0	0	0	0	20	8	0	0	2	7.7%
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1983	0	0	0	0	21	14	0	0	0	0	0	0	2	9.6%
# OF YRS.	1	1	1	1	4	4	3	3	6	4	2	1		
% OF TIME (DAYS)	7.7%	7.7%	2.7%	6.4%	18.4%	26.7%	16.9%	16.4%	29.7%	25.1%	8.5%	7.7%		14.5%

OUTSIDE BAND

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
# OF YRS.	1	1	1	2	8	8	5	3	7	6	3	2	
% OF TIME (DAYS)	7.7%	7.7%	2.7%	7.2%	35.5%	44.6%	22.3%	16.4%	32.8%	33.3%	16.1%	12.4%	19.9%

FIGURE 15

NAMAKAN LAKE

FREQUENCY OF DEVIATIONS FROM BAND

ABOVE BAND

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	NUMBER OF MNTHS	% OF TIME
						NUMBER OF DAYS								
1971	0	0	0	6	31	8	0	0	0	5	30	23	6	28.2%
1972	0	0	0	0	0	0	7	1	0	0	0	0	2	2.2%
1973	0	0	0	0	0	0	0	0	0	10	0	0	1	2.7%
1974	0	0	0	0	18	21	0	10	2	0	0	0	4	14.0%
1975	0	0	0	0	29	1	0	3	0	0	0	0	3	9.0%
1976	0	0	0	13	23	0	0	0	0	0	0	0	2	9.8%
1977	0	0	0	0	0	0	0	0	27	31	30	4	4	25.2%
1978	0	0	0	0	10	8	0	0	0	0	0	0	2	4.9%
1979	0	0	0	6	31	13	0	0	0	0	0	0	3	13.7%
1980	17	5	0	0	0	0	0	0	0	0	0	0	2	6.0%
1981	0	0	0	8	31	11	0	0	0	0	0	0	3	13.7%
1982	0	0	0	0	25	10	0	0	0	6	0	0	3	11.2%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
# OF YRS.	1	1	0	4	8	7	1	3	2	4	2	2		
% OF TIME (DAYS)	4.2%	1.4%	0.0%	8.5%	49.1%	18.5%	1.7%	3.5%	7.4%	12.9%	15.4%	6.70%		10.8%

BELOW BAND

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	NUMBER OF MNTHS	% OF TIME
1971	15	26	0	0	0	0	1	0	7	0	0	0	4	13.4%
1972	2	21	0	0	0	0	0	0	6	7	0	0	4	9.8%
1973	0	0	0	0	0	0	12	0	0	0	0	0	1	3.3%
1974	24	9	0	0	0	0	0	2	0	0	0	0	3	9.6%
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1976	0	0	0	0	0	0	0	9	30	31	30	31	5	35.8%
1977	31	19	0	0	28	30	31	16	0	0	0	0	6	42.5%
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1979	0	0	0	0	0	0	0	0	21	19	0	0	2	11.0%
1980	0	0	0	0	2	30	31	31	27	0	1	0	6	33.3%
1981	0	0	0	0	0	0	0	17	30	13	0	0	3	16.4%
1982	0	0	0	0	0	9	0	0	0	0	0	0	1	2.5%
1983	0	0	0	0	1	24	0	0	0	0	0	0	2	6.9%
# OF YRS.	4	4	0	0	3	4	4	5	6	4	2	1		
% OF TIME (DAYS)	17.9%	20.4%	0.0%	0.0%	7.7%	23.8%	18.6%	18.6%	31.0%	17.4%	8.0%	7.7%		14.2%

OUTSIDE BAND

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
# OF YRS.	5	5	0	4	11	10	5	7	8	8	4	3	
% OF TIME (DAYS)	22.1%	21.8%	0.0%	8.5%	56.8%	42.3%	20.4%	22.1%	38.5%	30.3%	23.3%	14.4%	25.0%

ABOVE FLOOD LEVEL

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	0	0	0	0	0	0	0	0	10	17	0	0	7.4%
# OF YRS.	0	0	0	0	0	0	0	0	1	1	0	0	
% OF TIME (DAYS)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.6%	4.2%	0.0%	0.0%	0.6%

FIGURE 16

NAMAKAN LAKE

FREQUENCY OF DEVIATIONS GREATER THAN 5 CM FROM BAND

ABOVE BAND

NUMBER OF DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	NUMBER OF MNTHS	% OF TIME
1971	0	0	0	5	31	6	0	0	0	4	25	18	6	24.4%
1972	0	0	0	0	0	0	4	0	0	0	0	0	1	1.1%
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1974	0	0	0	0	17	20	0	5	0	0	0	0	3	11.5%
1975	0	0	0	0	24	0	0	0	0	0	0	0	1	6.6%
1976	0	0	0	11	21	0	0	0	0	0	0	0	2	8.7%
1977	0	0	0	0	0	0	0	0	23	31	30	1	4	23.3%
1978	0	0	0	0	8	6	0	0	0	0	0	0	2	3.8%
1979	0	0	0	6	31	12	0	0	0	0	0	0	3	13.4%
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1981	0	0	0	7	31	8	0	0	0	0	0	0	3	12.6%
1982	0	0	0	0	22	7	0	0	0	0	0	0	2	8.0%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
# OF YRS.	0	0	0	4	8	6	1	1	1	2	2	2		
% OF TIME (DAYS)	0.0%	0.0%	0.0%	7.4%	45.9%	15.1%	1.0%	1.2%	5.9%	8.7%	14.1%	4.7%		8.7%

BELOW BAND

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	NUMBER OF MNTHS	% OF TIME
1971	4	13	0	0	0	0	0	0	0	0	0	0	2	4.7%
1972	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1976	0	0	0	0	0	0	0	2	20	11	24	29	5	23.5%
1977	31	13	0	0	27	30	26	0	0	0	0	0	5	34.8%
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1979	0	0	0	0	0	0	0	0	1	3	0	0	2	1.1%
1980	0	0	0	0	1	30	31	31	25	0	0	0	5	32.2%
1981	0	0	0	0	0	0	0	0	28	9	0	0	2	10.1%
1982	0	0	0	0	0	2	0	0	0	0	0	0	1	0.6%
1983	0	0	0	0	0	15	0	0	0	0	0	0	1	4.1%
# OF YRS.	2	2	0	0	2	4	2	2	4	3	1	1		
% OF TIME (DAYS)	8.7%	7.1%	0.0%	0.0%	7.0%	19.7%	14.1%	8.2%	19.0%	5.7%	6.2%	7.2%		8.6%

OUTSIDE BAND

# OF YRS.	2	2	0	4	10	9	3	3	5	5	3	3	
% OF TIME (DAYS)	8.7%	7.1%	0.0%	7.4%	52.9%	34.9%	15.1%	9.4%	24.9%	14.4%	20.3%	11.9%	17.3%

