Q. Please provide a copy of all reports or analyses prepared by SGE Acres for Hydro since the 2003 GRA in relation to the long-term average energy production capability of the Island Interconnected System.

A. See attached final reports.

Prepared for

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Adjustment of Bay d'Espoir Reference Inflow Sequences

Final Report

Prepared by
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SGE Acres

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Executive Summary

The *Island Hydrology Review*, completed in January 2003, noted some minor inconsistencies in Newfoundland and Labrador Hydro's reference inflow sequences for the Bay d'Espoir system. SGE Acres was retained by Hydro to make minor adjustments to the records to make them internally consistent, and free of random and systematic errors, as demonstrated by appropriate statistical and graphical tests.

Two types of adjustments were required. The first was an adjustment to the flows estimated for the pre-project period. These had originally been estimated for some of the Hydro basins using the standard technique of transfer from nearby gauged basins, using factors based on drainage area and mean annual runoff. The present work adjusted the transfer factors slightly, using the additional body of data now available from the Hydro basins themselves.

The second type of adjustment related to internal basin accounting, in particular, water transfer between Meelpaeg and Salmon River basins. The present study found that the data and the records used to calculate the water transfer are sound, but there appears to be an error in the curves used to calculate the amount of water transferred through the Ebbegunbaeg control structure. An alternative approach was used to estimate sequences for the three sub-basins within the overall Meelpaeg-Salmon River basin, which provided suitable inflow sequences. The study recommends that Hydro make additional measurements to verify or redevelop the curves for the Ebbegunbaeg control structure for future use. It should then recalculate the inflows for the sub-basins within the combined Meelpaeg-Salmon River basin to confirm the distribution among the basins. The period of approximately ten years for which electronic data are available would be suitable for this purpose.

The study found that with the minor adjustments made to the pre-project period, the Victoria and the combined Meelpaeg-Salmon River basins are internally consistent and free of random and systematic errors. No further work is therefore required on these sequences. The adjustments increased the volume of flow in the Victoria sequence by 2.5 percent, and increased the Meelpaeg-Salmon River basin volume by 0.6 percent. The overall Bay d'Espoir System increase in volume was 0.9 percent.

Introduction

1 Introduction

SGE Acres was retained by Newfoundland and Labrador Hydro (Hydro) to undertake the adjustment of Hydro's inflow sequences for the Bay d'Espoir system. This repair was one of several recommended in the *Island Hydrology Review*, a report prepared by SGE Acres for Hydro in January 2003, at the request of the Board of Commissioners of Public Utilities of Newfoundland and Labrador.

The purpose of the work was to make minor adjustments to the reference inflow sequences for the Bay d'Espoir system to make them internally consistent and free of random and systematic errors, as demonstrated by appropriate statistical and graphical tests.

Appendix A contains the Terms of Reference for this work.

The reference sequences considered in the study are for the Bay d'Espoir system, and consist of monthly flow volumes for Victoria, Meelpaeg, Upper Salmon and Lower Salmon basins. The sequences as provided by Hydro are contained in Appendix B.

Approach

2 Approach

The *Island Hydrology Review* had identified two types of adjustment that would be required to make the Bay d'Espoir inflow sequences internally consistent. The first arises from a difference in the method of deriving the flows before and after the projects came into service, and the second from internal basin water balance accounting.

The steps taken to repair the records were as follows.

1. Review the derivation of each of the four inflow sequences: Victoria, Meelpaeg, Upper Salmon and Lower Salmon.
2. Identify years when the records show apparent discontinuities, for example, when there is a break in slope in a double mass curve, or when a step trend has been identified. Check whether there was a physical change at that time that could explain the discrepancy. Also, work in the other direction; identify years when physical changes were known to have occurred, which could give reason for an adjustment (for example, change in location of a water level gauge). Examine the record particularly carefully around those years for internal consistency.
3. Identify the period or periods in each Hydro basin for which the data are most likely to be accurate, using the years identified in Item 2 above to assist with the definition of these periods.
4. Review the relationships among the Hydro basins and natural basins gauged by Environment Canada (EC) for the periods identified in Item 3 above. Similar relationships would be expected over time and over space for basins subject to similar hydrometeorologic conditions.
5. Based on an assessment of the relationships determined in Item 4, adjust the annual inflow volumes assuming that the error was systematic on an annual basis and proportional to flow volume.
6. Check inflow sequences after adjustments by assessing the resulting mass curves, statistical descriptors, mean annual runoff ratios over space and time, time series plots, and trend tests.
7. Distribute adjusted annual inflow to obtain the reference monthly inflow series.

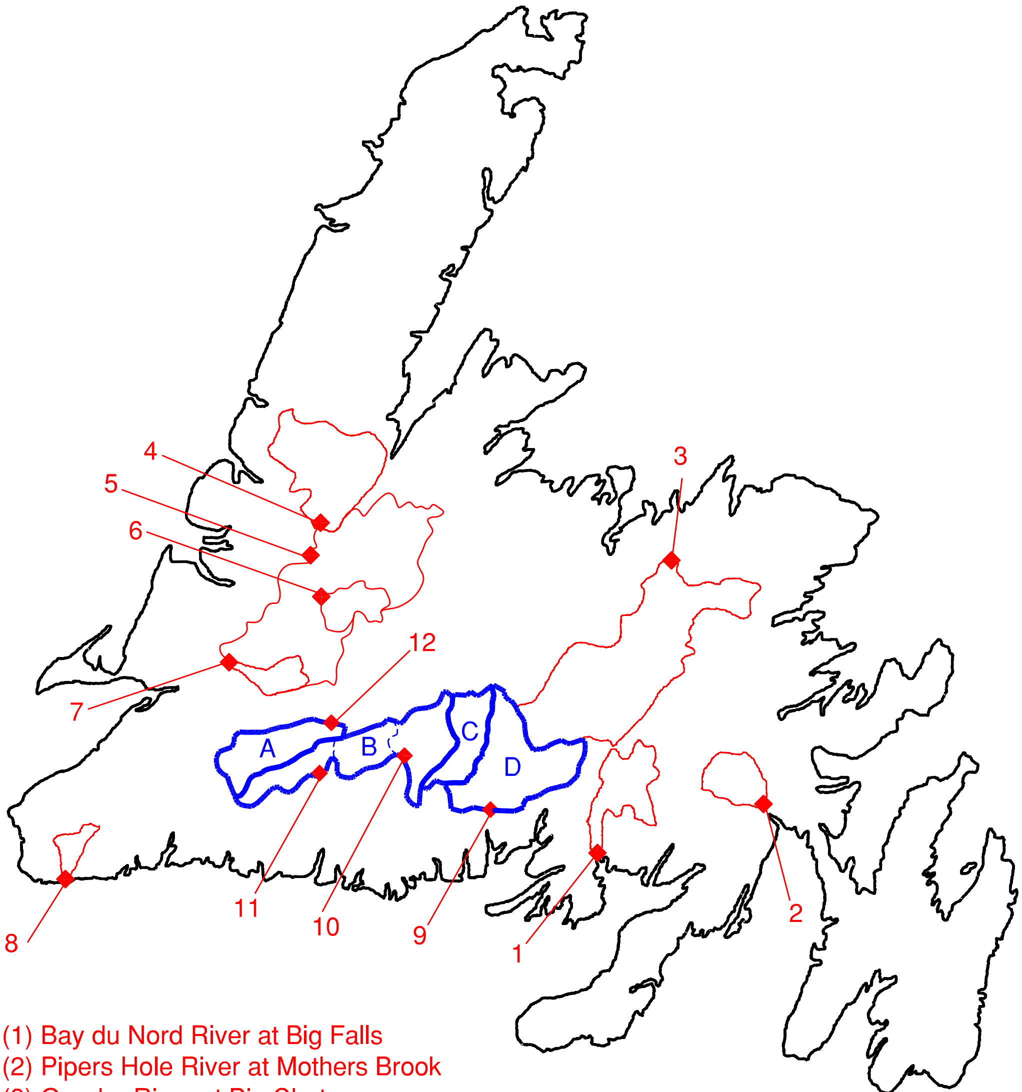
In carrying out the work described above, comparisons among basins were done using mean annual runoff, since this measure removes the effect of drainage area and therefore allows comparison among basins. Mean annual runoff is the average annual inflow expressed as an average depth in millimetres over the entire drainage area. It can be considered the effective precipitation over the area, that is, the average precipitation over the basin minus losses to evapotranspiration. The range of mean annual runoffs on the Island of Newfoundland is from over 2000 mm in the southwest near the coast, to about 750 mm in the northeast. For a basin with inflow records, it is calculated by dividing the annual inflow volume by the drainage area. In general, there is not much hydrological diversity across the main part of the Island of Newfoundland, that is, patterns of runoff in the long term are similar; wet areas tend to be consistently wetter, and vice versa. In any particular year, the patterns will vary, but over the longer term, for example, 15 years, the patterns tend to be stable.

Appendix C includes the mean annual runoff data from both the Hydro reference inflow sequences and the EC streamflow stations used in the analysis. The drainage areas provided by EC and by Hydro were assumed to be correct. All EC streamflow data are available in the published HYDAT database.

For all the Hydro basins, pre-project inflows were originally derived from the records of gauged basins. Post-project inflows were derived by a process called backrouting. Backrouting is a calculation procedure in which inflows to a basin are calculated from the known outflows through a structure such as a gate, spillway, or power station, taking account of the volume of water that may have been added to or drawn from the reservoir during the time period. If the reservoir level has not changed, the inflows equal the outflows. If the reservoir level has gone down, the inflows equal the outflows minus the volume of water drawn from storage. If the reservoir level has gone up, the inflows equal the outflows plus the volume of water stored. If there is a source of inflows other than natural local runoff, such as a canal delivering flow from another basin, then these additional inflows have to be subtracted as well to obtain the natural local inflows. This additional calculation is required in all the Bay d’Espoir basins except Victoria. Hydro’s calculations also take account of water transport time, that is, the time taken for water to travel from one reservoir to another.

The locations of the Bay d’Espoir basins and the other gauged basins used in the analysis are shown in Figure 2.1. Some of the gauged basins are subbasins of a larger basin. A system schematic showing the locations of reservoirs and structures in the Bay d'Espoir system provided by Hydro is also included for reference in Appendix A.

Sections 3 to 6 below describe the derivation of each of the four reference inflow sequences used by Hydro for the Bay d'Espoir basins, and the assessment of the sequences. Section 7 then describes the adjustments made to correct the sequences. Section 8 describes the testing of the adjusted sequences, and Section 9 provides conclusions and recommendations.



(1) Bay du Nord River at Big Falls
(2) Pipers Hole River at Mothers Brook
(3) Gander River at Big Chute
(4) Upper Humber River near Reidville
(5) Humber River at Deer Lake
(6) Hinds Brook near Grand Lake
(7) Lewaseechjeech Brook at Little Grand Lake
(8) Isle aux Morts River below Highway Bridge
(9) Salmon River at Long Pond
(10) Grey River near Pudops Lake
(11) White Bear River at White Bear Lake
(12) Victoria River below Highway Bridges

Drainage Areas
(A) Victoria
(B) Grey
(C) Upper Salmon
(D) Lower Salmon

Figure 2.1
Locations of Drainage Basins
Adjustment of Bay d'Espoir Reference Inflow Sequences
Newfoundland and Labrador Hydro

SGE Acres

Victoria Reservoir Basin

3 Victoria Reservoir Basin

The reference inflow sequence falls into three periods, the pre-project period from 1950 to 1967, the reservoir filling period from approximately 1968 to 1970, and the period of reservoir operations or post-project period, from 1971 to the present.

3.1 Description of Victoria Inflow Sequence

3.1.1 Victoria Pre-Project Description

The pre-project inflow sequence is an estimated sequence, based on transposing flows from gauged basins. The method for estimating the inflow sequence for the pre-diversion period 1950 to1967 is shown on the timeline in Figure 3.1. For the period January 1950 to September 1966, the flows were transposed from EC hydrometric station 02YK002, Lewaseechjeech Brook at Little Grand Lake, by proration by drainage area, adjusted for runoff. The Victoria basin was assumed to have 90 percent of the mean annual runoff of the Lewaseechjeech Brook basin.

For about a year during construction, from October 1966 to September 1967, a gauge on Victoria River measured flows from the Victoria basin itself. A slight adjustment was required to take account of the small difference in drainage area.

While the documents from Hydro indicate that the sequence to 1966 was based on the Lewaseechjeech Brook record, the EC database of records for the Lewaseechjeech Brook contains no data for 1950 and 1951, only one monthly value for 1952, nine monthly values for 1953, and eight monthly values for each of 1954 and 1955. The first year with continuous data is 1956. EC staff confirm that to the best of their knowledge, all the Lewaseechjeech Brook data available are in the HYDAT data base. The missing data may have been reconstructed from some other undocumented source for Lewaseechjeech Brook, or from another basin.

3.1.2 Victoria Reservoir Filling Period Description

In the fall of 1967, Victoria Dam construction cut off the flow to Victoria River, so from October 1967 to the present, the flows have been calculated from project data.

The Victoria Reservoir filling process took several years. The record from the hydrometric station on the Victoria River ends in September 1967, since the dam closed off all inflows except spill. Spill to Victoria River ended in mid-February 1971 and water was first diverted through Victoria Canal to the Meelpaeg Reservoir basin in late April 1971. The engineers working on the construction of the project provided Hydro with an estimate of inflows from January 1965 to November 1969. To the best of Hydro's knowledge, the estimate of flows for December 1969 to April 1971 comes from the same source.

There is an anomaly in the data for the transition period at the end of the reservoir filling period; the average recorded runoff in 1970 is unusually low, and in 1971 it is unusually high. This anomaly is due to a few months in which the backrouting during reservoir filling resulted in large negative inflows, with proportionately low values in adjacent months when compared with natural basins. These low values can readily be seen in Figure 3.1. This anomaly was noted by Hydro in 1972, but no adjustment was made at that time.

3.1.3 Victoria Operations Period Description

From May 1971 on, inflows were calculated by Hydro from the outflows measured at the Victoria Canal control structure and the Victoria spillway, and the change in storage in the reservoir.

The gate curves for the Victoria Canal control structure were checked in 1976, and no changes were made. The flows have continued to be calculated in the same way, using the same volume-elevation curve and gate discharge curve.

Water levels in Victoria Reservoir are read from a staff gauge by water controllers stationed at the nearby Burnt Dam, and reported by telephone to the control centre. There have been no changes to water level recording procedures except a conversion from imperial to metric in the early 1980's.

3.2 Assessment of Victoria Inflow Sequence

The *Island Hydrology Review* identified a step trend around the time of the implementation of the diversion of the Victoria basin into the Meelpaeg River basin. This event also was shown as a break in the double mass curve of the Victoria inflow sequence and the natural Gander River flows, as shown in Figure 3.2.

3.2.1 Victoria Pre-Project Assessment

The Victoria pre-project sequence was assessed by comparing it with records from natural gauged basins.

The closest natural flow basins with continuous records extending back into the 1950's include

- EC 02YQ001, Gander River at Big Chute (1950 to present);
- EC 02ZF001, Bay du Nord River at Big Falls (1952 to present, except two months in 1980); and
- EC 02YL001, Upper Humber River near Reidville (1953 to present).

The two missing months in 1980 in the Bay du Nord record were filled in as described in Appendix D, to allow use of the complete series from 1952 to 2002.

Information for the Humber River basin above Deer Lake was also used. The series was called Humber River at Deer Lake in this report to avoid confusion with the regulated EC hydrometric station 02YK001, Humber River at Grand Lake Outlet. The sequence consists of backrouted natural inflows provided by Deer Lake Power for the Grand Lake basin. It was used because data are sparse in the west-central region. In particular, it serves as a proxy for the Lewaseechjeech Brook record, since Lewaseechjeech Brook is part of the larger Grand Lake basin. The Lewaseechjeech Brook record was not used because of data quality concerns in the early part of the record. There are no problems with data from any other EC station used in this report.

The table below shows the mean annual runoff for the Victoria Reservoir basin and for other available stations for the pre-project and post-project periods. The pre-project period is taken as 1953 to 1967 rather than 1950 to 1967 so that data from all the above stations could be used. This table also shows the pre-project mean annual runoff as a fraction of the post-project value.

Table 3.1
Runoff Comparison, Victoria Pre-Project and Post-Project

Basin	Mean Annual Runoff (mm)		
	Pre-Project 1953 to 1967	**Post-Project 1971 to 2002**	**Ratio of Pre to Post-Project**
Victoria Reservoir (unadjusted)	*1010*[1]	1152	0.877
Gander River at Big Chute	814	853	0.954
Upper Humber River near Reidville	1132	1217	0.930
Bay du Nord River at Big Falls	1016	1095	0.928
Humber River at Deer Lake[2]	873	938	0.931

1 Calculated from Victoria inflows as estimated by project designers

2 Natural inflows backrouted by Deer Lake Power

The annual pattern of inflows to Victoria in the pre-project sequence seems reasonable. As Table 3.1 shows, however, the Victoria runoff is considerably lower pre-project compared to the post-project value than the natural gauges, suggesting that the original designers underestimated the flows. The Gander River ratio is slightly higher, but this difference appears to be simply the result of natural hydrological diversity, since the pre-project and post-project annual flows for the Gander River correlate well with those of other stations in the region for periods of overlapping records.

It is not surprising that the pre-project estimates made by project designers require adjustment, because they had little measured data from the basin itself on which to base their correlations. Nevertheless, as an additional check, the post-project period was split into two parts, from 1971 to 1985 and from 1986 to 2002. The ratios of the two periods for Victoria basin are similar to the ratios for the natural basins, as shown in Table 3.2. This result indicates that the adjustment is required for the pre-project period only.