FIGURE 17

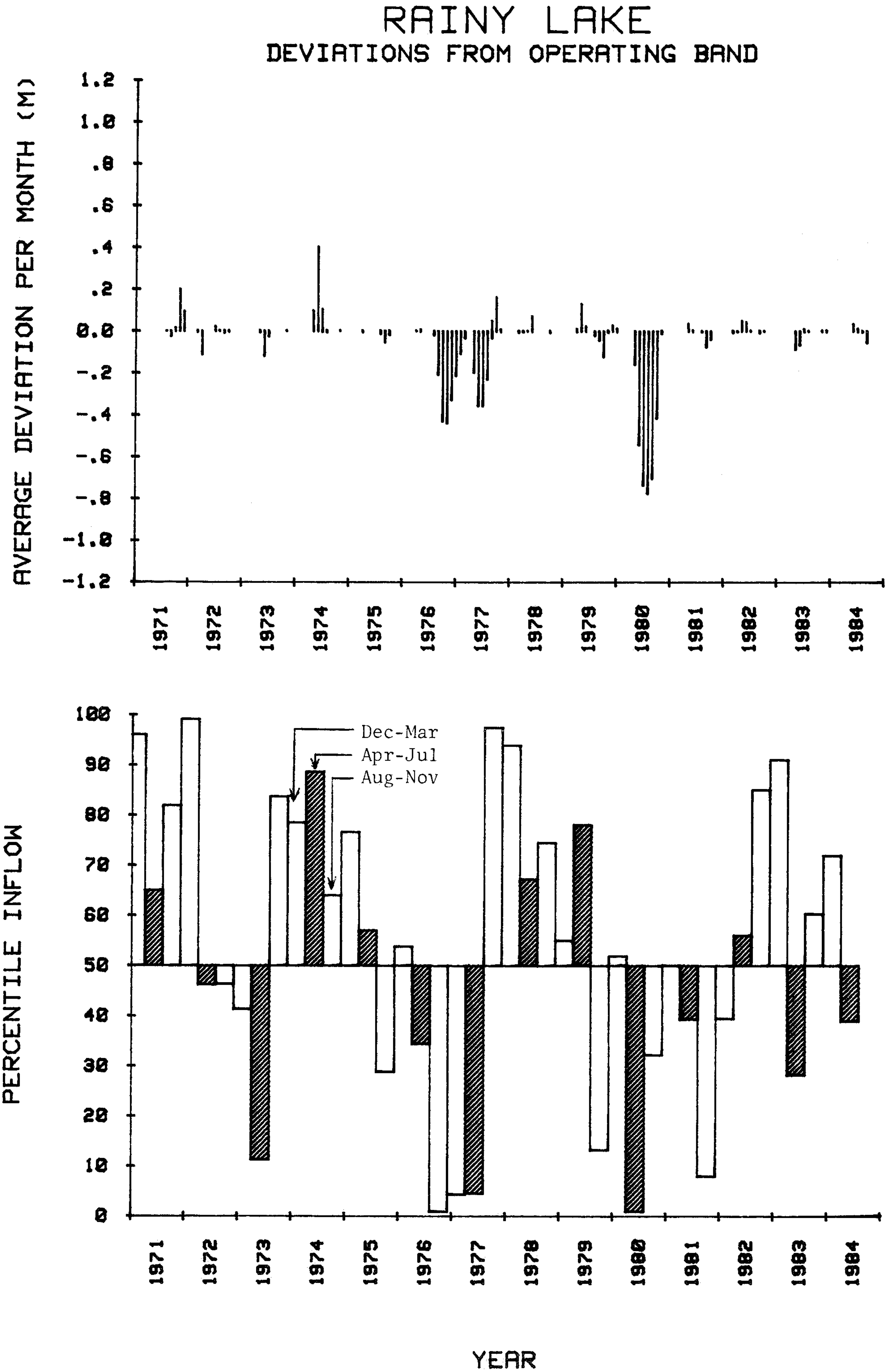

RAINY LAKE
DEVIATIONS FROM OPERATING BAND
AVERAGE DEVIATION PER MONTH (M)
1.2
1.0
.8
.6
.4
.2
0.0
-.2
-.4
-.6
-.8
-1.0
-1.2
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
PERCENTILE INFLOW
100
90
80
70
60
50
40
30
20
10
0
Dec-Mar
Apr-Jul
Aug-Nov
YEAR

FIGURE 18

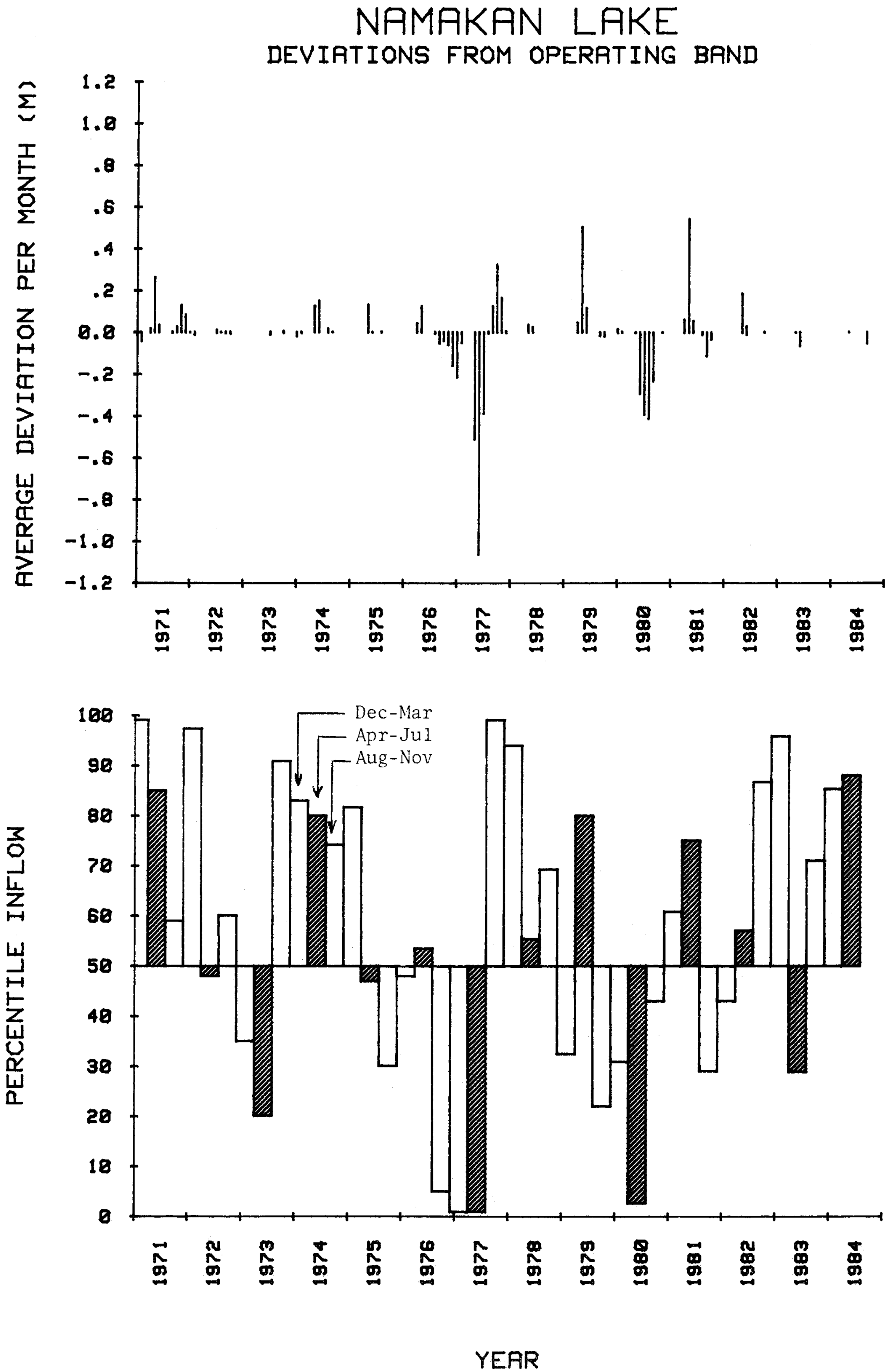
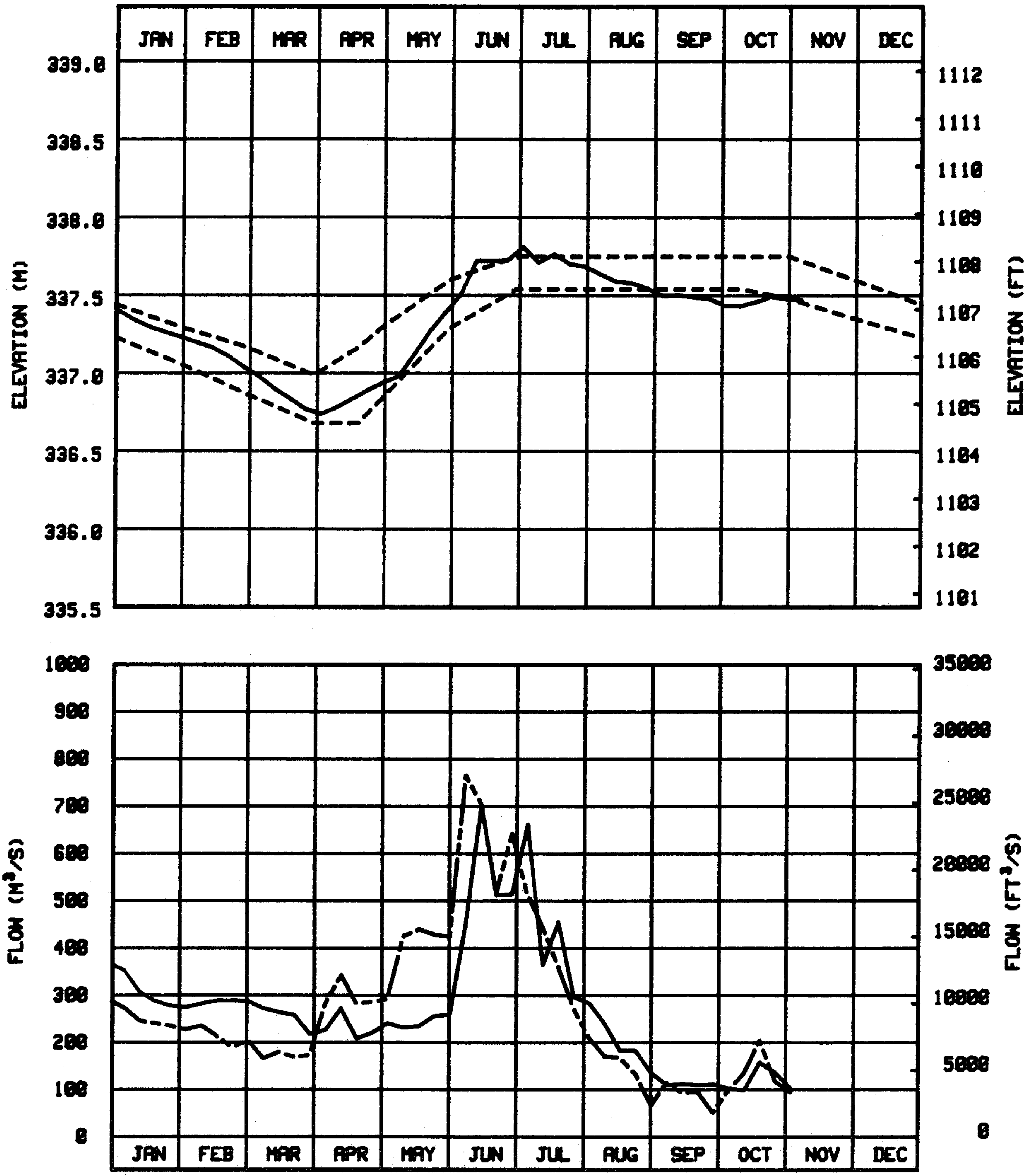

NAMAKAN LAKE
DEVIATIONS FROM OPERATING BAND
AVERAGE DEVIATION PER MONTH (M)
1.2
1.0
.8
.6
.4
.2
0.0
-.2
-.4
-.6
-.8
-1.0
-1.2
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
PERCENTILE INFLOW
100
90
80
70
60
50
40
30
20
10
0
Dec-Mar
Apr-Jul
Aug-Nov
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
YEAR