Table 3.2
Runoff Comparison, Victoria: Two Post-Project Periods

Basin	Mean Annual Runoff (mm)		
	Post-Project 1971 to 1985	Post-Project 1986 to 2002	Ratio Two Post-Project Periods
Victoria Reservoir (unadjusted)	1187	1120	1.060
Gander River at Big Chute	865	843	1.027
Upper Humber River near Reidville	1277	1165	1.096
Bay du Nord River at Big Falls	1139	1057	1.078
Humber River at Deer Lake[1]	937	939	0.998

1 Natural inflows backrouted by Deer Lake Power

If the post-project data during the operations period since 1971 can be accepted, then the pre-project data can be adjusted accordingly. A minor adjustment will be required to a couple of months in 1950, which are unnaturally high.

3.2.2 Victoria Reservoir Filling Period Assessment

The pattern of monthly inflows during the reservoir filling period seems reasonable, with the exception of a couple of large negative inflows with unusually high inflows in other months.

Overall, the volumes are relatively lower than the natural basins during this period (1968 to 1970), perhaps due to non-continuous monitoring or difficulties of recording and calculating outflows.

3.2.3 Victoria Operations Period Assessment

The mass curve analysis and statistical tests in the *Island Hydrology Review* indicated that there were no problems with the data for the post-project period, from 1971 to the present. This conclusion was checked by replotting and examining double mass curves using other records, including the most recent data. Also, the mean annual runoff value for the Victoria Reservoir basin for the post-project period of about 1150 mm is consistent with the mean annual runoffs for the other stations, given its location and elevation.

3.2.4 Summary of Victoria Assessment

Since the data for the sequence developed in the reservoir operations period (1971 to 2002) are internally consistent and show similar patterns as natural gauged basins, these data provide the best basis for adjusting the pre-project and reservoir filling period sequences.

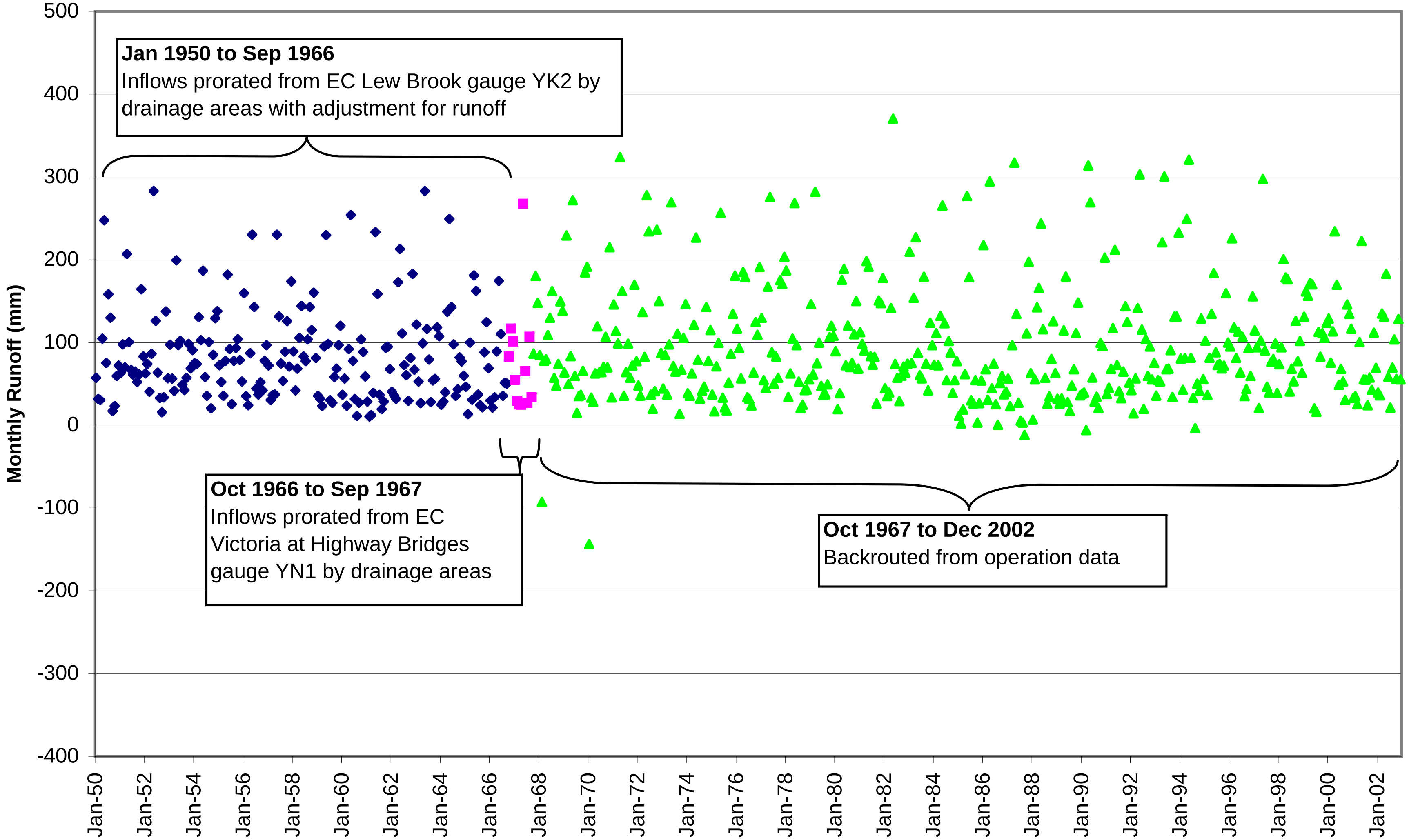


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Figure 3.1
Victoria Reservoir Basin Monthly Runoff
Adjustment of Bay d'Espoir Reference Inflow Sequences
Newfoundland and Labrador Hydro

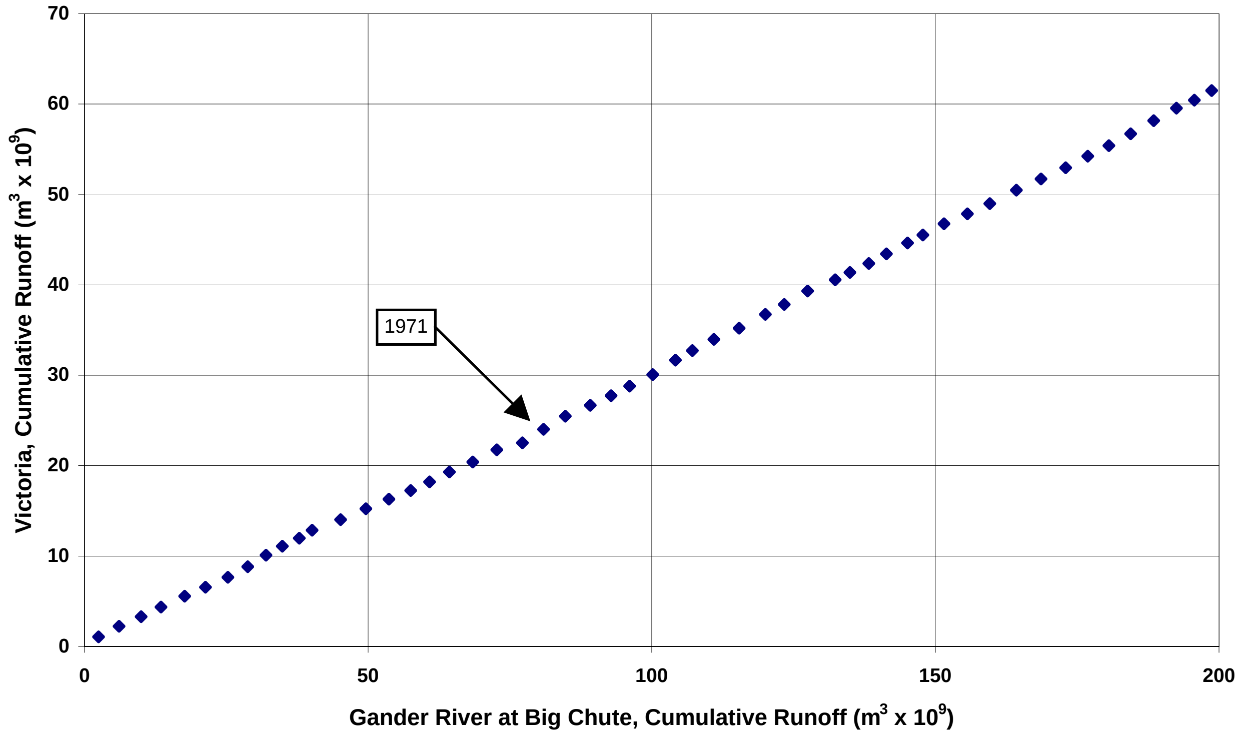

Figure 3.2
Double Mass Curves:
Unadjusted Victoria Runoff

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Adjustment of Bay d'Espoir Reference Inflow Sequences
Newfoundland and Labrador Hydro

Meelpaeg Reservoir Basin

4 Meelpaeg Reservoir Basin

4.1 Description of Meelpaeg Inflow Sequence

Like the Victoria basin inflow sequence, the Meelpaeg Reservoir basin inflow sequence is composed of two parts developed using different techniques. The pre-project flows are estimates based principally on transposing or prorating flows from gauged basins. The post-project flows are calculated from project data; first during the reservoir filling period, and since about 1971 from operations data.

The basin is hydrologically more complex than the Victoria basin. Besides being just over twice as large, 2152 km^2 compared to 1058 km^2 for Victoria, it is long and narrow, over 120 km along an approximately east-west axis. This distance is approximately one-third of the width of the Island. The upper part of the basin, to the west-southwest above Burnt Pond, is relatively wet, whereas the lower part, to the east around Meelpaeg Reservoir, is drier. As water flows from Victoria Reservoir towards Meelpaeg Reservoir, it first passes through Burnt Pond, then through a large lake, Granite Lake. The routing of flows through these water bodies, especially Granite Lake, affects the monthly flow pattern into Meelpaeg Reservoir.

4.1.1 Meelpaeg Pre-Project Description

Before the diversions were constructed, the upper part of the basin above Granite Lake, just over half the total area, flowed south into the White Bear River through two branches, Burnt Pond Brook and Granite Lake Brook. The remaining part of the basin flowed south into Grey River. The pre-project sequence was constructed by the engineers working on the construction of the project in the mid-1960's by estimating flows separately for the Grey River and White Bear River diversions, and then adding them together.

The timeline in Figure 4.1 shows the sources for the different parts of the sequences for the two basins. Two stations referred to on this timeline are in the larger Meelpaeg basin. These are EC stations 02ZD001, Grey River near Pudops Lake, and 02ZC001, White Bear River at White Bear Lake. The locations of these basins within the Meelpaeg basin are shown in Figure 2.1.

4.1.2 Meelpaeg Reservoir Filling Period Description

Three lakes, Ebbegunbaeg, Meelpaeg, and Pudops, were filled and joined as part of the Stage I Diversions to become Grey Reservoir (now called Meelpaeg Reservoir). It began filling in mid-March 1967, when the construction of Pudops Dam cut off flow to Meelpaeg River. Project engineers calculated monthly inflows based on month end storage positions and estimated volume-elevation curves. Water levels began being taken weekly in 1968 while Granite Canal was being constructed. This canal brought water from the White Bear diversions to Meelpaeg Reservoir.

For the first few years, all the inflows were stored in the reservoir, until the elevation of the reservoir was high enough to allow the water to flow out through the new outlet at Ebbegunbaeg Canal. Excess water during construction was first recorded as having spilled through Ebbegunbaeg Canal in April 1969. In November 1969, project engineers provided a memo with calculated monthly inflows from January 1965 to September 1969. The memo noted that adjustments would be required once the Ebbegunbaeg control structure discharge curve had been verified. It also expressed concerns about apparent negative inflows in the summer of 1969.

4.1.3 Meelpaeg Operations Period Description

Victoria diversions into Meelpaeg began in early 1971; at this time, Hydro started keeping records of water being diverted from Victoria basin to Meelpaeg basin. For the purpose of this report, the start of the reservoir operations period is taken as 1971. From about that time on, local inflows to Meelpaeg Reservoir were backrouted by Hydro from the inflows at Victoria control structure, outflows from Burnt Dam spillway for fisheries compensation and spill, outflows at Ebbegunbaeg control structure, and the change in storage in Meelpaeg Reservoir.

Hydro's backrouting calculations take into account the water transport time from Victoria control structure to Ebbegunbaeg control structure. They do not take into account any loss over the overflow spillways at Granite Lake, because until recently, the water levels in Granite Lake were not measured. Spill from Granite Lake out of the system would have occurred infrequently, only in large floods, and total volumes would have been small. A small release is also occasionally made from a fish compensation structure near Pudops Dam, at the west end of Meelpaeg Reservoir.

In the early years, because the water from the diversions was not always required at Bay d'Espoir, water was frequently spilled at Burnt Dam spillway to White Bear River rather than being passed through Granite and Ebbegunbaeg Canals. It was not until around 1975 that the water from the diversions began to be fully utilized.

From 1971 to the present the methodology for calculating flows has not changed. A curve is used to calculate the outflows through Ebbegunbaeg control structure, relating reservoir water level to outflow through one or more of the three gates. A similar type of curve is used at Burnt Dam spillway to calculate flows released through that structure for fisheries compensation as well as spill. The outflows from Ebbegunbaeg control structure are by far the largest of the outflows from the Meelpaeg basin. Any change to or error in these curves has the potential to cause discrepancies in the inflow record. The history of the Ebbegunbaeg gate operations and flow calculations is provided in some detail below, since the anomalies identified in the inflow sequences appear to relate to water transfer through Ebbegunbaeg control structure.

April 1969 to November 1982

The gates were manually operated to release water to Long Pond for generation requirements at Bay d'Espoir or for spilling out of Long Pond when necessary, since there is no spillway from Meelpaeg Reservoir itself. The gates were either closed, or operated in the full open position. The gate operations were done locally by Water System Attendants.

Water flows were calculated based on reported gate openings elevation readings telemetered to the Bay d'Espoir plant control room. Look-up tables derived from curves were used to determine flows. The first curve used was provided by the project designers. A gauging program was undertaken in 1975 to check the gate curve, and it was slightly revised.

November 1982 to April 1992

The Upper Salmon plant began initial operations in November 1982 with the impounding of water in Great Burnt Lake and Cold Spring Pond. Operation of the Ebbegunbaeg gate was made remote using communications through the

Upper Salmon plant. Partial gate operations began in November 1982, in order to more closely match the water releases to the requirements of the Upper Salmon plant.

The datum at Ebbegunbaeg was changed to match Upper Salmon on January 11, 1983. The elevation was increased by 4.42 m.

Water flows through the gates were calculated in the same manner as previously, using look-up tables. However, partial gate flows were assumed to be proportional to full gate flows (that is, 50 percent open was assumed to give 50 percent of full flow). The calculation of flows was made by the Energy Control Centre staff at Bay d'Espoir using the telemetered readings.

April 1992 to January 1994

The operation of the gates did not change. The calculation of flows was changed, however, to a computer program within Hydro's Energy Management System (EMS) rather than manual look-up tables. The look-up tables were converted to mathematical formulas, and the flow is calculated every five minutes based on the water levels in Meelpaeg Reservoir and the gate opening. Prior to being used in the EMS, the results of the formulas were checked to ensure that the results were reasonably close to those obtained using the look-up tables.

January 1994 to March 1999

In January 1994 it was discovered that the Ebbegunbaeg gates were out of the stream flow when approximately 75 percent open by the gate indication. This was causing operational difficulties when the gates were open greater than 75 percent because of ice accumulation on the gate gains. The opening is 12 feet and the full gate travel is 16 feet.

On January 20, 1994 the opening of the gates was restricted to 75 percent so that ice would not build up. This did not cause a water control problem because at 75 percent indication the opening was actually 100 percent and full flow was achieved. It was concluded at this point that the indication was showing gate travel and not gate opening.

In February 1994 when the hydrological report with the results of the backrouting calculations was issued, it showed a large discrepancy in the

Upper Salmon and Meelpaeg inflows. This was found to be an error in partial gate flow calculations. The error in the calculation for partial gate openings was corrected in the EMS program in February 1994. The correction reflected the fact that the relationship of flow to gate opening was not a straight line but varies in accordance with a theoretical curve supplied by the Upper Salmon project engineers.

At that time (February 1994), Hydro also undertook a review to determine whether the flow calculation should be adjusted to reflect the fact that an indication of 75 percent open was actually 100 percent opening. The resulting flows calculated using the adjustment were unrealistic, however. It was therefore decided to continue calculating flows based on the percent open indication and not the actual percent open. Although technically incorrect, there appeared some other compensating error resulting in a reasonable result.

In 1994, because of the discrepancy in indication and actual opening, Hydro identified the need for the local indication at Ebbegunbaeg to be changed to meters open rather than percent open, and installed a device to measure gate travel. Remote indication was not changed at that time.

Hydro also initiated a request at that time to have canal flow metering done on the Ebbegunbaeg gates and canal. This field work was carried out by Water Survey of Canada in 1995 and in-house by Hydro in 1996. The results did not cause a change in the relationship of gate opening to flow for a given reservoir level used for calculating flows. In particular the flow for one gate fully open was checked and reasonably matched the EMS program and look-up table results.