FIGURE 19

RAINY LAKE
LEVELS & FLOWS
1984



NOTE: WEEKLY DATA

———— OUTFLOW

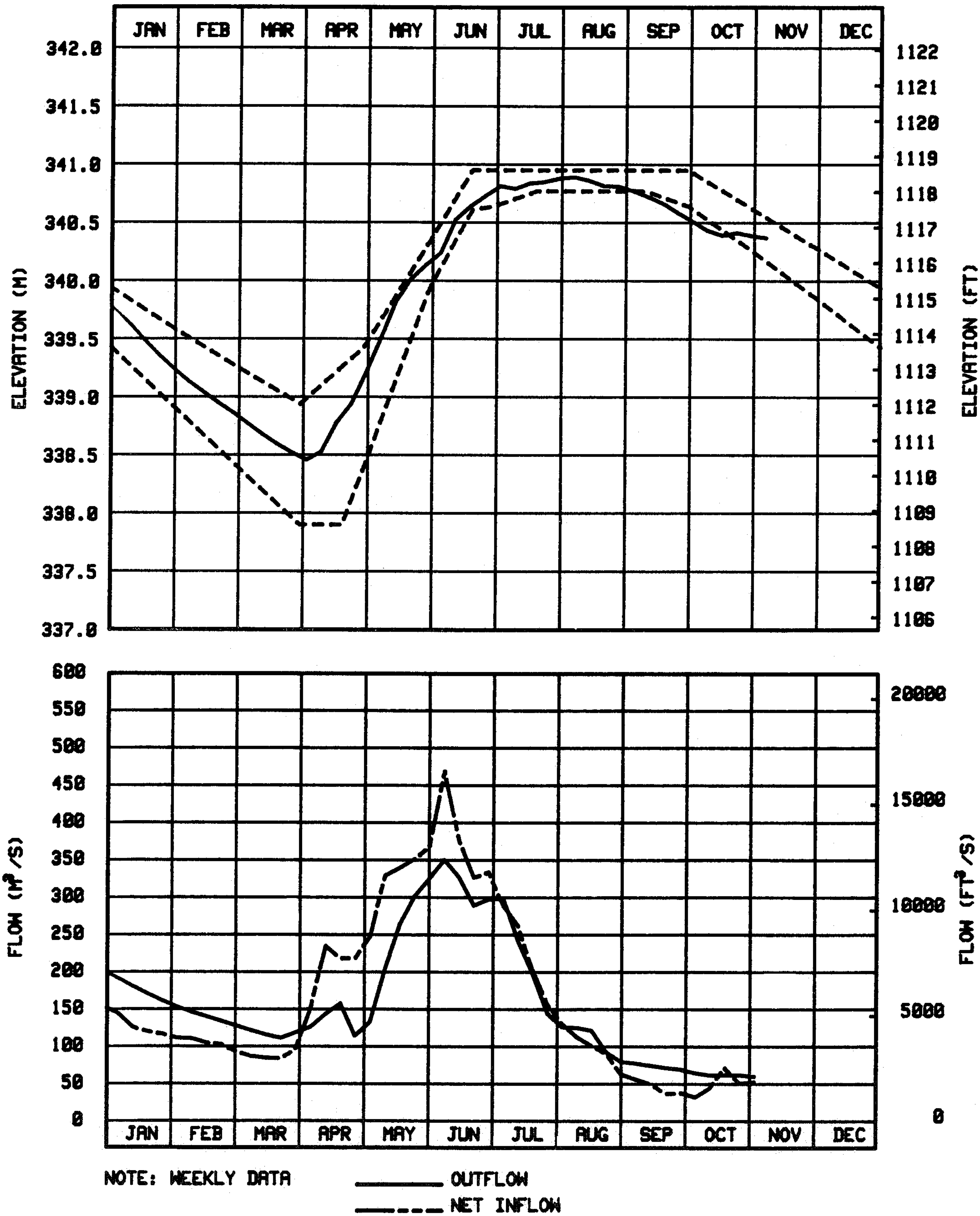
— — — — NET INFLOW

FIGURE 20

NAMAKAN LAKE

LEVELS & FLOWS

1984

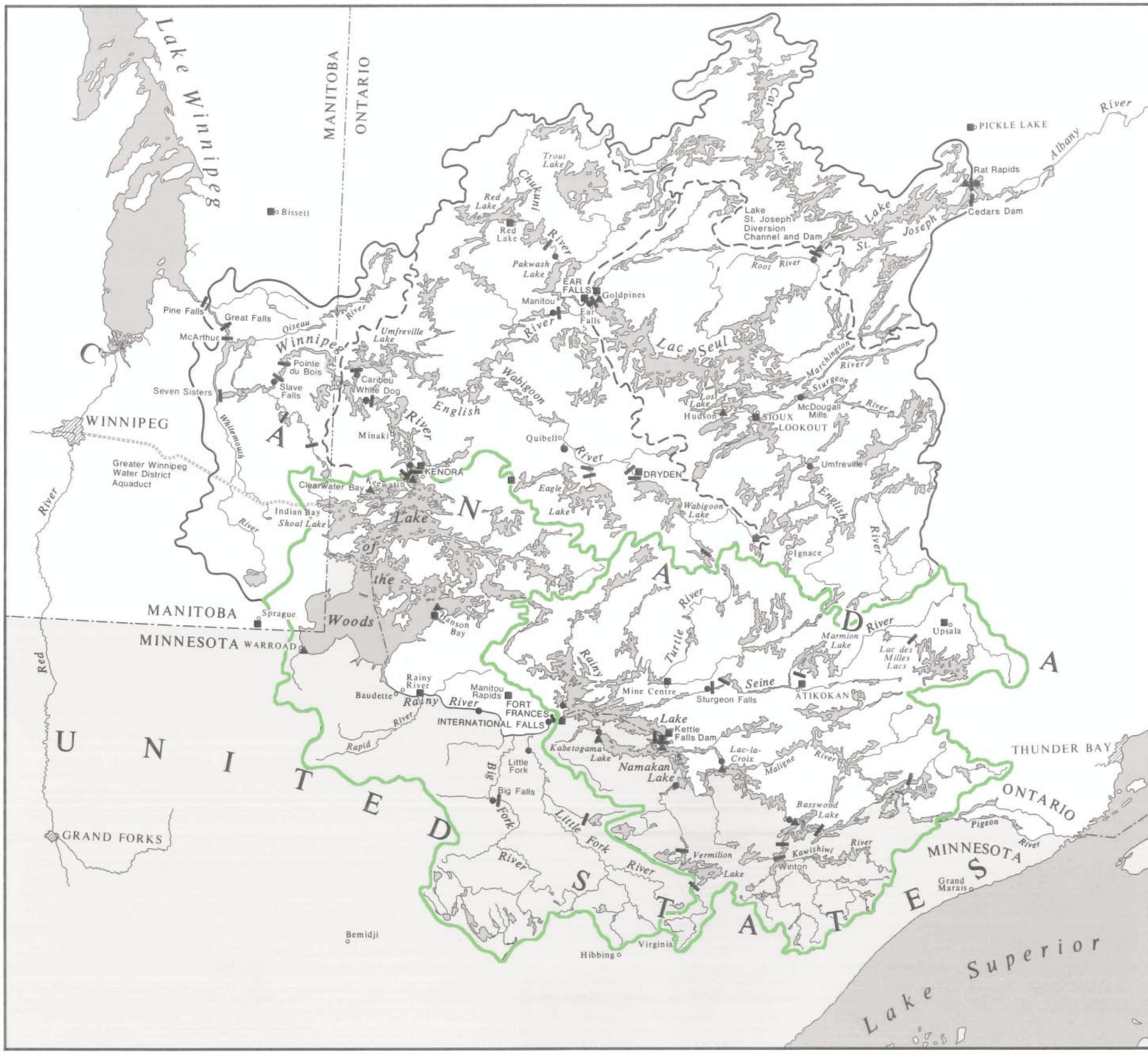


APPENDIX

1. Basin Map
2. Rainy-Namakan Lakes Level Plot 1912-1983 *(Legend plus 8 graphs)*
3. References
4. LWCB Brochure

A paper copy of the LWCB Brochure (1982 version) was included in a back cover pocket in the original paper version of this report. The current version of the LWCB brochure can be found at www.lwcb.ca.

September 2006



KEY MAP

LEGEND

PROVINCIAL BOUNDARY

INTERNATIONAL BOUNDARY

DRAINAGE BASIN

SUB-BASIN

CONTROL DAMS AND / OR GENERATING STATIONS

DATA GAUGES (NEAR REAL TIME)

STREAMFLOW

WATER LEVEL

PRECIPITATION

KILOMETRES
0 10 20 30 40 50 60 70 80

0 10 20 30 40 50 60 70 80
MILES

WINNIPEG RIVER DRAINAGE BASIN

LWCB
Lake of the Woods Control Board

83-12

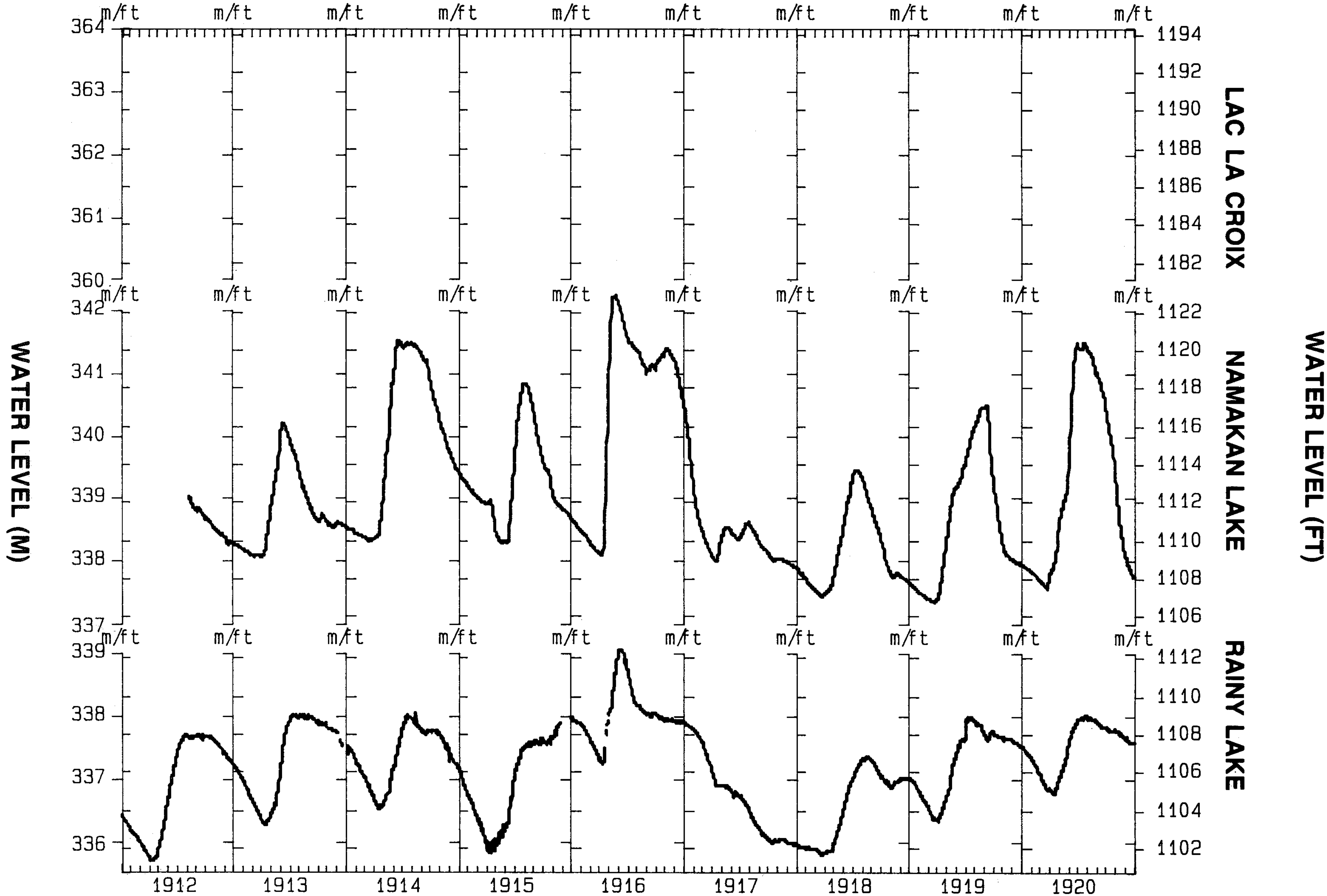
WATER LEVEL PLOTS FOR: LAC LA CROIX

NAMAKAN LAKE

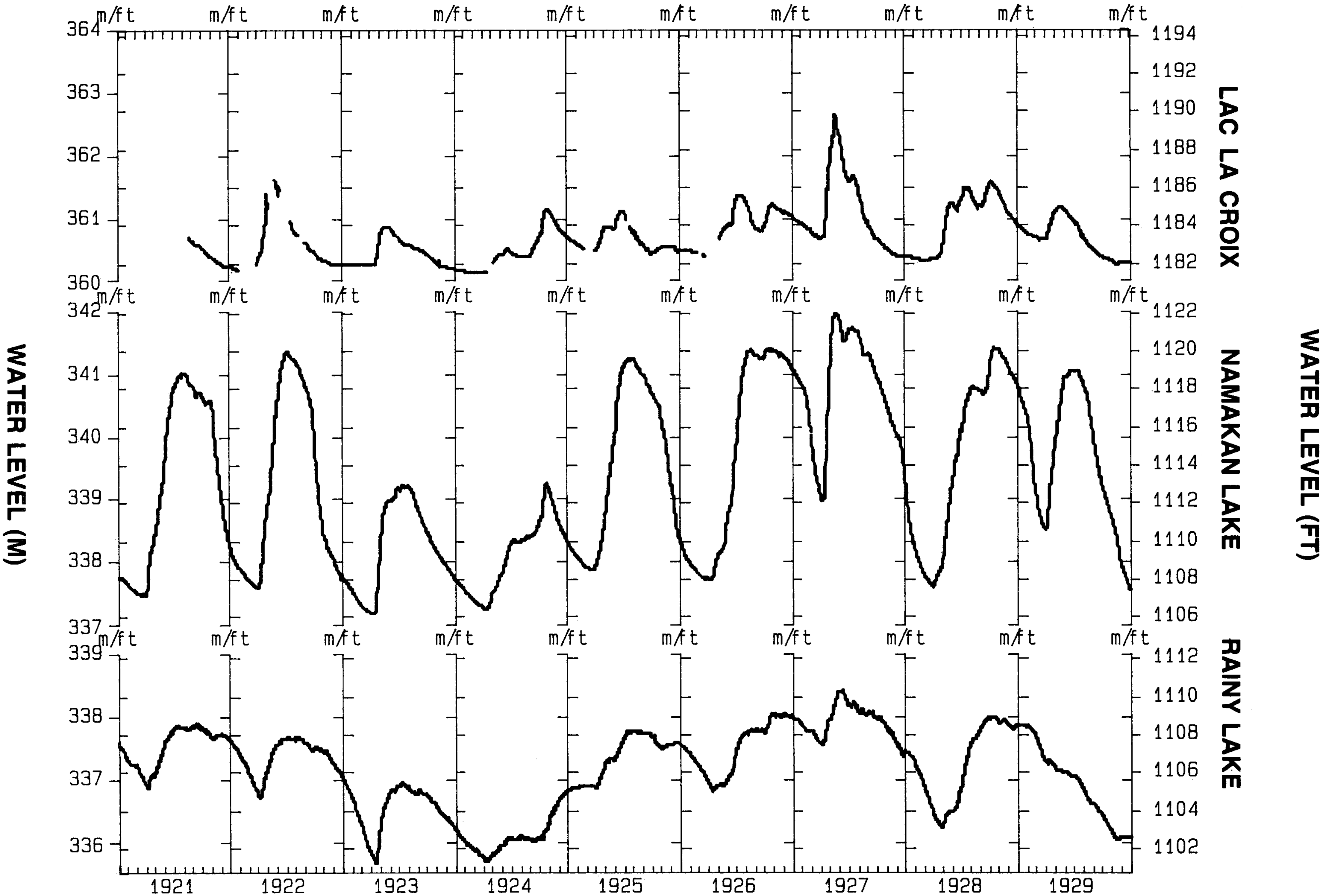
RAINY LAKE

LEGEND

RECORDED WATER LEVEL	————————
HISTORICAL RULE CURVES (IJC ORDERS OF 1949, 1957, 1970)	- - - - - - - - - - - - -
LAKE LEVELS ABOVE WHICH ALL GATES MUST BE OPEN (1970 IJC ORDER)	——— — ——— — —



LAC LA CROIX
NAMAKAN LAKE
RAINY LAKE
WATER LEVEL (M)
WATER LEVEL (FT)
m/ft
364
363
362
361
360
342
341
340
339
338
337
339
338
337
336
1194
1192
1190
1188
1186
1184
1182
1122
1120
1118
1116
1114
1112
1110
1108
1106
1112
1110
1108
1106
1104
1102
1912
1913
1914
1915
1916
1917
1918
1919
1920