March 1999 to Present

In 1999, Hydro made adjustments to the partial gate flow calculations to correct for the wrong indication (percent open rather than meters open). At that time the gate opening indication was adjusted in the flow calculation to reflect the true opening (that is, the true opening was 12/16 of the indicated opening). The curves used to calculate flow for partial gate openings were consistent with those issued as part of the Upper Salmon reservoir operations manual. Therefore, since 1999 the flows have been calculated as intended when the Upper Salmon project went in service. The result, however, has been larger anomalies in the Upper Salmon and Meelpaeg Reservoir inflows. This is consistent with the problem previously identified in February 1994.

In April 2002 the telemetered gate opening was changed to meters of gate travel rather that percent open. At the same time the control of gate position was improved to setpoint control as opposed to the operator manually jogging the gates to the desired position. As part of this project the gate position indicator was replaced to give more reliable gate position. The old device was found to be inaccurate for setpoint control. This did not result in any changes in flow calculations but added clarity to the operator on the gate position.

4.2 Assessment of Meelpaeg Inflow Sequence

The double mass curve in Figure 4.2 shows a step trend around 1971, the time of the implementation of the diversion of the Meelpaeg and Victoria inflows to the Salmon River basin. It also shows several other break points, a possible one around 1976, another around 1982/1983 at the time of construction of the Upper Salmon project, one in the early 1990's, and another around 1998. These correspond to times when changes occurred relating to the Ebbegunbaeg control structure curve, as described further below.

Any adjustments for the post-project Meelpaeg Reservoir inflow sequence will involve outflows through Ebbegunbaeg control structure because these flows are an essential part of the backrouting calculations. Adjustments must also be made in conjunction with corresponding adjustments in the Salmon River basin, since the Meelpaeg Reservoir outflows are inflows to the Salmon River basin, and are used in Salmon River basin backrouting calculations.

4.2.1 Meelpaeg Pre-Project Assessment

As at Victoria, the pattern of annual runoffs during the pre-project period 1950 to 1967 is similar to the natural gauged basins for which data are available, with the exception of 1950. The mean annual runoffs for various pre-project periods were tabulated, to determine whether any adjustments appear to be required for the pre-project period based on data from natural basins.

The periods were chosen to allow comparison of different basins over the region for overlapping periods. The stations are the same as those used for the Victoria comparison, with the addition of the two stations with short records in the Meelpaeg Reservoir basin itself and Salmon River at Long Pond. As mentioned in Section 4.1.1 above, the stations within the Meelpaeg Reservoir basin are Grey River near Pudops Lake, with eight complete years of record (1959 to 1966), and White Bear River at White Bear Lake, with four complete years (1965 to 1968). Although the record lengths are short, they are important because they provide information on natural runoff from the two subbasins within the Meelpaeg Reservoir drainage area. The Salmon River at Long Pond station has 21 years of record (1944 to 1964).

Table 4.1 presents the mean annual runoffs for the relevant periods from 1953 to 1968 to allow comparisons to be made among basins.

The data in this table show the decrease in average runoff in the Meelpaeg Reservoir basin from west to east (refer to Figure 2.1 for the locations of the gauged basins). During the period 1965 to 1968 when the White Bear station was in service, the gauged White Bear basin is the wettest, at an average mean annual runoff of 1160 mm for the four years of complete record. This relatively high runoff is consistent with its location, since it is on the windward side of the major east-west divide across the island, and about two-thirds of the gauged White Bear basin is oriented in a southwesterly direction towards the incoming weather systems. Upper Humber is the next wettest, at 1113 mm for the concurrent period, and is in fact wetter than White Bear for the short 1965 to 1966 period.

Table 4.1
Runoff Comparison, Meelpaeg Pre-Project

Basin	Mean Annual Runoff (mm)					
	1953 to 1964	1953 to 1967	1959 to 1964	1959 to 1966	1965 to 1968	1965 to 1966
Meelpaeg Reservoir (unadjusted)[1]	*987*	*982*	*948*	*938*	*1007*	*910*
Gander River at Big Chute	819	814	812	810	831	805
Upper Humber River near Reidville	1138	1132	1152	1150	1113	1144
Bay du Nord River at Big Falls	1023	1016	972	968	1056	953
Pipers Hole River at Mothers Brook	1006	992	972	957	987	911
Salmon River at Long Pond	952	-	930	-	-	-
White Bear River at White Bear Lake	-	-	-	-	1160	1131
Grey River near Pudops Lake	-	-	875	855	-	794

1 Estimated by project designers before construction

The Salmon River record does not extend to 1968, but as can be seen from the data for the period 1953 to 1964, it is slightly drier than the Bay du Nord basin. The driest area within the Bay d'Espoir system is the original Meelpaeg River basin, surrounding what is now Meelpaeg Reservoir. Gander River, not in the Bay d'Espoir system, is the driest of those examined.

For the period of overlapping record, 1959 to 1966, the Grey River basin is slightly wetter than the Gander basin, with an average of 855 mm compared with 810 mm. This result is expected given its location further southwest. In individual years Grey has been drier than Gander; for example, in 1965 to 1966 the value for Grey River is 794 mm, slightly less than Gander at 805 mm.

Review and plots of these mean annual runoffs suggest that the general pattern of the inflows to Meelpaeg Reservoir in the pre-project period is reasonable. If part or all of the post-project record can be accepted as correct, then the pre-project record can be checked to determine whether an adjustment is required. In addition, a couple of months in 1950 will require minor adjustments, since they are unnaturally high.

4.2.2 Meelpaeg Reservoir Filling Period Assessment

The pattern of monthly flows in the filling period appears low overall when compared with the records from natural basins. In particular, 1970 is unusually low, perhaps due to non-continuous monitoring or difficulties of recording and calculating outflows, which would have been high as the reservoir reached its full supply level.

4.2.3 Meelpaeg Operations Period Assessment

A review of the data indicated that post-project record falls into three distinct periods. These are

- 1971 to 1982, from diversion through Ebbegunbaeg Canal to construction of Upper Salmon;
- 1983 to 1997, from construction of Upper Salmon to around 1997 to 1998;
- 1998 to 2002.

The first curves used by Hydro for Ebbegunbaeg control structure were based on theoretical curves provided by the project engineers. As described in Section 4.1, the curves were revised around 1975. The flows calculated prior to 1975 were sometimes slightly underestimated at low reservoir levels and slightly overestimated at high levels, with not much difference at intermediate levels; the overall effect on annual flow volumes may therefore be small. The period 1971 to 1982 is thus considered as one interval, with no break in 1975.

1971 to 1982

The recorded mean annual runoff for this period for the Meelpaeg Reservoir basin averages 1276 mm, higher than the runoff for either the Victoria basin at 1199 mm or the Salmon River basin at 856 mm, as shown in Table 4.2. A comparison with the mean annual runoffs for gauged basins during this period suggests that the runoff for the Meelpaeg Reservoir basin would not be expected to be more than about 1150 mm. Similarly, the mean annual runoff in the Salmon River basin would be expected to be less than 1000 mm.

It would appear that there was an error in the curve, which led to a consistent overestimate of outflows from Meelpaeg Reservoir for this period. An overestimate of outflows averaging around 9 to 10 m^3/s, or about 5 percent of the flow through one gate full open continuously, could lead to this difference.

1983 to 1997

After the construction of the Upper Salmon project, the flows from Ebbegunbaeg Canal had to be more carefully controlled, to match water requirements at the Upper Salmon generating station. Changes were made more frequently, still manually, and gates were frequently set at partial openings. Partial gate settings were recorded as a percent of full open. From 1983 to 1994, for example, 50 percent open was probably the most common setting, followed by 75 percent open. The gate status was recorded at midnight, or when there was a change.

With the installation of the EMS in the early 1990's, the recording interval for water level and gate position readings was reduced to five minutes. Flows though Ebbegunbaeg control structure were calculated every five minutes, using a curve fit to the tabular data. Since the mid-1990's, Hydro has been using economic dispatch software to ensure that units are always running at the most economic setting; as a result, gate changes have become more frequent.

Although the data in Table 4.2 suggest that the mean annual runoffs for the Meelpaeg and Salmon River basins are within the range expected, in fact an examination by Hydro of the gate operations and flow calculations suggests that the flows for partial gate openings were understated and the flows for full gate openings were overstated. The apparent reasonableness of the resulting overall inflow volumes in the Meelpaeg and Salmon River basins could be the result of these compensating errors.

1998 to 2002

As described in Section 4.1.3, having recognized some of the problems in the flow calculations for Ebbegunbaeg releases, Hydro made changes to the EMS to improve the calculations. During this period, however, the outflows from Ebbegunbaeg appear to have been overestimated, by perhaps 11 to 12 m^3/s on average. An overestimate of outflows from Meelpaeg Reservoir would lead to low estimates of natural inflows to Upper Salmon. This would be consistent with the mean annual runoffs shown in Table 4.2 for this period. The change made in 1999 in effect removed the compensating error in partial gate openings first introduced in 1983.

As of April 26, 2002, the control centre has started receiving data on the actual gate opening in meters, not as a fraction of full open. The correct information is being received, but the curves for both full gate and partial gate require detailed checking and revision.

Table 4.2
Runoff Comparison, Meelpaeg Post-Project

Basin	Mean Annual Runoff (mm)		
	1971 to 1982	1983 to 1997	1998 to 2002
Meelpaeg Reservoir (unadjusted)	1276	1112	1270
Victoria Reservoir (including January 1971 adjustment)	1199	1105	1157
Lower Salmon (unadjusted)	856	948	999
Upper Salmon (unadjusted)	856	1008	698
Gander River at Big Chute	864	858	814
Bay du Nord River at Big Falls	1135	1090	1016
Upper Humber River near Reidville	1308	1148	1209
Humber River at Deer Lake[1]	947	914	988

1 Natural inflows backrouted by Deer Lake Power

4.2.4 Summary of Meelpaeg Assessment

There is some evidence to indicate that there may be an error in determining the flow through the Ebbegunbaeg control structure. Accordingly, the calculated Meelpaeg Reservoir post-project inflows cannot be used without verification of gate curves and if necessary, data adjustment.

Although the pre-project record seems reasonable, there is no corresponding post-project record that can be used as the basis of a decision on whether a pre-project adjustment is required.

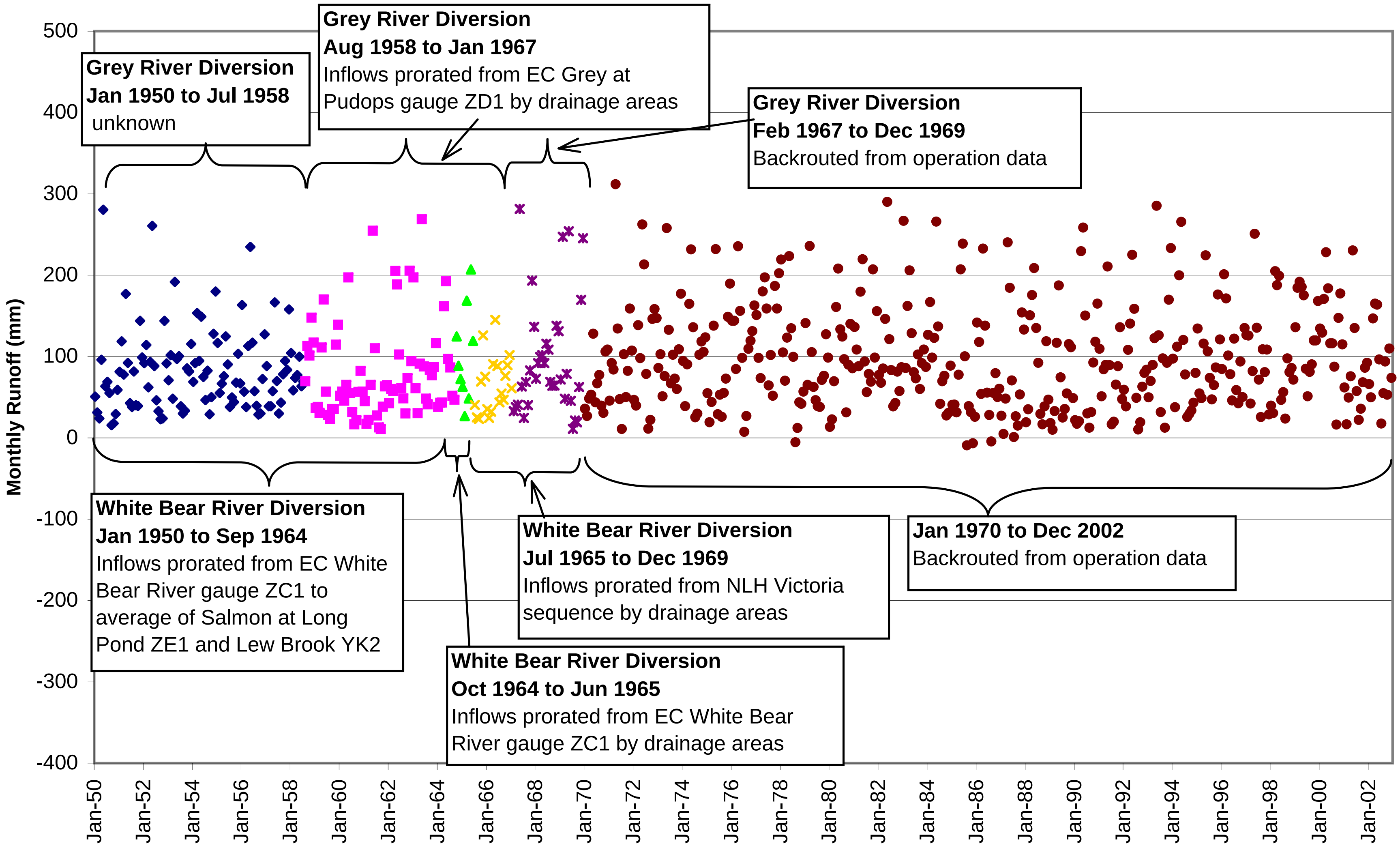

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Figure 4.1

Meelpaeg Reservoir Basin Monthly Runoff

Adjustment of Bay d'Espoir Reference Inflow Sequences

Newfoundland and Labrador Hydro

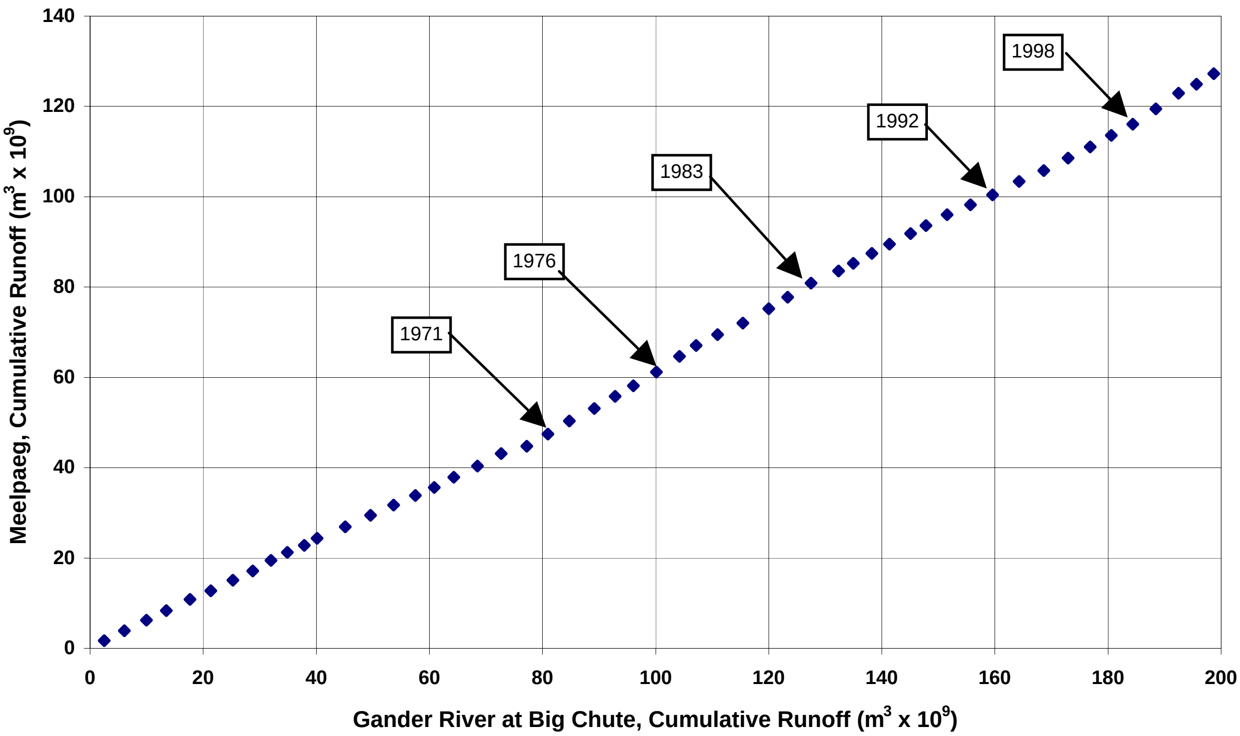

Figure 4.2
Double Mass Curves:
Unadjusted Meelpaeg Runoff
Adjustment of Bay d'Espoir Reference Inflow Sequences
Newfoundland and Labrador Hydro

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Salmon River Basin

5 Salmon River Basin

The Upper and Lower Salmon basins together make up the 2694 km^2 Salmon River basin above the intake to the Bay d'Espoir generating station. Before the construction of the generating station, the basin was gauged by EC; only 54 km^2 was added as a result of the construction of the Bay d'Espoir project.