LAC LA CROIX
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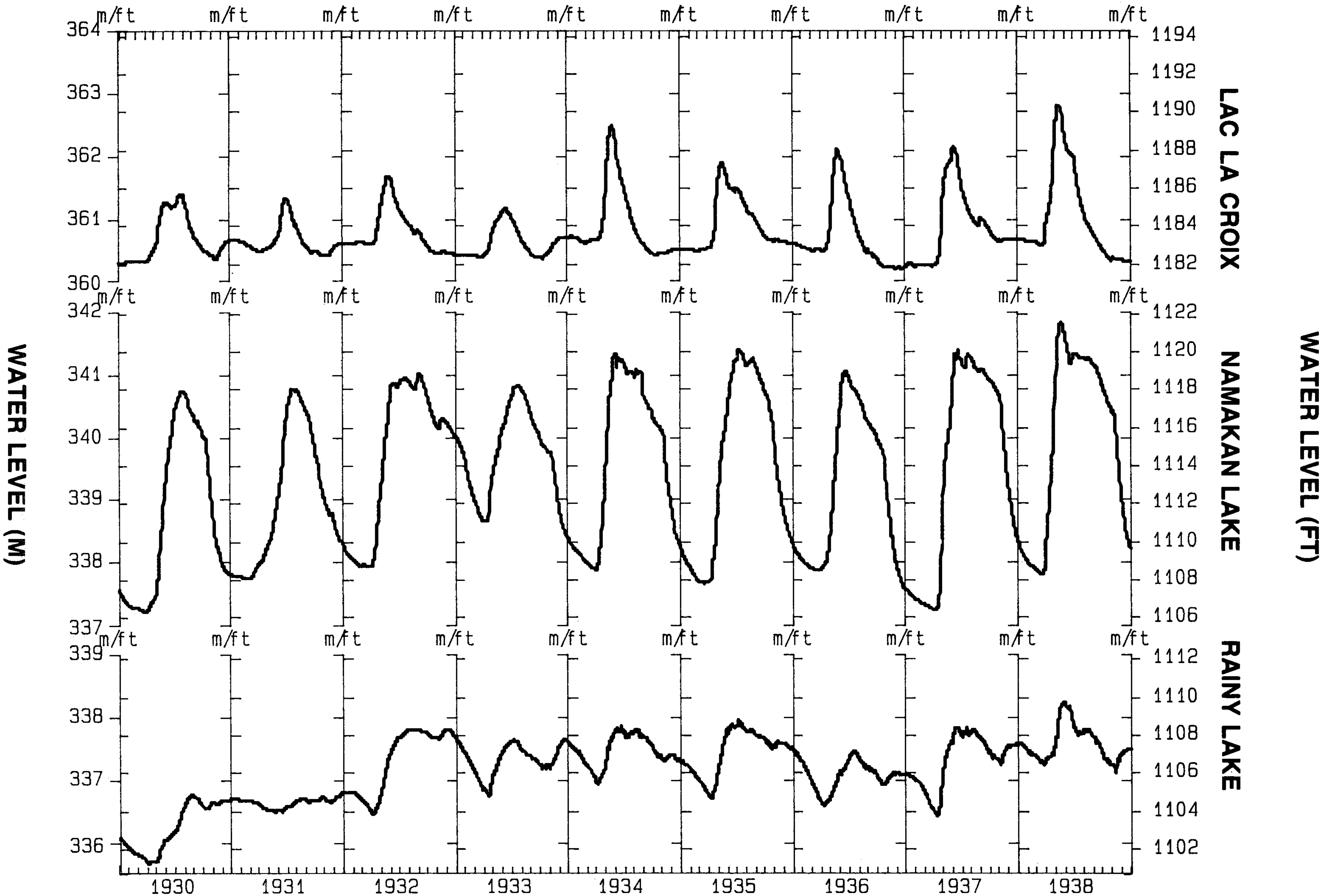
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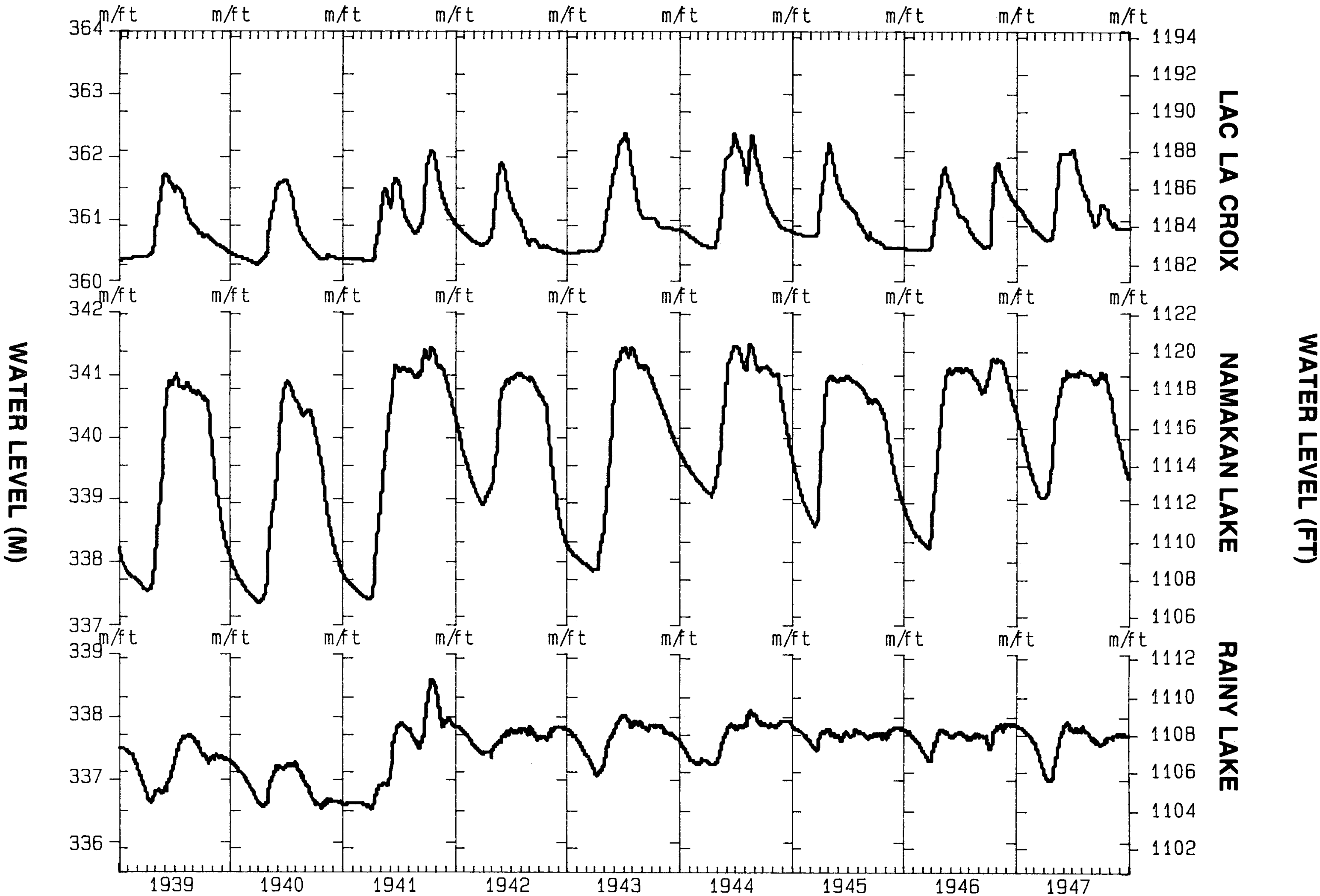

WATER LEVEL (M)
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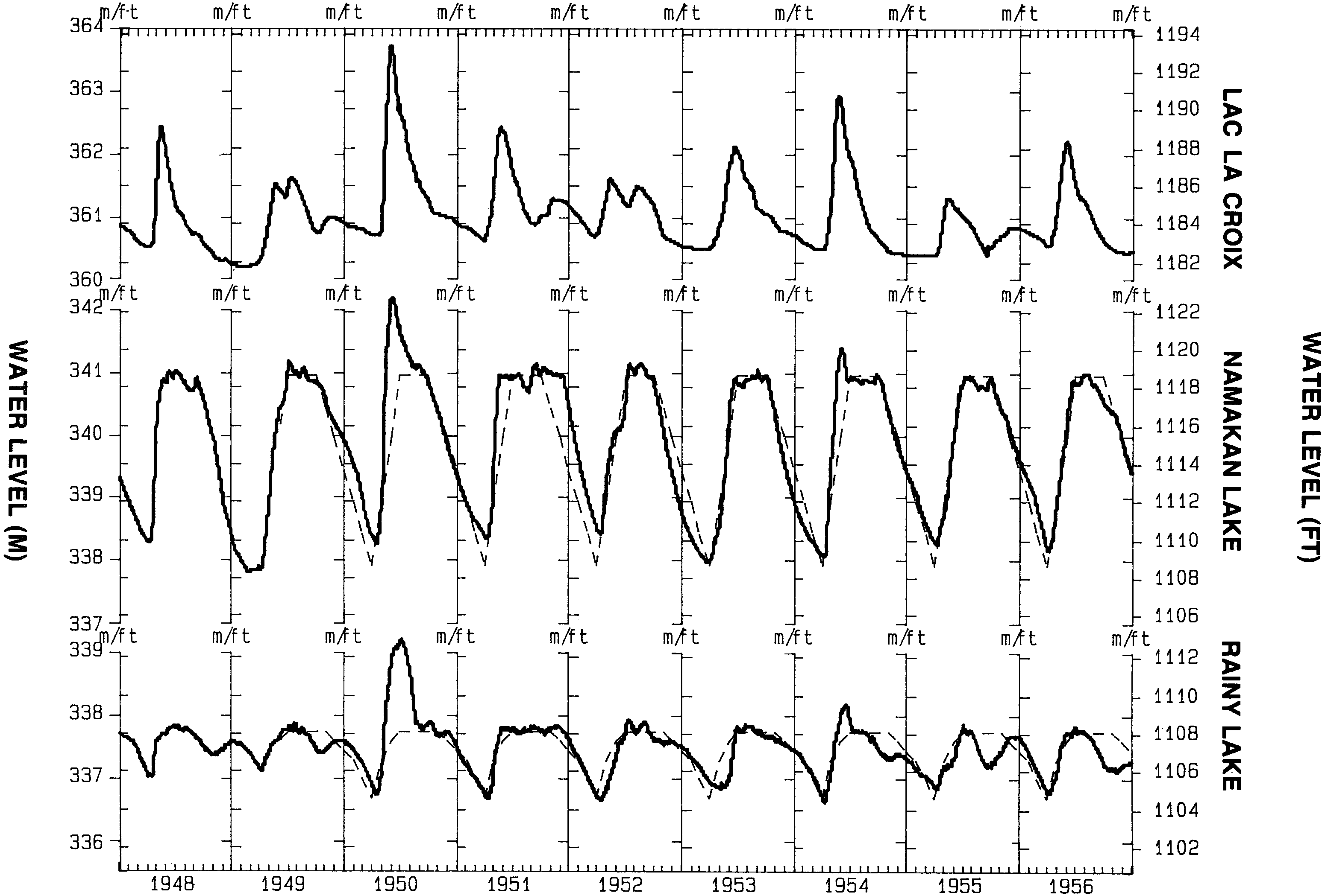

LAC LA CROIX
NAMAKAN LAKE
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WATER LEVEL (M)
WATER LEVEL (FT)
m/ft
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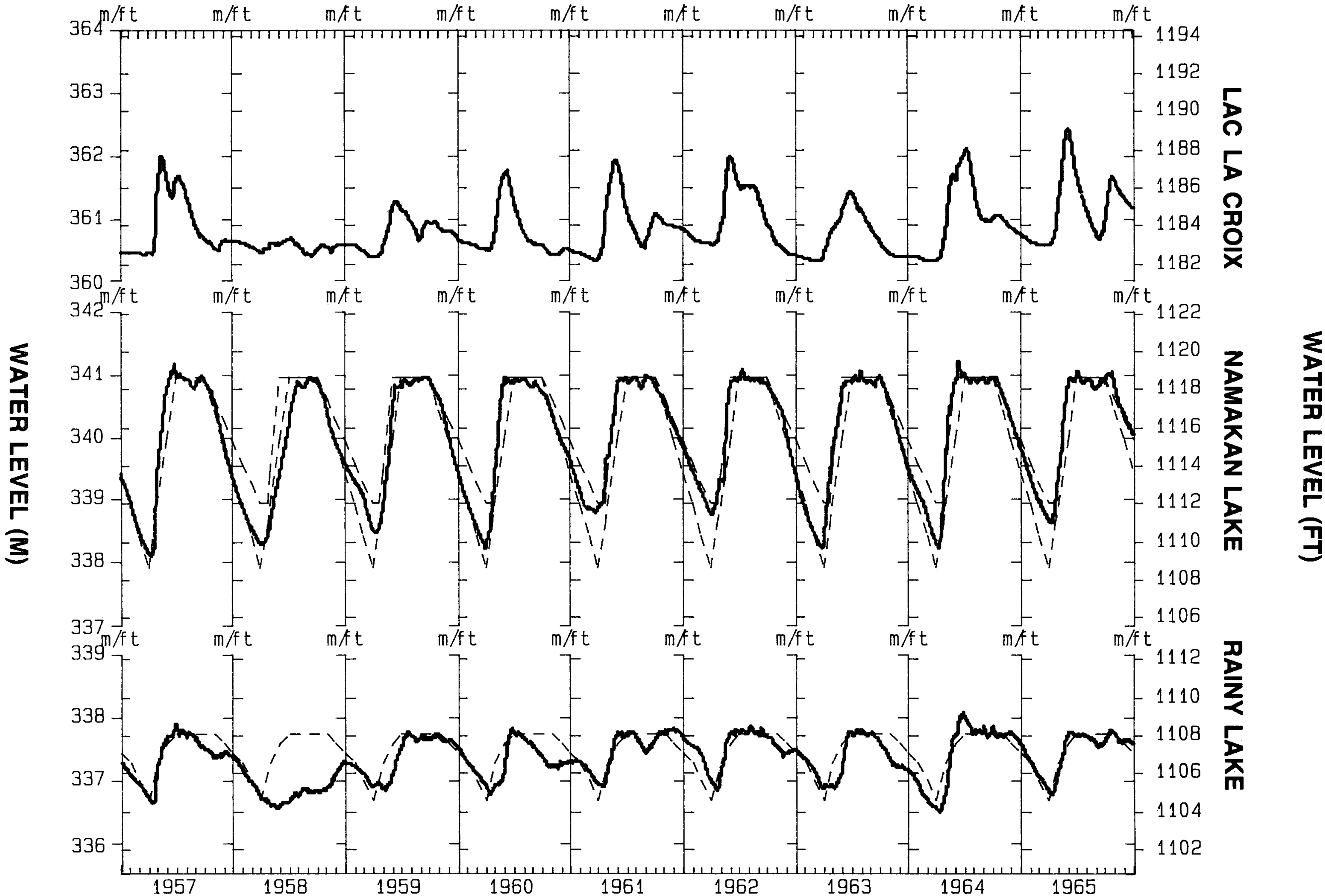