With the construction of the Upper Salmon project, the basin was subdivided. The upper 902 km^2 contributes to the Upper Salmon generating station, and the remaining 1792 km^2, called Lower Salmon, lies between Upper Salmon and Bay d'Espoir generating stations. Until the construction of the Upper Salmon project, only one sequence was used for the whole Salmon River basin. After the Upper Salmon generating station came into service in 1983, records were kept separately for the two drainage basins. Figures 5.1 and 5.2 summarize the sources of data for the estimation of the Upper and Lower Salmon sequences, respectively.

5.1 Description of Salmon River Inflow Sequences

5.1.1 Salmon River Pre-Project Description

The pre-project data comes from EC station 02ZE001, Salmon River at Long Pond. The period of record is 1944 to 1966, but for consistency among all basins in the Bay d'Espoir system the start year for the reservoir inflow sequences is 1950.

The record was prorated by drainage area in order to develop separate inflow sequences for the Upper and Lower Salmon basins.

5.1.2 Salmon River (Long Pond) Reservoir Filling Period Description

Three lakes, Brazil Pond, Long Pond, and Jeddore Lake, were filled in the mid-1960's and became interconnected, forming Long Pond Reservoir. At Long Pond the water level measurements in Hydro's record start on October 1, 1965, presumably the start of the filling period. The Salmon River dam was closed on May 1, 1967, with generation from the first three units in May, June, and October 1967. Units 4 to 6 came on line between October 1969 and March 1970. A seventh unit was added in 1977.

At Upper Salmon, the small reservoir formed by the joining of Great Burnt Lake and Cold Spring Pond has little storage compared with the other Bay d'Espoir reservoirs.

5.1.3 Salmon River (Long Pond) and Upper Salmon Operations Period

As of May 1, 1967, the inflow sequence for the Salmon River basin was developed by backrouting using information from project facilities. The data includes flows through the generating station, spill, and change in storage. The outflows from Meelpaeg Reservoir through Ebbegunbaeg Canal are also included in the calculations.

The separate sequences for Upper and Lower Salmon were developed by proration by drainage area until 1982. From 1983 on, Upper Salmon inflows were calculated separately from Lower Salmon inflows.

5.2 Assessment of Salmon River Inflow Sequences

Double mass curves of both the Upper and Lower Salmon unadjusted inflow sequences are included in Figure 5.3

5.2.1 Salmon River Pre-Project Assessment

The pre-project values are taken from the Salmon River hydrometric record. The data for this period were therefore accepted for the total basin.

5.2.2 Lower Salmon (Long Pond) Reservoir Filling Period

The inflow volumes calculated for the Long Pond reservoir filling period, and the subsequent years as the units came on line successively, seem reasonable. (The Upper Salmon reservoir is small and the filling period did not require separate assessment for the purposes of this study.)

5.2.3 Lower Salmon (Long Pond) and Upper Salmon Operations Period

The Salmon River Basin sequences were reviewed in conjunction with the periods for Meelpaeg River, as follows. Runoff data are included in Table 4.2.

1971 to 1982

The recorded mean annual runoff of 856 mm for this period for the Salmon River basin is lower than expected. This discrepancy is consistent with the assessment of the Meelpaeg Reservoir sequence, in which the mean annual runoff was higher than expected. The amount of water passed through the Ebbegunbaeg control structure appears to have been incorrectly determined.

1983 to 1997

A review of the data for both Upper and Lower Salmon basins suggests that the values are not unreasonable. As discussed in Section 4, however, the apparent reasonableness of the sequences in this period is most likely the result of compensating errors.

1998 to 2002

As discussed in Section 4, the improved interpretation of the gate curves has not resolved the errors in Ebbegunbaeg flows, and it appears that the curves themselves may require redevelopment. Upper Salmon mean annual runoff is lower than Gander (698 mm compared to 814 mm) for this period, whereas it would be expected to be higher. This observation is consistent with the apparent overestimate for Meelpaeg, indicating that the problem is with the calculation of water transfer through Ebbegunbaeg control structure.

The mean annual runoff estimate for Lower Salmon of 999 mm for this period is slightly higher than expected, but is reasonable and likely attributable to hydrological diversity, which is more apparent when considering short time periods. Data from other stations show that some areas of the south coast had a wetter summer and fall in 1998 than was experienced elsewhere.

5.2.4 Summary of Salmon River Basin Assessment

The pre-project and reservoir filling period data can be accepted for the Salmon River basin. Data after 1971, however, cannot be accepted due to the uncertainty of the outflows from Meelpaeg Reservoir through Ebbegunbaeg control structure. The Lower Salmon record can be accepted for the period 1983 to 2002, since the water transfer discrepancy applies only to Meelpaeg and Upper Salmon for this period.

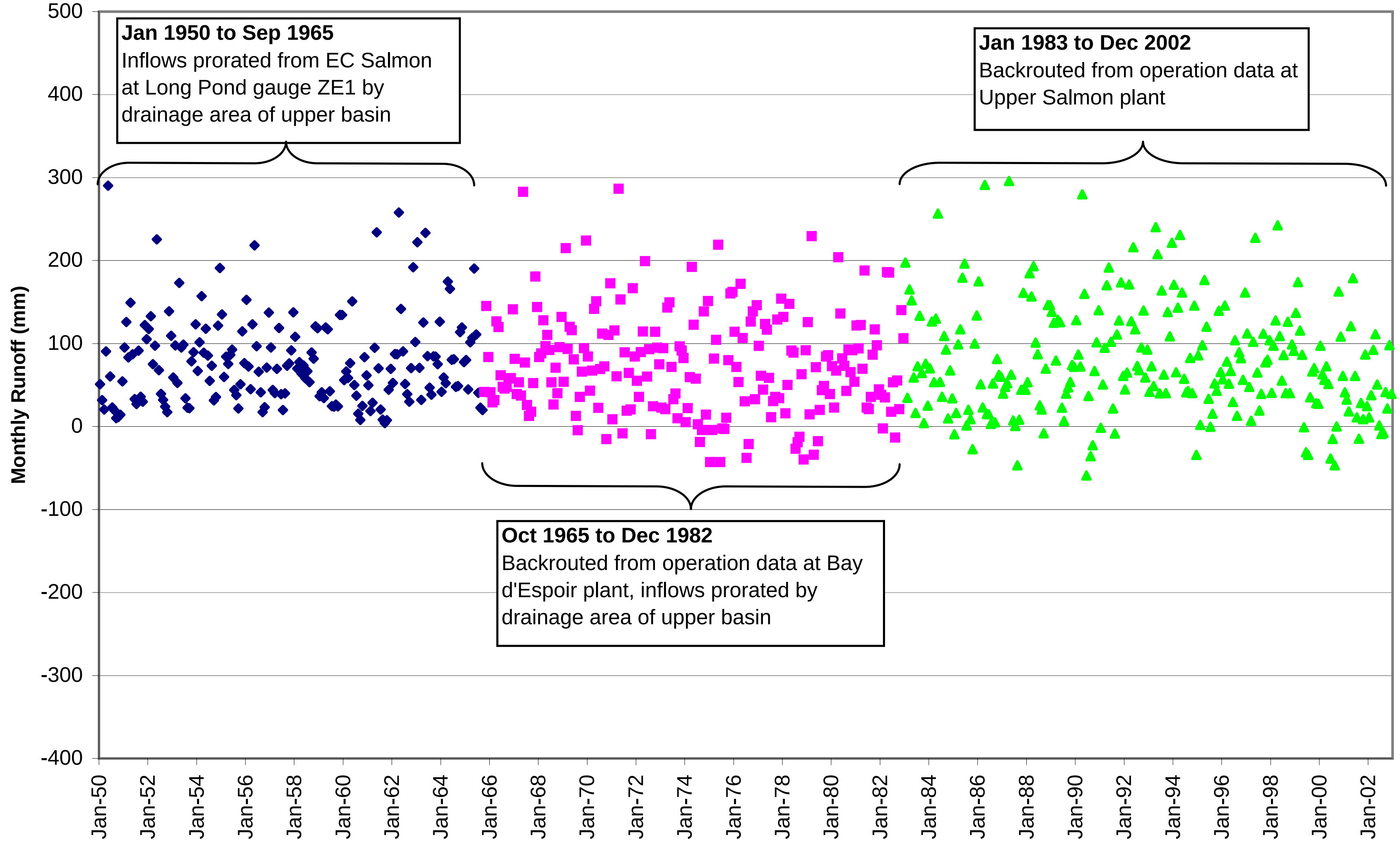

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Figure 5.1

Upper Salmon Basin Monthy Runoff

Adjustment of Bay d'Espoir Reference Inflow Sequences

Newfoundland and Labrador Hydro

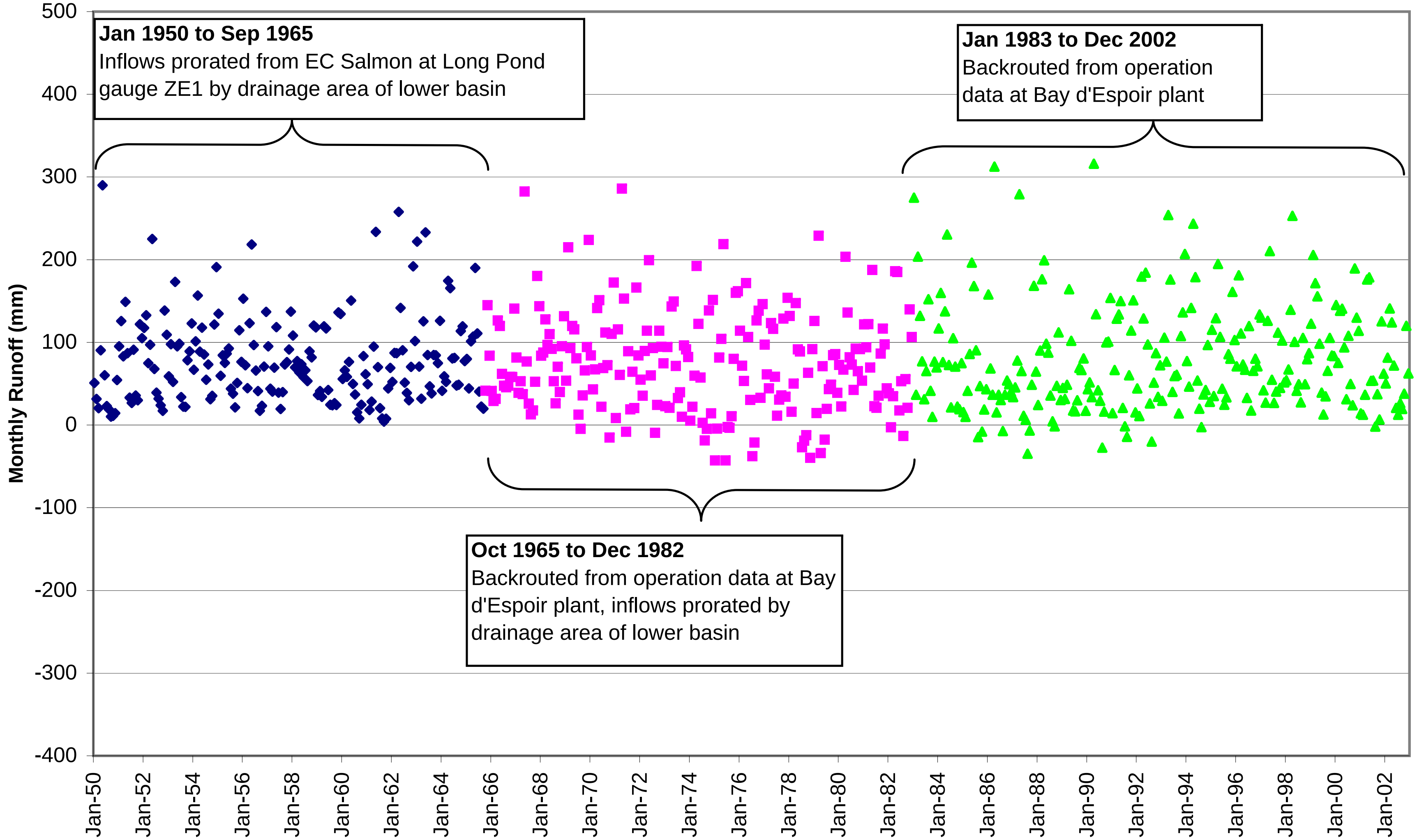

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Figure 5.2
Lower Salmon Basin Monthy Runoff
Adjustment of Bay d'Espoir Reference Inflow Sequences
Newfoundland and Labrador Hydro

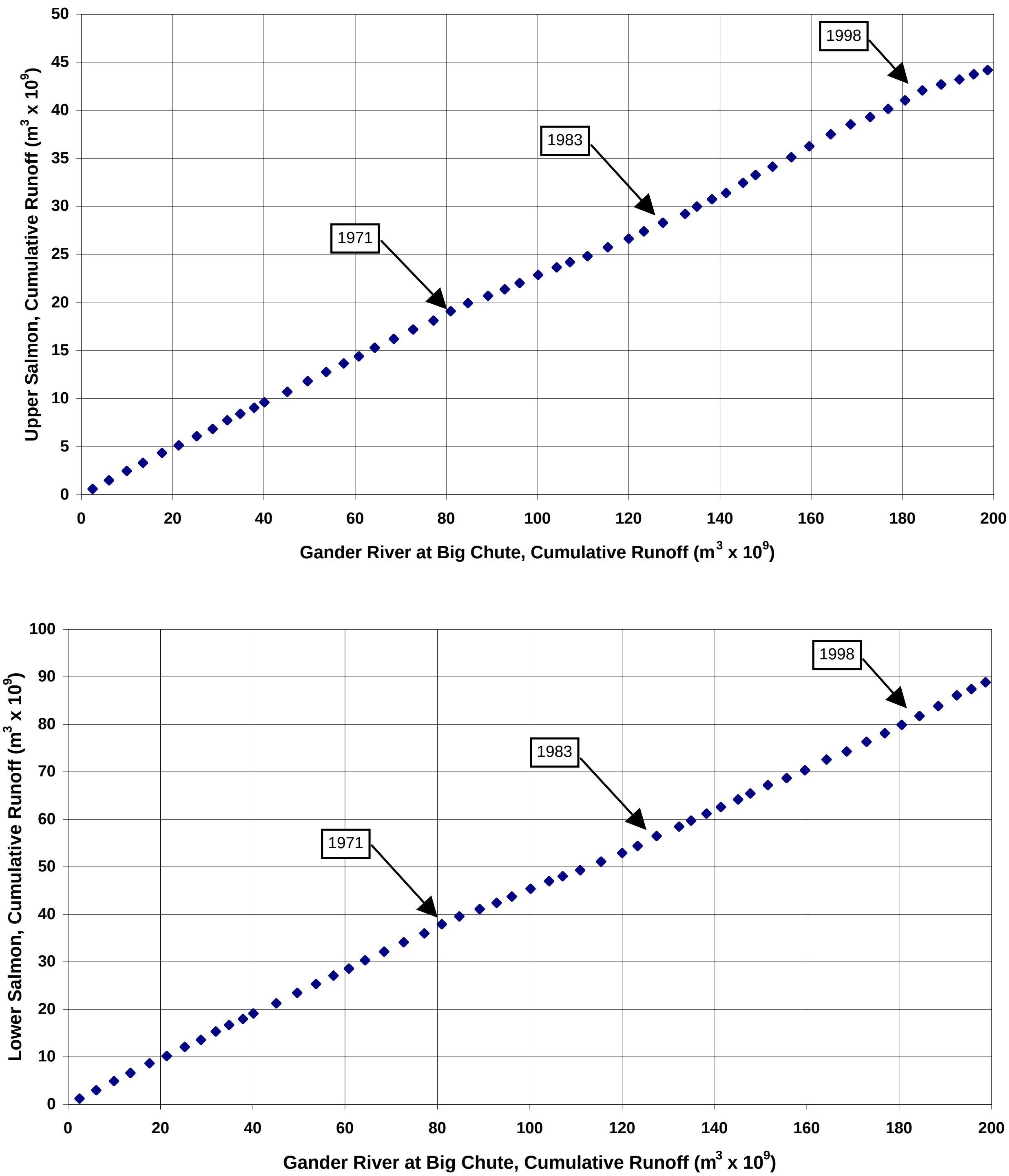


Figure 5.3
Double Mass Curves:
Unadjusted Upper and Lower Salmon Runoff
Adjustment of Bay d'Espoir Reference Inflow Sequences
Newfoundland and Labrador Hydro

Combined Meelpaeg and Salmon Basin

6 Combined Meelpaeg and Salmon Basin

The problem with the individual Meelpaeg Reservoir and Salmon River basin inflow sequences lies with the uncertainty of the water transfer between the two basins through Ebbegunbaeg control structure. The inflow sequences for the two basins were therefore combined to eliminate the need for calculation of this water transfer. The combined sequence was then assessed in the same fashion as the Meelpaeg Reservoir and Salmon River sequences.

6.1 Description of Combined Meelpaeg and Salmon Inflow Sequence

The combined inflow sequence was obtained by adding the original sequences for Meelpaeg Reservoir and Upper and Lower Salmon basins. The derivation of each of these was described in Sections 4.1 and 5.1.

6.2 Assessment of Combined Meelpaeg and Salmon Inflow Sequence

The double mass curve for the combined Meelpaeg and Salmon sequence in relation to the Gander River basin is shown in Figure 6.1. There are some minor fluctuations, but no major breaks are evident. An apparent offset in 1998, for example, is the result of a slightly wetter summer and fall in that region than in the Gander area. Preliminary statistical tests show no step trends in 1971 (as had previously been evident for the Meelpaeg Reservoir inflows) and no monotonic trends. A comparison of mean annual runoff for the combined basin with other basins is provided in Table 6.1.

The inflow sequence for the combined Meelpaeg and Salmon Basins can be accepted for the post-project period, since the source of the uncertainty has been eliminated by combining the basins.

Table 6.1
Runoff Comparison, Combined Meelpaeg and Salmon Basin Pre-Project and Post-Project

Basin	Mean Annual Runoff (mm)		
	Pre-Project 1953 to 1967	Post-Project 1971 to 2002	Ratio of Pre to Post-Project
Combined Meelpaeg and Salmon (unadjusted)	*962*[1]	1041	0.925
Gander River at Big Chute	814	853	0.954
Upper Humber River near Reidville	1132	1217	0.930
Bay du Nord River at Big Falls	1016	1095	0.928
Humber River at Deer Lake[2]	873	938	0.931

1 Meelpaeg flows estimated by project designers; Salmon River flows measured
2 Natural inflows backrouted by Deer Lake Power

The combined Meelpaeg and Salmon River Basin pre-project flows should theoretically be adjusted slightly, since there were no data at the time the estimates were made for correlating the estimated flows with measured flows. Although there are some data from individual gauges within the Meelpaeg Basin, there were no measurements covering the total Meelpaeg drainage area in the pre-project period. An adjustment can now be made using the post-project record for improving the estimate. The adjustment should be made to the Meelpaeg sequence only, because the pre-project record for the Salmon River basin was based on EC data and was therefore accepted.

Minor adjustments are required to the Meelpaeg sequence to 1950 and during the reservoir filling period, as noted in Section 4.2.

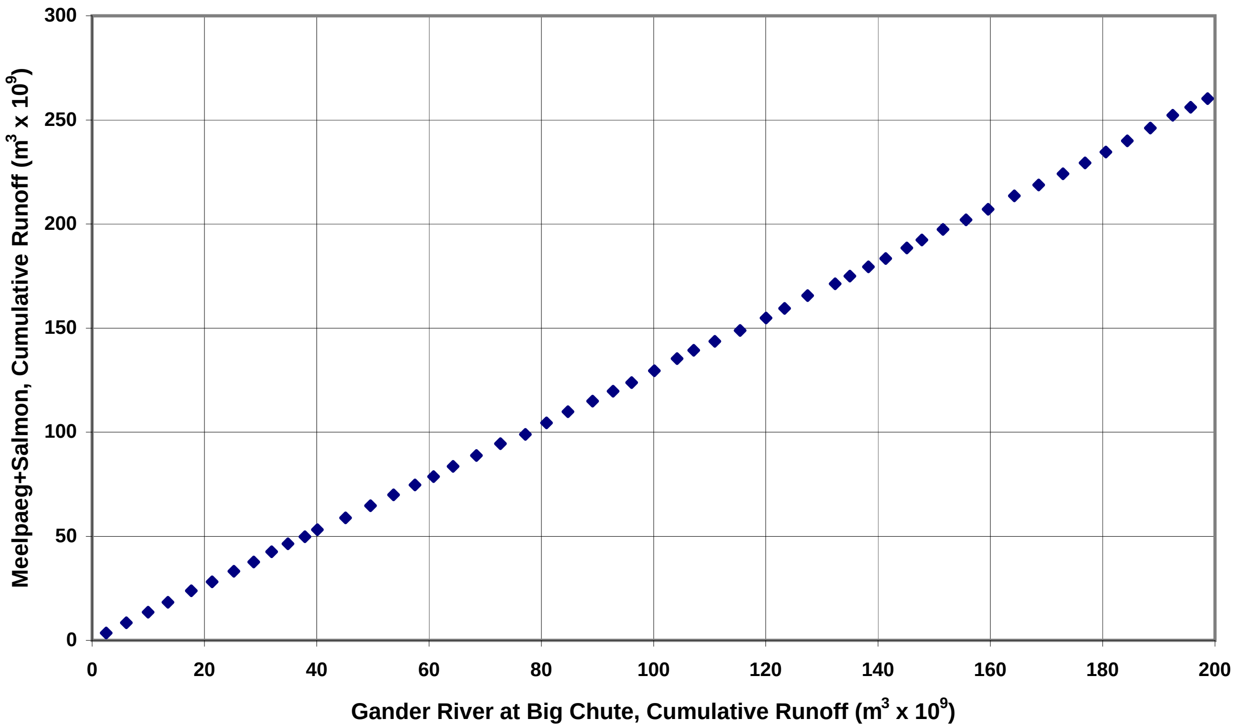


Figure 6.1
Double Mass Curve:
Unadjusted Combined Meelpaeg and Salmon Basin Runoff

Adjustment of Bay d'Espoir Reference Inflow Sequences
Newfoundland and Labrador Hydro

Development of Bay d'Espoir Basin Adjusted Inflow Sequences

7 Development of Bay d'Espoir Basin Adjusted Inflow Sequences

Based on the assessments of the inflow sequences in Sections 3 to 6, revised sequences for the Bay d'Espoir basins were prepared by making the following adjustments.

Victoria Reservoir Sequence

- Make minor adjustments: redistribute flows during reservoir filling period to eliminate large negative inflows, increase overall volumes during reservoir filling period to reflect expected hydrologic ratios, and correct two months in 1950.
- Adjust pre-project flows using post-project data.

Combined Meelpaeg and Salmon Basin Sequence

- Make minor adjustments: increase volumes during Meelpaeg Reservoir filling period to reflect expected hydrologic ratios, and correct two months in 1950 in Meelpaeg Reservoir inflow sequence.
- Calculate required pre-project flow adjustment for combined sequence, using same approach as for Victoria.
- Adjust pre-project Meelpaeg Reservoir sequence to give correct result for combined sequence. (As noted in Section 6, the Meelpaeg adjustment is small and recommended for theoretical consistency. For practical purposes it may not be necessary, particularly if Hydro will be recalculating the water transfers.)
- Calculate the ratio of Meelpaeg and Salmon basin inflows to combined Meelpaeg and Salmon River inflows using pre-project sequences; distribute post-project inflows in the same proportion.
- Calculate the ratio of Upper and Lower Salmon inflows to total Salmon basin inflows using the 1983 to 2003 period; distribute flows for remaining years in the same proportion.

The following sections give details on the pre-project adjustments to Victoria and combined Meelpaeg and Salmon inflow sequences, and then on the distribution of the combined sequence among Meelpaeg, Upper Salmon, and Lower Salmon basins. Appendix D describes the minor adjustments; these were made before the final revised sequences were prepared.

7.1 Pre-Project Inflow Sequence Adjustments

The assessments of the pre-project inflow sequences for both the Victoria Reservoir and the combined Meelpaeg and Salmon sequence had shown that the post-project flows could be accepted, and that upward adjustments were required for the pre-project period.

The adjustment factors were calculated by comparing the mean annual runoff ratios of the pre-project to post-project periods to the natural gauged basins. Information from the closest natural gauged basins was used. The *Island Hydrology Review* had shown that there is little hydrological diversity on an annual basis among these basins. A review of the annual time series plots and a correlation analysis confirmed that using data from four basins with records extending back into the early 1950's should give a reasonable representation of the hydrology in the Bay d'Espoir basins. Two basins, Gander and Bay du Nord, are to the east, and Upper Humber and Humber River at Deer Lake are to the west, so using all four takes account of east-west variations in weather patterns.

These four basins all correlate reasonably well with the recorded annual data for the Hydro basins for the post-project period. For the Victoria Reservoir sequence, Humber River (DLP data) and Bay du Nord have about the same correlation coefficients (0.79 and 0.77), as do Gander and Upper Humber (0.70 and 0.69). For the combined Meelpaeg and Salmon River basin, the correlations are best with Bay du Nord, Gander, and Humber River (0.83, 0.81, and 0.78), with Upper Humber at 0.62. These results, as well as a review of data and plots, suggest that it is appropriate to consider basins both to the east and the west. The weighted mean of the four basins, weighted by correlation coefficients, is almost exactly the same as the arithmetic mean, for both the Victoria Reservoir sequence and combined Meelpaeg and Salmon River sequence.

Table 7.1 shows the mean annual runoff for the pre-project and post-project periods for stations with the longest periods of overlapping record, 15 years in the pre-project period, and 32 years in the post-project period.

Table 7.1
Calculation of Pre-Project Adjustment Factors

	Mean Annual Runoff (mm)		
Basins	**Pre-Project 1953 to 1967**	**Post-Project 1971 to 2002**	**Ratio of Pre to Post-Project**
Hydro Basins			
Victoria Reservoir (with minor adjustments, Appendix D)	*1010*[1]	1149	0.879
Combined Meelpaeg and Salmon (unadjusted)	*962*[2]	1041	0.925
Natural Basins			
Gander River at Big Chute	814	853	0.954
Upper Humber River near Reidville	1132	1217	0.930
Bay du Nord River at Big Falls	1016	1095	0.928
Humber River at Deer Lake[3]	873	938	0.931
Mean of Ratios, Natural Basins			0.936

1 Calculated from Victoria inflows as estimated by project designers
2 Meelpaeg flows estimated by project designers; Salmon River flows measured
3 Natural inflows backrouted by Deer Lake Power

Using the mean of the four natural basin ratios leads to a pre-project value of 1075 mm for Victoria and 974 mm for the combined Meelpaeg and Salmon River basin. The corresponding adjustment factors for the pre-project sequences are 1.065 for Victoria, and 1.012 for the combined Meelpaeg and Salmon basins. Since the methodology for obtaining the original sequences for the 1950 to 1952 period were similar to the 1953 to 1957 periods, the adjustment factor was assumed to apply to the period 1950 to 1967.

Other sources of data with shorter records, such as Hinds Brook, were also considered. Although the exact adjustment factors calculated using shorter records were slightly different, they confirmed that upward adjustments in the pre-project period were required. The method selected took advantage of the largest and most reliable data sets available, and the results reflect the hydrology of the region.

7.2 Preparation of Separate Meelpaeg, Upper Salmon and Lower Salmon Inflow Sequence Adjustments

The preferred method for developing individual sequences for the Meelpaeg and Salmon basins would be to recalculate the water transfer through Ebbegunbaeg control structure. Some or all of the record can be recalculated when Hydro has carried out additional measurements and completed the investigations required to redevelop the Ebbegunbaeg control structure curves. There are enough data at present, however, to reasonably distribute the combined inflows into individual sequences for Meelpaeg, Upper Salmon, and Lower Salmon using the proportional approach described below as an interim measure. These sequences may also be used for comparison with, and possibly extension of, the recalculated sequences.

The combined Meelpaeg and Salmon basin sequence for the entire period was accepted, with the adjustments as discussed. The Salmon River basin pre-project flows were also accepted, since they were based on EC gauging. The allocation of flows between the Meelpaeg Reservoir and Salmon River basins was therefore calculated from the pre-project data; on the average it is about 46 percent to Meelpaeg Reservoir basin and about 54 percent to Salmon River basin. These proportions are similar to those that would be calculated using the ratio of drainage areas, with Meelpaeg slightly wetter. The Meelpaeg Reservoir basin is 44.4 percent of the total basin drainage area, Upper Salmon is 18.6 percent, and Lower Salmon is 37.0 percent.

This ratio was then applied to every year in the post-project sequence. One effect of this proportioning is that there is no diversity between the two basins in the post-project flows; by comparison, in the adjusted pre-project period, the fraction of the combined flows coming from Meelpaeg Reservoir basin ranged from 44 to 48 percent. The lack of diversity is not particularly important for Hydro's purposes, given the large volumes of storage in the Bay d'Espoir reservoirs. A variable component could be added in the future as more information becomes available. The diversity of the combined sequence from year to year is maintained.

A similar proportioning technique was used to subdivide the Salmon River basin sequence into inflows to Upper Salmon and Lower Salmon. The ratio of the flows in the period 1983 to 2003 was used for the subdivision, since for that period the Lower Salmon basin inflows were accepted.

7.3 Dry Sequence Assessment

The critical dry period (based on past regulation studies) started in February 1959 and continued up to and including April 1962. Since this period is essential for Hydro's operational and long term planning, the intent of this assessment was to ensure that the sequences are reasonably representative of the dry period.

The average monthly runoff in this period was compared to both the pre-project period (1953 to1967) and the post-project period (1971 to 2002). The first ratio indicates how the dry sequence compares to the longer pre-project period within which it lies. The second ratio provides a slightly different comparison, using the ratios of the dry sequence to the post-project period. The ratios are summarized for the Hydro basins and for three natural basins in Table 7.2.

Considering the ratio of the dry period to the pre-project period, the table shows that the ratio does not change from the unadjusted to the adjusted case for the combined Meelpaeg and Salmon basin because the adjustment factor within the dry sequence was the same as for the entire pre-project period. In the case of the Victoria basin, however, the record from October 1966 to September 1967 was accepted without adjustment, and thus there is a slight difference between the adjusted and unadjusted pre-project ratios.

Table 7.2
Runoff Comparison, Dry Sequence

	Dry to Pre-Project Period		Dry to Post-Project Period	
Basins	**Unadjusted**	**Adjusted**	**Unadjusted**	**Adjusted**
Hydro Basins				
Victoria Reservoir	0.867	0.870	0.760	0.815
Salmon River Basin[1]	0.826	0.826	-	-
Combined Meelpaeg and Salmon Basin	0.823	0.823	0.761	0.770
Natural Basins				
Gander River at Big Chute	0.863		0.824	
Upper Humber River near Reidville	0.894		0.831	
Bay du Nord River at Big Falls	0.856		0.794	
Natural Basin Average	0.871		0.816	

1 Salmon pre-project data accepted

Since the dry period consists of only three years, greater hydrological diversity may be apparent than would be seen over the entire pre-project period. However, the ratios for the natural basins shown in Table 7.2 provide an indication of the range of hydrological diversity that could reasonably be expected for this period.

Compared to the ratios of the natural basins for the pre-project period, the Hydro basin ratios seem reasonable. The ratio of the combined Meelpaeg and Salmon basin is low because the available data indicate that the dry period in the southcentral part of the Island between Grey River and Bay du Nord River was drier than the areas to the west. The ratio for Victoria basin is higher than the combined Meelpaeg and Salmon basin, since it is more like the western basins.

The dry period runoff was also compared to the part of the pre-project period for which the Salmon River gauge record was available (1953 to September 1965). Results of this analysis were similar to the comparison of the dry period with the entire pre-project period.

The ratio of the dry period to the post-project period provides a comparison of two separate periods instead of a comparison of a short period within a longer one. The unadjusted ratios for both Victoria and the combined Meelpaeg and Salmon basin are lower than the lowest natural basin ratio. Once adjusted, the Victoria ratio comes very close to the natural basin average, and the combined Meelpaeg and Salmon basin ratio increases slightly, remaining below the lowest natural basin ratio.

The review of the dry period suggests that it is reasonable to make the same adjustment to the dry period as to the rest of the pre-project period. Although the methodology used in developing the original series was sound, data are now available which show that a slight upward adjustment is required to the entire pre-project period.

7.4 Summary of Adjustments

The adjustment process started with the inflow sequences provided by Hydro, as presented in Appendix B (monthlies) and Appendix C (annuals). The minor adjustments described in Appendix D were then applied. Finally the overall adjustments were made to the annual series to bring the pre-project series in line with the natural basins. The resulting annual flows are given in Appendix E, and the reference monthly inflow sequences are provided in Appendix F.

Monthly values were obtained by maintaining the same proportion of the annual volume as in the original combined Meelpaeg and Salmon Hydro sequence after the minor adjustments to selected monthly values. Some months in the operations period have negative inflows. This result is not unusual in systems with large reservoirs, because of the nature of the backrouting calculations. There will also be some variation in monthly flows due to Hydro's accounting for lag. The original monthly sequences (which were added together to get the combined sequences) did take account of lag (up to 15 days). Since the monthly flows were obtained by assuming that the monthly fraction of the annual inflow into the separate basins was the same as the monthly fraction into the combined basin, there was some accounting for lag. No additional accounting for lag was possible, since it would have had to be extracted from the original data set, and then recalculated. Given the large volume of storage in both Meelpaeg and Long Pond reservoirs, small shifts of volume from one month to the next due to lag or negative inflows are not likely to affect estimates of energy production.

The overall adjustment to the total Bay d'Espoir basin inflow volume was just under one percent, 3011 $m^3 \times 10^6$. All the volume adjustments were made to the Victoria and Meelpaeg sequences pre-1971; post-project adjustments consisted of a redistribution of flows among Meelpaeg, Upper Salmon, and Lower Salmon basins. Table 7.3 presents a summary of overall adjusted mean annual runoff, and Table 7.4 summarizes the volume adjustments in each period and for each basin.

A graphic summary of the differences in total annual flow volumes before and after the adjustments is provided in Figure 7.1.