WATER LEVEL (M)
WATER LEVEL (FT)
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NAMAKAN LAKE
RAINY LAKE
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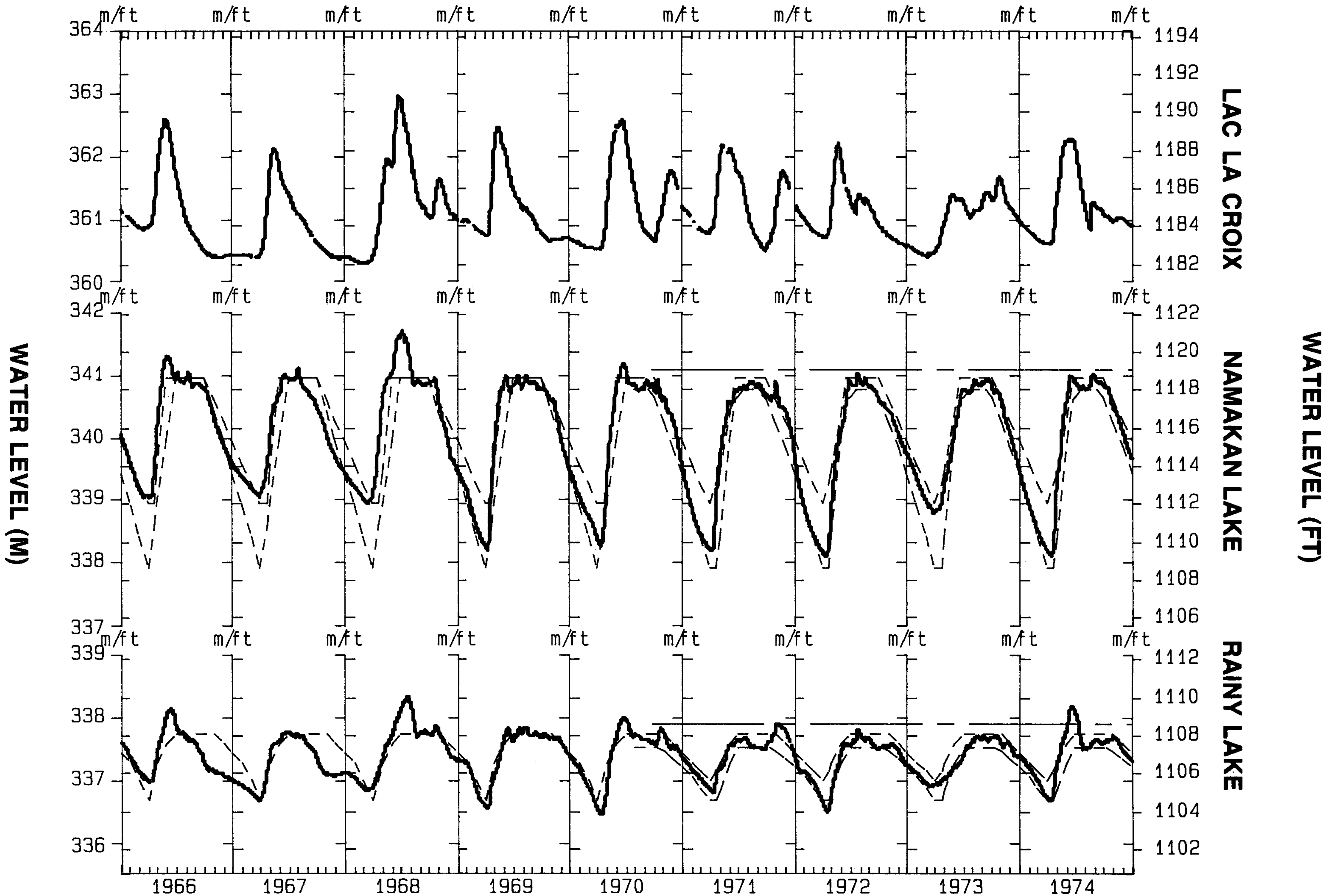

m/ft
WATER LEVEL (M)
WATER LEVEL (FT)
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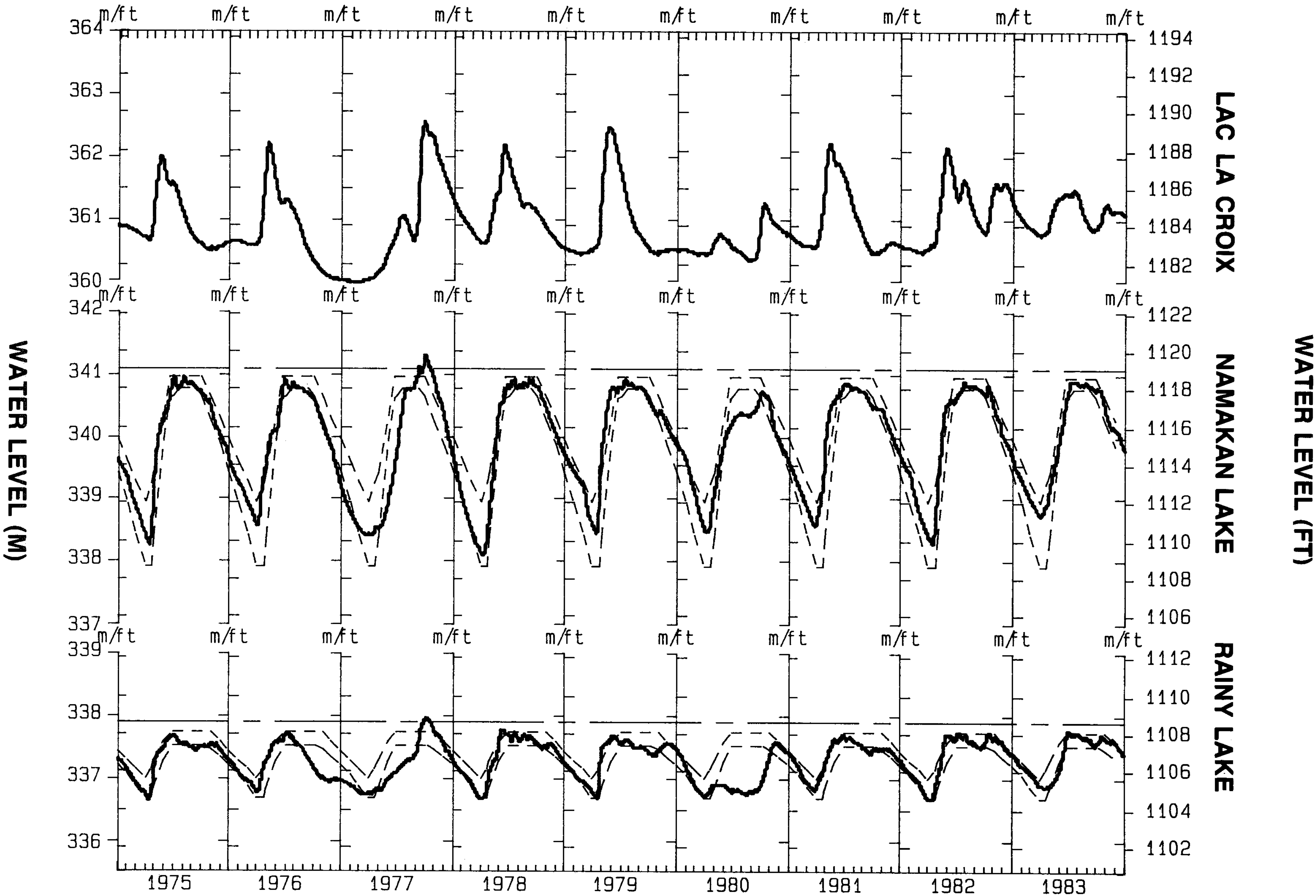
m/ft
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NAMAKAN LAKE
RAINY LAKE
WATER LEVEL (M)
WATER LEVEL (FT)
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