Table 7.3
Summary of Overall Adjusted Mean Annual Runoff

	Mean Annual Runoff (mm)		
Basins	**Pre-Project 1950 to 1970**	**Post-Project 1971 to 2002**	**Ratio of Pre to Post-Project**
Hydro Basins			
Victoria Reservoir	1087	1149	0.947
Meelpaeg Reservoir	1023	1078	0.949
Upper Salmon Reservoir	1057	1112	0.950
Lower Salmon Reservoir	906	960	0.944
Combined Meelpaeg and Salmon	986	1041	0.948
Natural Basins			
Gander River at Big Chute	826	853	0.968
Upper Humber River near Reidville	1144	1217	0.940
Bay du Nord River at Big Falls	1056	1095	0.964
Humber River at Deer Lake[1]	882	938	0.940

1 Natural inflows backrouted by Deer Lake Power

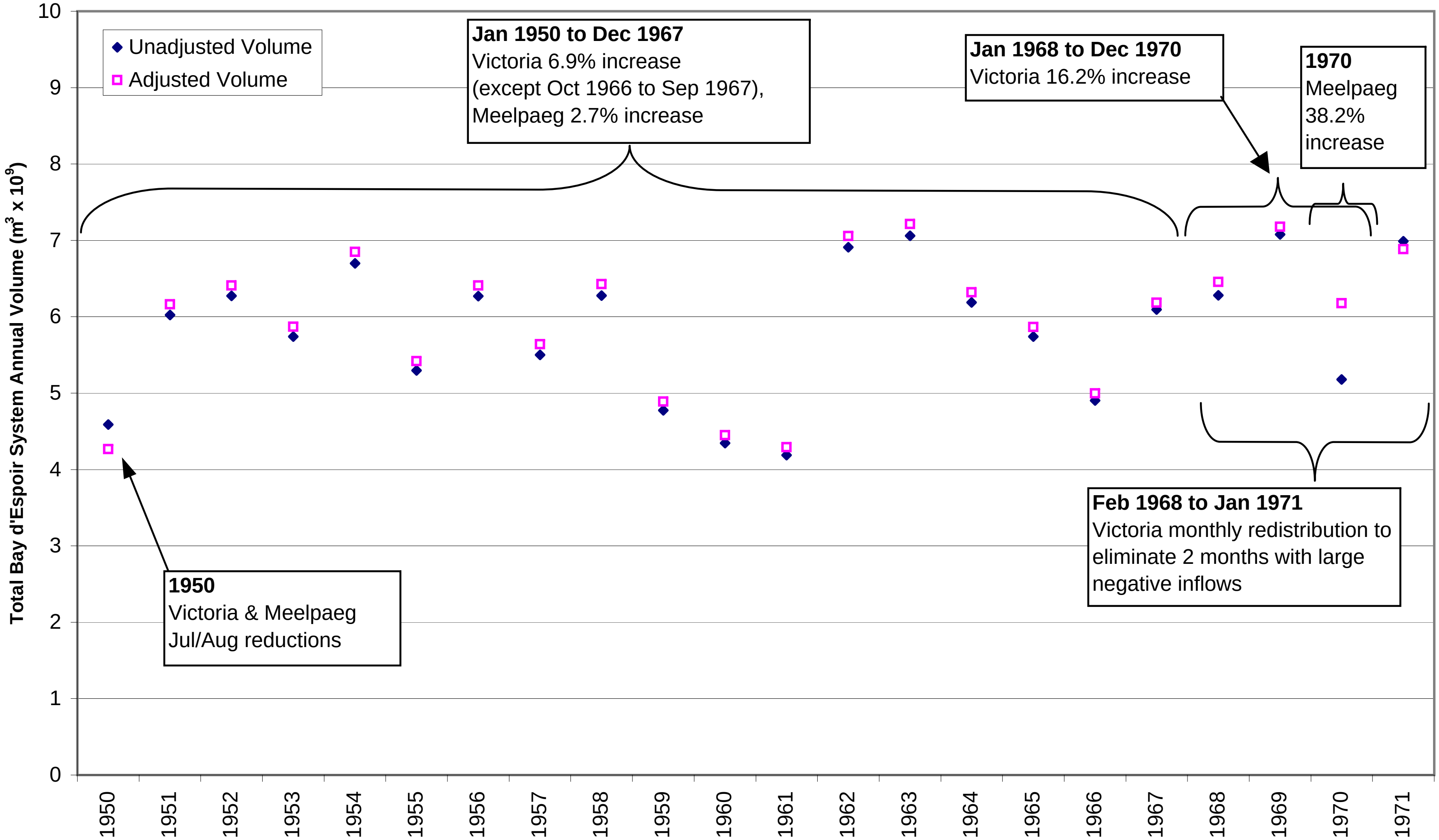
Before the final adjustments were made, a comparison was done to determine whether simply making the reservoir filling period adjustments would bring the pre-1971 Hydro basin sequences in line with the natural basins. This comparison showed that the ratios for Victoria would be 0.901, rather than the 0.947, as shown in Table 7.3, and Meelpaeg Reservoir would be 0.928, instead of 0.949. These comparison values are not in the range of the natural basins, whereas all the ratios in Table 7.3 are within the range. The calculated adjustment factors for the pre-project period were thus used, as described.

Table 7.4
Overall Volume Adjustments

Basins	Volume Adjustment ($m^3 \times 10^6$)					
	Jul/Aug 1950	Pre-Project		Post-Project	Total	% Change
		1950-1967	1968-1970	1971 - 2002		
Victoria	-250	+1247	+536	-	+1533	+2.5 %
Meelpaeg	-169	+1019	+627	-8265	-6788	-5.3 %
Upper Salmon	-	+1897		+6045	+7942	+18 %
Lower Salmon	-	-1897		+2221	+324	+0.4 %
Total	-419	+3429		0	+3011	+0.9 %

The total Victoria pre-project increase was 1533 $m^3 \times 10^6$, corresponding to an average increase of 73 $m^3 \times 10^6$ per year over the 21-year period. The reservoir filling period required an increase in volume of 642 $m^3 \times 10^6$, approximately 42 percent of the total. The Meelpaeg pre-project increase was 1477 $m^3 \times 10^6$, or an average of about 70 $m^3 \times 10^6$ annually from 1950 to 1970. The additional volume required in the reservoir filling period was 627 $m^3 \times 10^6$. Overall, the Meelpaeg adjustment was a 5.3 percent reduction in flow volume.

The annual pre-project and post-project flows for all four basins as well as the total Bay d'Espoir basin, unadjusted and adjusted, are shown in Figures 7.2 to 7.4.



Note: No volume adjustments were made to the Total Bay d'Espoir System after 1971.

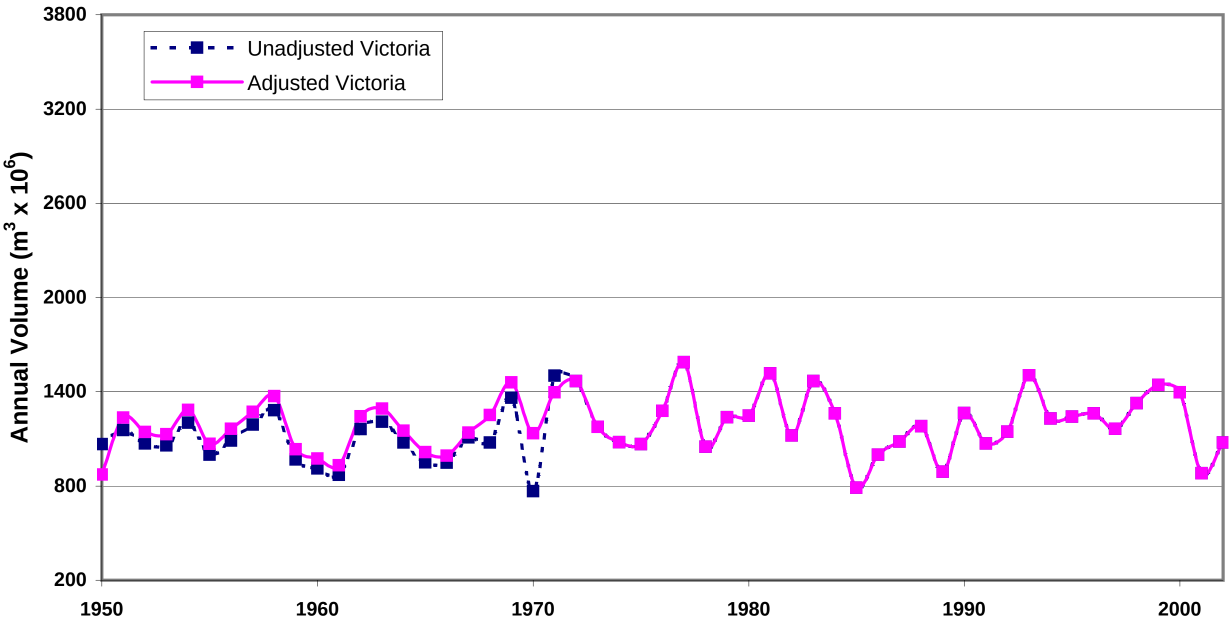
Figure 7.1

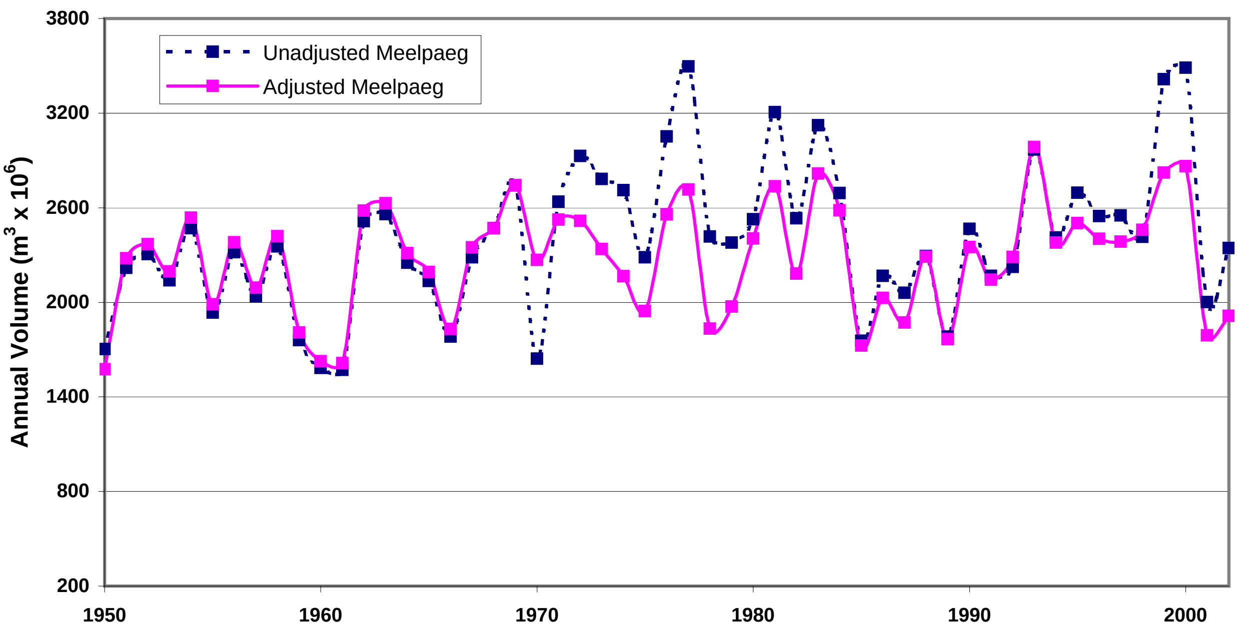
Summary of Total Bay d'Espoir Volume Adjustments

Adjustment of Bay d'Espoir Reference Inflow Sequences

Newfoundland and Labrador Hydro

SGE Acres





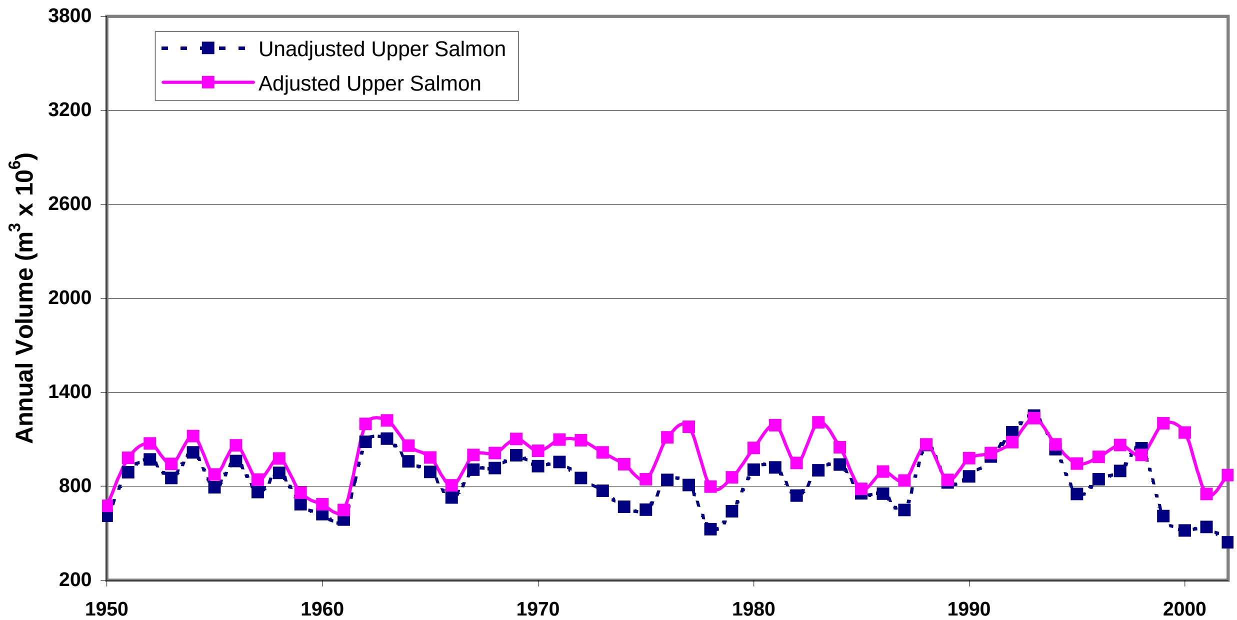
Note: Points connected and lines rounded for graphical clarity.

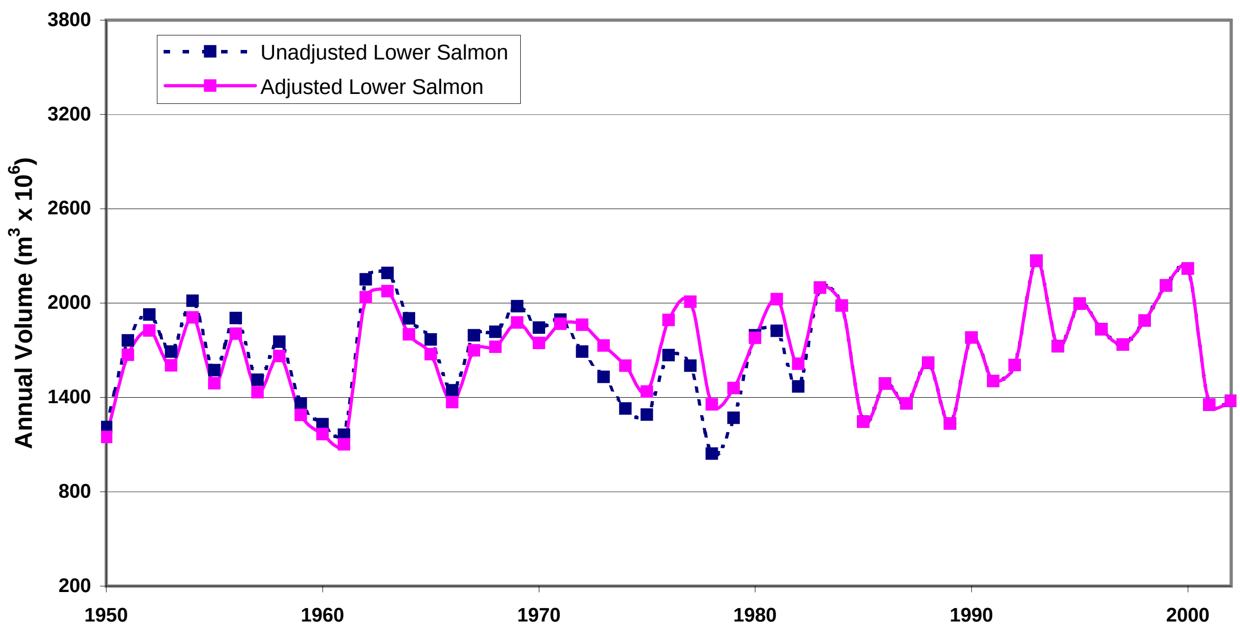
Figure 7.2

Unadjusted and Adjusted Victoria and Meelpaeg Annual Volumes

SGE Acres

Adjustment of Bay d'Espoir Reference Inflow Sequences
Newfoundland and Labrador Hydro





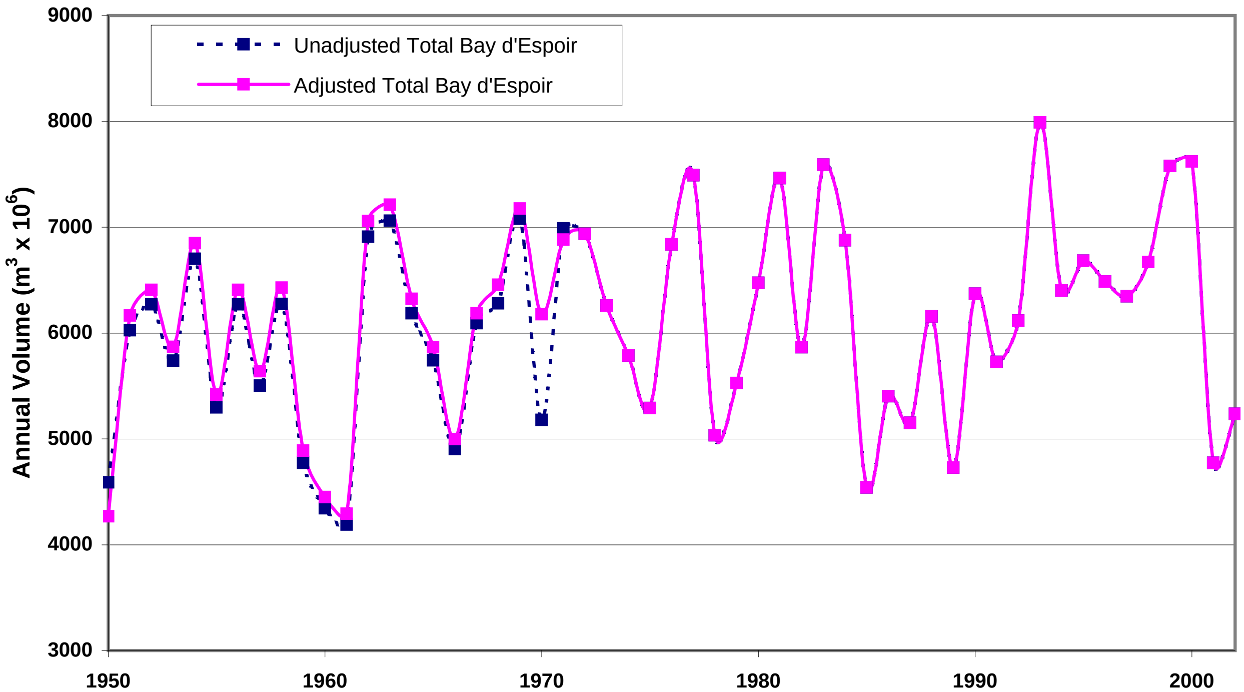
Note: Points connected and lines rounded for graphical clarity.

Figure 7.3

Unadjusted and Adjusted Upper and Lower Salmon Annual Volumes

SGE Acres

Adjustment of Bay d'Espoir Reference Inflow Sequences
Newfoundland and Labrador Hydro



Note: Points connected and lines rounded for graphical clarity.

Figure 7.4

Unadjusted and Adjusted Total Bay d'Espoir Annual Volumes

SGE Acres

Adjustment of Bay d'Espoir Reference Inflow Sequences
Newfoundland and Labrador Hydro

Tests of Adjusted Sequences

8 Tests of Adjusted Sequences

The adjusted Victoria annual sequence and the adjusted combined Meelpaeg and Salmon Basin annual sequences were tested using double mass curves and statistical tests similar to those used in the *Island Hydrology Review*. In addition, a sequence for total Bay d'Espoir flows was calculated by adding the separate sequences, and it was tested as an overall check.

The purpose of the testing was to determine whether the adjustments were successful in removing the internal inconsistencies, and in bringing the Hydro basins in line with the natural basins. Because of the small number of natural basins with records extending back into the 1950's, in general, the same gauges were used for the testing as for the analysis.

8.1 Double Mass Curves

The double mass curves for the Victoria Reservoir, the combined Meelpaeg and Salmon basin, separate Meelpaeg and Salmon River basins, and the total Bay d'Espoir basin inflow sequences are shown in Figures 8.1 to 8.3. A figure for the total Bay d'Espoir basin unadjusted sequence is also included.

As in the *Island Hydrology Review,* Gander River was used as the reference station based on its good relationship with other gauged basins on the Island. All the adjusted Bay d'Espoir basin sequences appear to be internally consistent with no breaks in slope or unusual offsets. The slight waviness of the curves is due to natural hydrologic variability with some basins experiencing wet or dry periods that were not experienced by others.

8.2 Statistical Tests

The statistical approaches used for testing the adjusted flow sequences were described in Section 3.0 of the *Island Hydrology Review*. A combination of various graphical and formal statistical tests was carried out. These included examining the similarity of time series plots, testing for similar probability distributions, tests for both linear and monotonic trends, testing for a step trend in both means and variances between pre-project and post-project periods, and an analysis of runs. All statistical tests were based on a significance level of five percent. The mean annual runoff series were used, to be consistent with the

Island Hydrology Review. The values in the tables relating to the statistical tests are therefore presented in units of millimetres.

8.2.1 Victoria Basin

The adjusted Victoria basin record was compared to the unadjusted record and also to four other nearby rivers, Gander, Bay du Nord, Upper Humber, and Humber at Deer Lake. The first three are naturally flowing and monitored by EC. Humber River at Deer Lake flows are natural inflows backrouted by Deer Lake Power. The results from the graphical and statistical tests are given in Appendix G and are summarized below.

- The adjusted Victoria flows have a slightly increased overall mean but a slightly smaller standard deviation than the original. The coefficient of variation, however, is within the range of the other rivers. See summary statistics in Sections G1 and G2.

- The general pattern of flow of the adjusted Victoria basin record is similar to those of the nearby rivers. The probability distribution of all six series is normally distributed. See time series plots and normal probability plots of mean annual runoff in Sections G3 and G4 respectively.

- The adjustment has eliminated the outlying value seen in the boxplot of the original Victoria flows. This outlying value is not seen in the other rivers. See boxplots in Section G5.

- Trend analyses using both Mann-Kendall's and Linear Regression show that there is no significant monotonic or linear trend in the adjusted record. The regression slope has reduced by about half compared to the original record. See Table G1.

- The results of the runs analysis for the Victoria record are consistent with the results for the natural rivers in the length of runs and number of runs. See Table G2.

- The highly significant step trend (pre-project vs. post-project mean values) in the unadjusted Victoria flow has now been eliminated. See Table G3 and the boxplots by pre-project and post-project periods in Appendix G6.

- The variances between the pre-project and post-project periods are also not statistically significantly different for all six series considered. See Table G4.

Conclusion

From the statistical evidence, it can be assumed that the adjusted Victoria flows can be accepted. The highly statistically significant step trend has now been eliminated and the pattern of flows is now very similar to those of nearby rivers.

8.2.2 Combined Meelpaeg and Salmon Basin

The adjusted mean annual runoff record of the combined Meelpaeg and Salmon Rivers was compared to the unadjusted record and also to four nearby rivers, Gander, Bay du Nord, Upper Humber, and Pipers Hole River, all of which are naturally flowing and monitored by EC. The results from the graphical and statistical tests are given in Appendix H and are summarized below.

- Since only a minor adjustment was made, the adjusted combined Meelpaeg and Salmon flows have only a very slight increase in overall mean and standard deviation compared to the unadjusted record. The coefficient of variation remains about the same and is within the range of the other rivers. See summary statistics in Section H1 and boxplots shown in Section H5. For all rivers compared, the pre-project period has a lower mean flow than the post-project period. See Section H2 and the boxplots shown in Section H6.

- The general pattern of runoffs of the adjusted combined Meelpaeg and Salmon record is similar to those of the nearby rivers and the unadjusted record. The probability distribution of all six series is normally distributed. See time series plots and normal probability plots of mean annual runoff in Sections H3 and H4 respectively.

- Trend analyses using both Mann-Kendall's and Linear Regression show that there is no significant monotonic or linear trend in the adjusted and unadjusted records. This is similar to all the other rivers tested. See Table H1.

- The results of the runs analysis are consistent with the results for the other rivers in the length or runs or number of runs about the median. See Table H2.

- There is no step trend (pre-project vs. post-project mean values) in the unadjusted and adjusted records. This is similar to all the nearby rivers. See Table H3.

- The variances between the pre-project and post-project periods are also not statistically significantly different for all six series considered. See Table H4.

Conclusion

From the statistical evidence, it can be assumed that the adjusted combined Meelpaeg and Salmon basin flows can be accepted. The minor adjustments made did not adversely affect the statistical properties of the record.

8.2.3 Bay d'Espoir Total Basin

The adjusted mean annual runoff record of the total Bay d'Espoir basin was compared to the unadjusted record and the four natural rivers, Gander, Bay du Nord, Upper Humber, and Pipers Hole. The results from the graphical and statistical tests are given in Appendix I and are summarized below.

- The adjusted total system runoffs have a very small increase in the overall mean. The standard deviation and coefficient of variation remain about the same. The summary statistics of both the unadjusted and adjusted total system runoffs are within the range of the other rivers. See summary statistics in Section I1 and the boxplots shown in Section I5. For all rivers compared, the pre-project period has a lower mean flow than the post-project period. See Section I2 and the boxplots shown in Section I6.

- The general pattern of the adjusted and unadjusted total system runoffs is similar to those of the nearby rivers, the only difference being that pre-project adjusted total system runoff has a slightly higher mean. The probability distribution of all six series is normally distributed. See time series plots and normal probability plots of mean annual runoff in Sections I3 and I4 respectively.

- Trend analyses using both Mann-Kendall's and Linear Regression show that there is no significant monotonic or linear trend in the adjusted total system runoffs which is similar to the all the other rivers tested. The mild trend seen in the unadjusted total system runoffs has been eliminated with the adjustments. See Table I1.

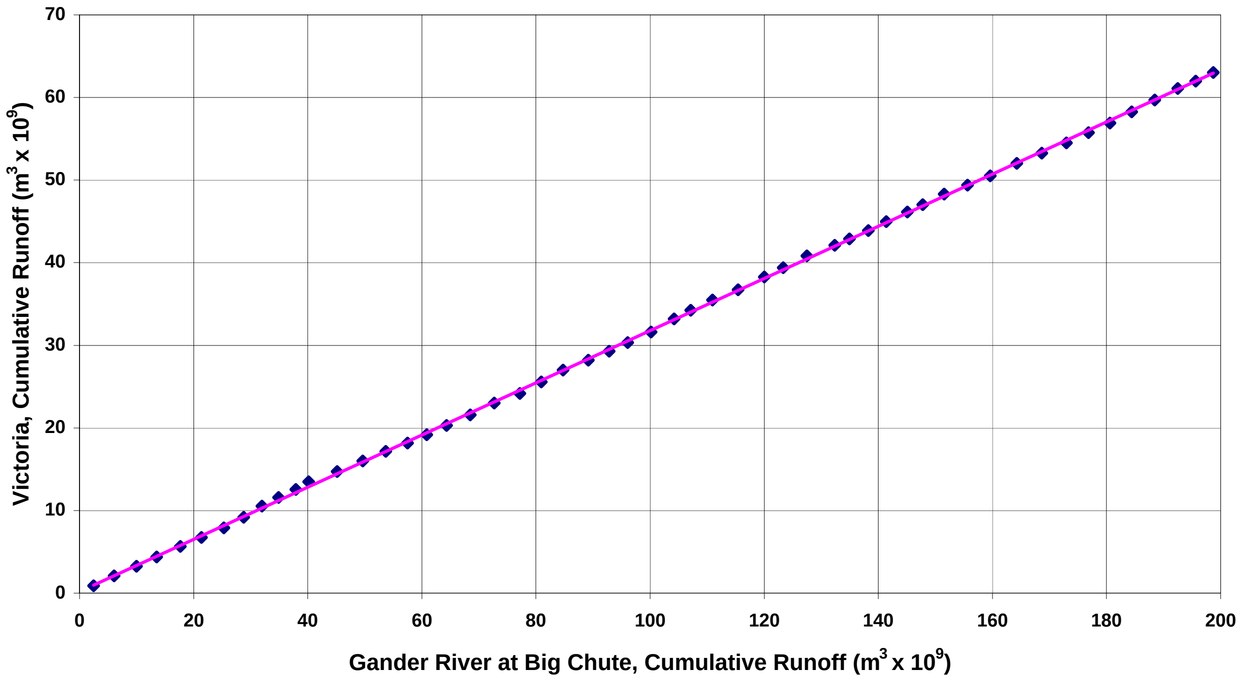
- The results of runs analysis are consistent with the results for the other rivers in the length or runs or number of runs about the median. See Table I2.

- There is no statistically significant step trend (pre-project vs. post-project mean values) in the adjusted runoffs. This is similar to all the nearby rivers. There is a statistically significant step trend at the 10 percent level for the unadjusted total system runoffs. This step trend has been effectively eliminated by the adjustments. See Table I3.

- The variances between the pre-project and post-project periods are also not statistically significantly different for all six series considered. See Table I4.

Conclusion

From the statistical evidence, it can be assumed that the adjusted Bay d'Espoir total system runoffs can be accepted. The adjustments have eliminated the mild trend seen in the unadjusted runoffs and the pattern of flows is now similar to the nearby rivers.



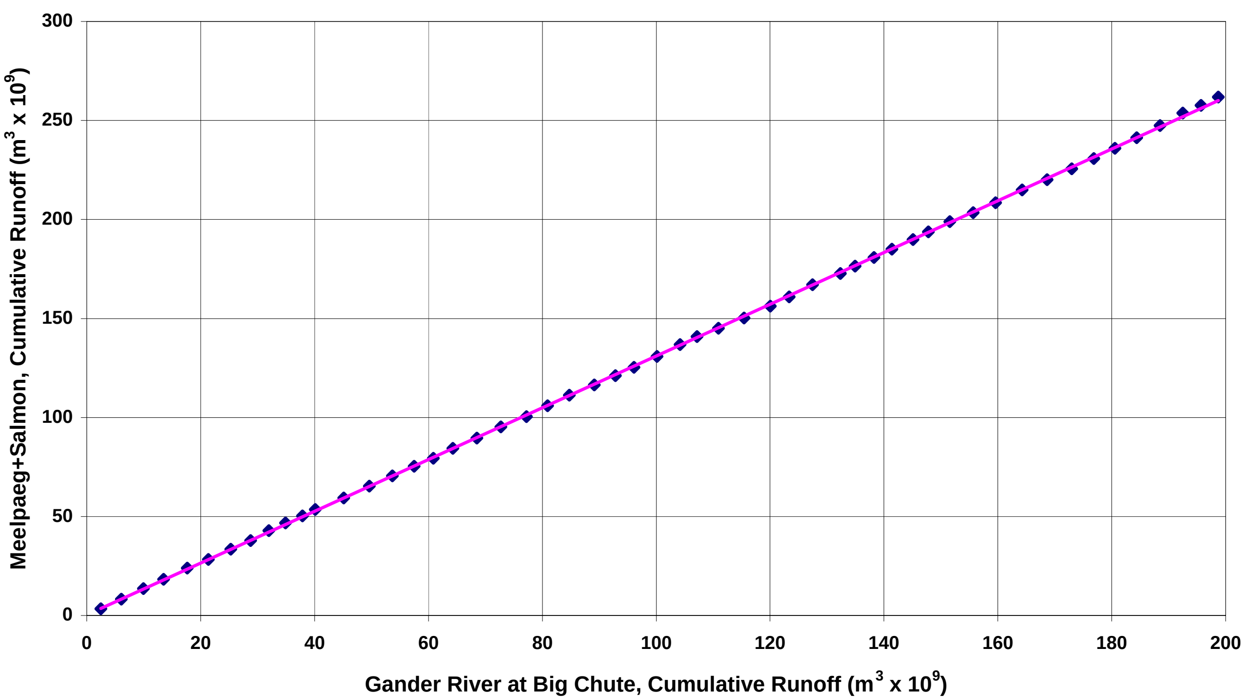
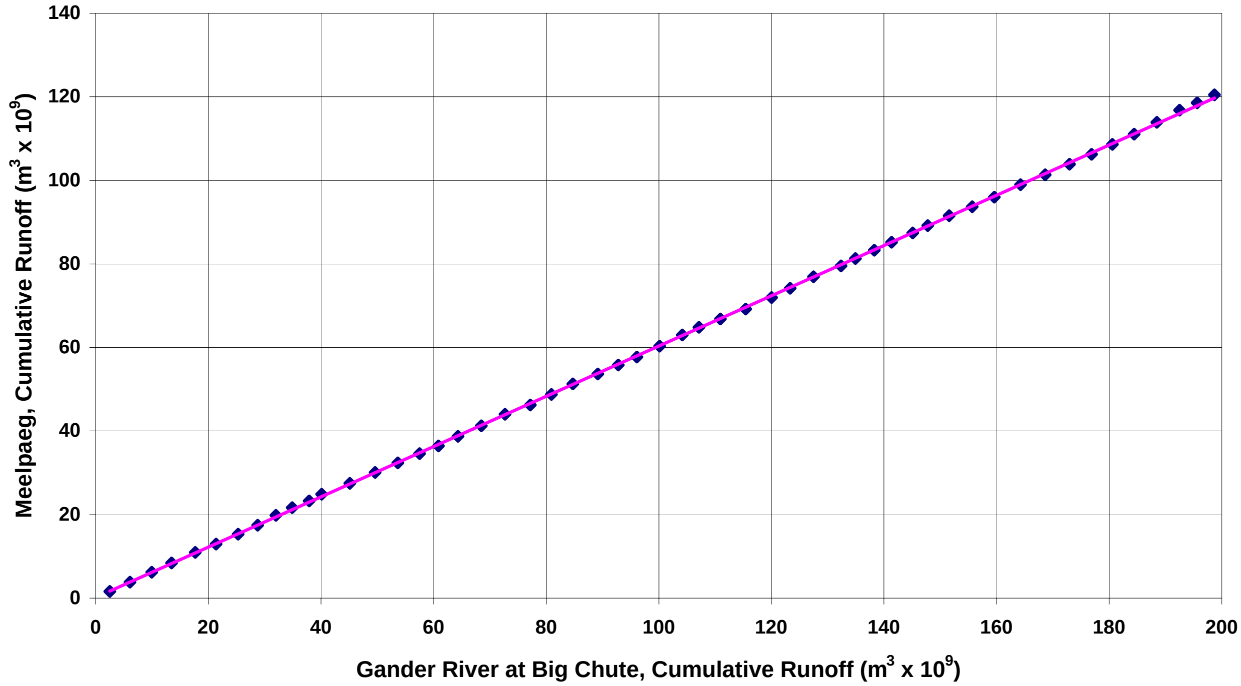


Figure 8.1
Double Mass Curves:
Adjusted Victoria and Combined Meelpaeg and Salmon Basin Runoff

SGE Acres

Adjustment of Bay d'Espoir Reference Inflow Sequences
Newfoundland and Labrador Hydro



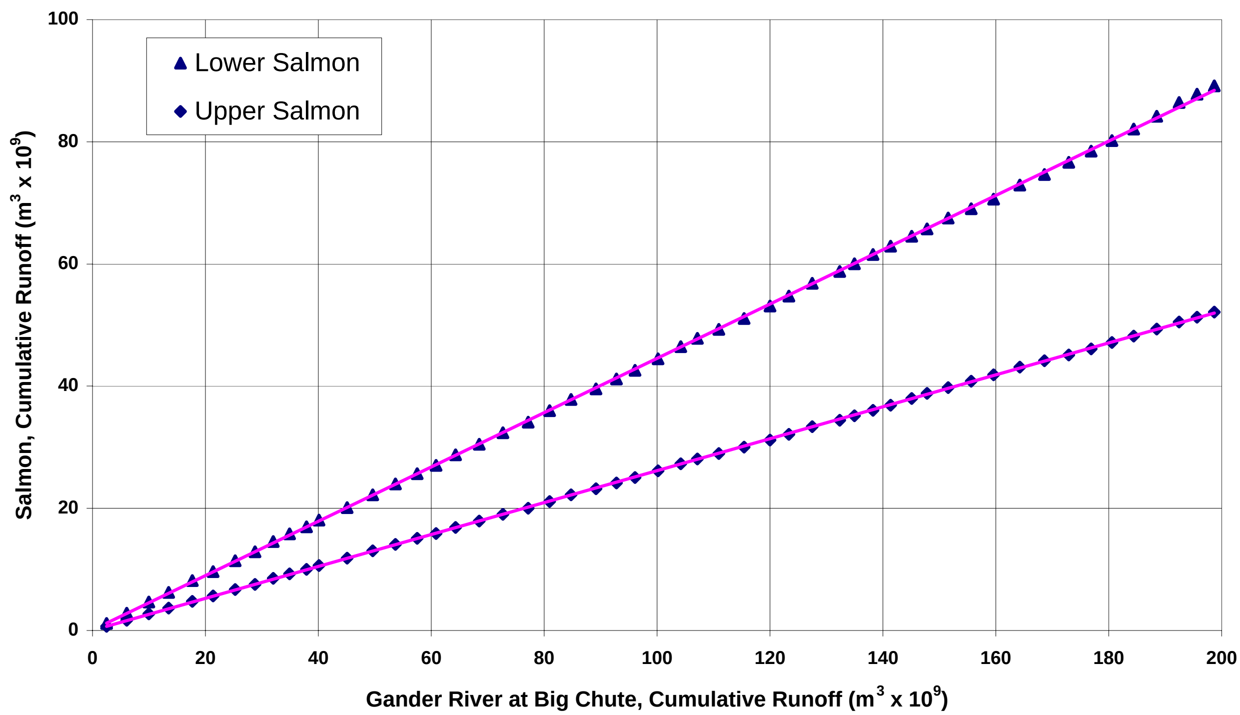
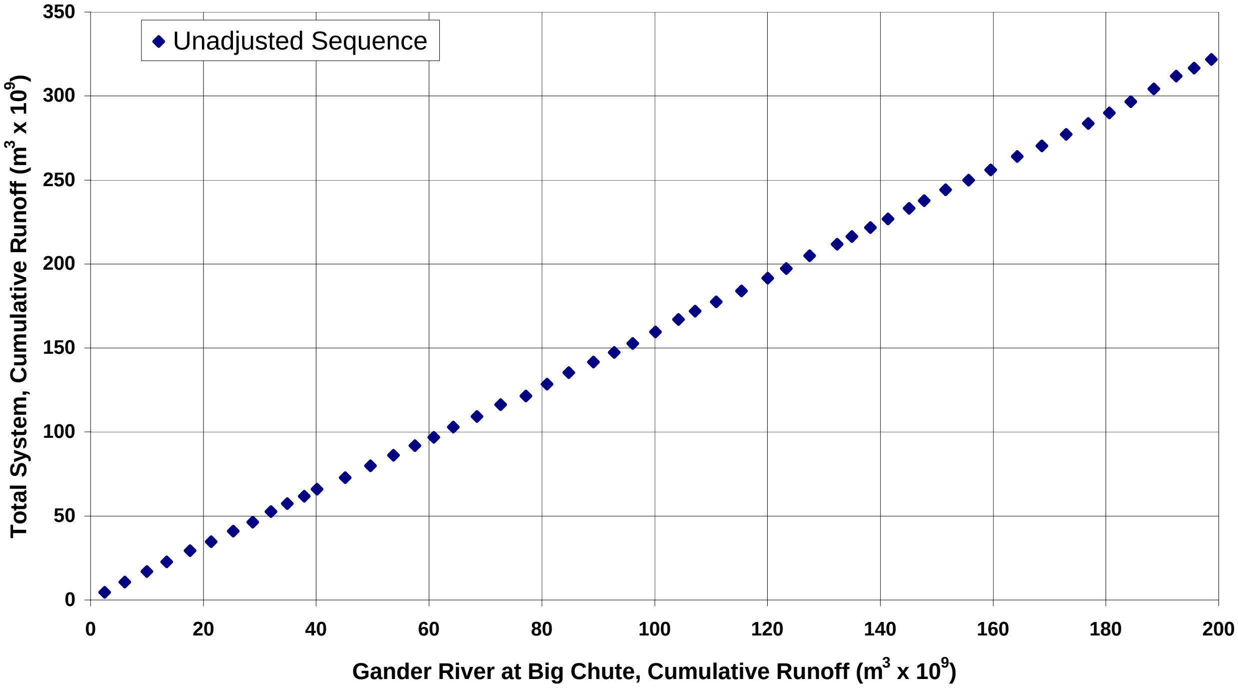


Figure 8.2
Double Mass Curves:
Adjusted Meelpaeg and Salmon Runoff

SGE Acres

Adjustment of Bay d'Espoir Reference Inflow Sequences
Newfoundland and Labrador Hydro



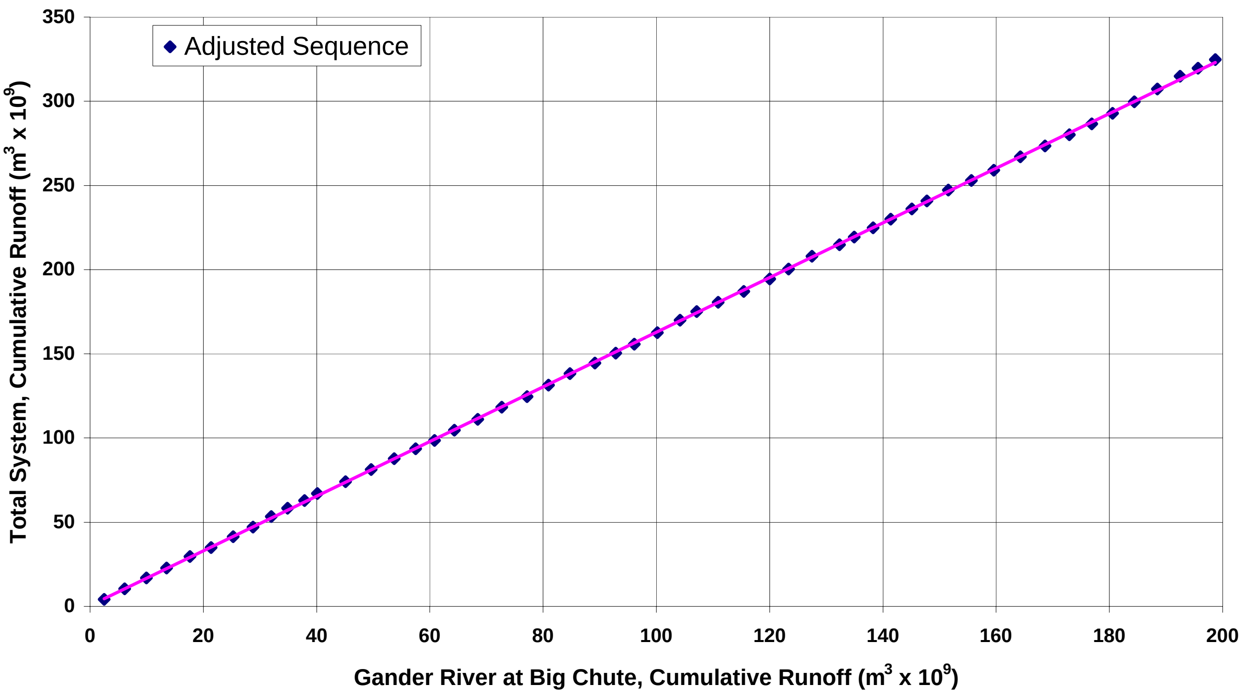


Figure 8.3
Double Mass Curves:
Unadjusted and Adjusted Total Bay d'Espoir Runoff

SGE Acres

Adjustment of Bay d'Espoir Reference Inflow Sequences
Newfoundland and Labrador Hydro

Conclusions and Recommendations

9 Conclusions and Recommendations

9.1 Conclusions

The conclusions of this study are as follows.

- The Victoria Reservoir inflow sequence can be accepted, once adjustments have been made to the period prior to 1971.
- The Salmon River inflow sequence can be accepted for the period prior to 1971.
- The Lower Salmon inflows from 1983 to 2002 can be accepted.
- The water transfers from Meelpaeg Reservoir to the Salmon River basin as they have been calculated to date are incorrect. The recording has been consistent, and the problem appears to be with the gate curves. As a result, no part of the Meelpaeg Reservoir basin post-project inflow sequence can be accepted, and the pre-project data cannot be confirmed until the curves are corrected and the flows are recalculated.
- A combined Meelpaeg and Salmon River inflow sequence can be accepted, once adjustments have been made to the period prior to 1971.
- The Meelpaeg pre-project sequence prior to 1967 can be adjusted using data from the combined sequence and the Salmon River sequence.
- Reasonable sequences can be estimated for the full period for the Meelpaeg, Lower Salmon, and Upper Salmon basins using a proportional approach.
- The methodology used to develop the inflow sequences is sound; adjustments proposed in this study are minor (0.9 percent overall). The study found that with the minor adjustments made to the pre-project period, the Victoria and the combined Meelpaeg-Salmon River basins are internally consistent and free of random and systematic errors. No further work is therefore required on these sequences.

9.2 Recommendations

The recommendations arising from the study are as follows.

- Hydro should make additional measurements as required to verify or redevelop the curves for the Ebbegunbaeg control structure for use in the Energy Management System.

- Hydro should use the revised gate curves to recalculate post-project sequences for Meelpaeg, Upper Salmon, and Lower Salmon for the length of record which the data support and of sufficient length to re-estimate pre-project adjustment factors.
- Hydro should use the sequence so constructed to confirm the hydrologic difference between Upper and Lower Salmon basins.
- It may not be necessary or possible to reconstruct the entire post-project period. If the reconstructed sequence does not cover the complete post-project period, then the remainder of the sequence should be generated using the relationships determined in the reconstructed portion.
- Hydro may consider replacing its Bay d'Espoir inflow sequences with the ones developed in this study, as an interim measure until new post-project sequences have been reconstructed for Meelpaeg, Upper Salmon and Lower Salmon, as recommended above. These may also be used for comparison with, and possible extension of, the recalculated sequences.

Appendix A – Terms of Reference and Bay d'Espoir System Schematic

HYDRO
THE POWER OF COMMITMENT

File No. 101 80.05/11.00 .

NEWFOUNDLAND AND LABRADOR HYDRO
Head Office St. John's, Newfoundland P.O.Box 12400 A1B 4K7
Telephone (709) 737-1400 - Fax (709) 737- 1231 – Website: www.nlh.nf.ca

September 8, 2003

SGE Acres Ltd.
Bally Rou Place Suite E 200
280 Torbay Road
St. John's, NL
A1A 3W8

Attn: Mme. Susan Richter

BY FAX

RE: Request for Proposal for Repairing Hydro's Hydrological Record

Dear Sue:

In late 2002 and early 2003, SGE Acres conducted a review of Hydro's hydrological records and average energy estimation methods in response to an order by the Board of Commissioners of Public Utilities of Newfoundland and Labrador (the "Board"). One of the recommendations of that study was a repairing of apparent inconsistencies in Hydro's hydrological record for the Bay d'Espoir river system. Accordingly we are requesting that SGE Acres prepare a proposal for accomplishing this work. In preparing the proposal, please include the following:

- A synopsis of the methodologies that may be used in repairing the records;
- An indication as to the preferred methodology and the rationale for this preference;
- A description of the steps required to identify, repair, and test the required changes to the record;
- A detailed cost estimate for SGE Acres in performing all of the above steps, as well as documenting the above for future reference.

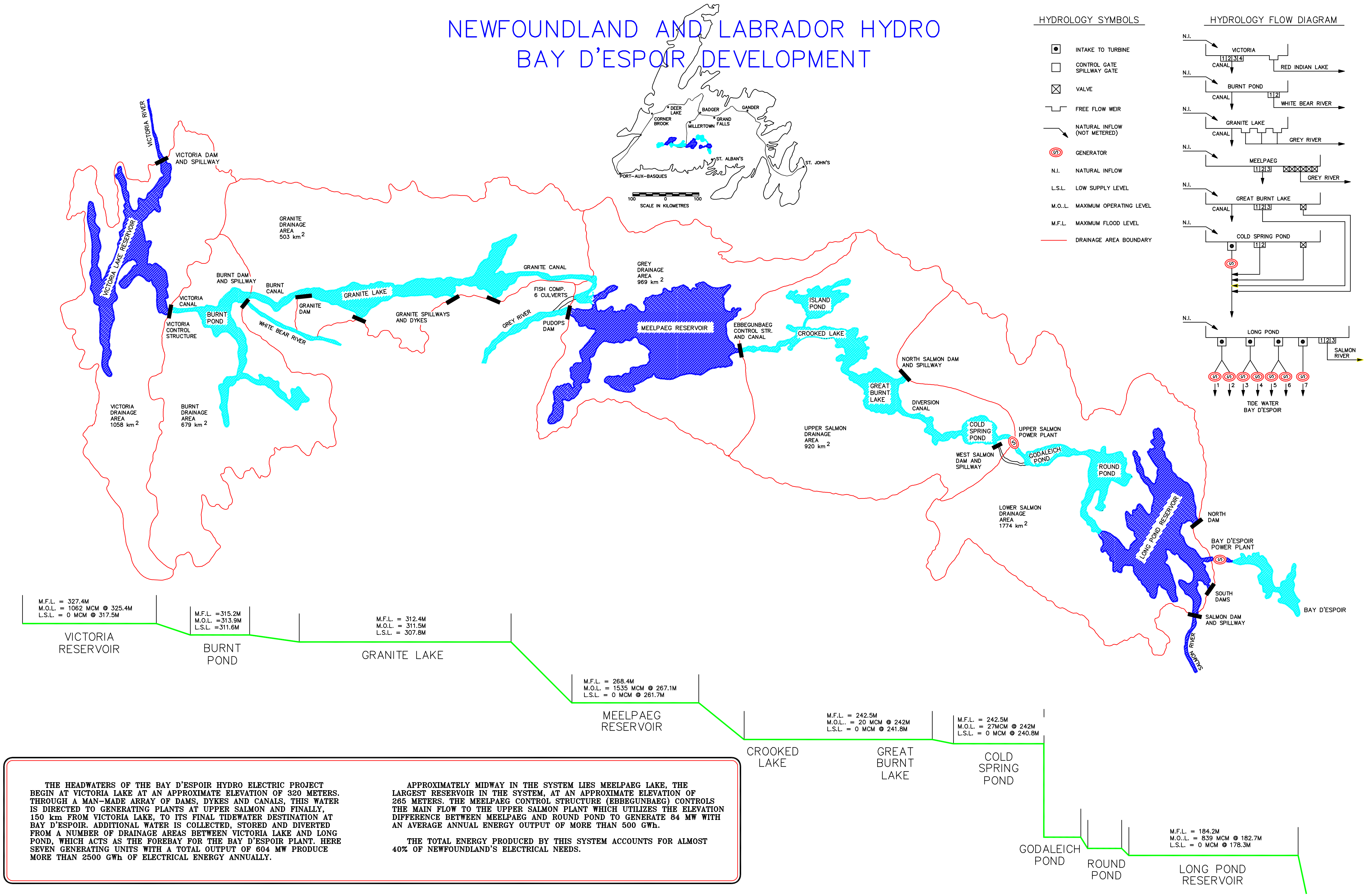
In addition to the above, please provide a separate proposal wherein Hydro staff would perform the actual repair activities under the guidance of SGE Acres. Note that SGE Acres would still be responsible for selecting the methodology, overseeing the repair activities, testing/confirming the results, and documenting the process and results.

Please submit your proposal to the undersigned on or before September 24, 2003. It is our intention to have this work completed by year's end. Should you have any comments or questions, please contact Mr. David Harris (phone: 737-1964, e-mail: dharris@nlh.nf.ca).

Best regards,

Robert Henderson
Manager, System Operations
Newfoundland & Labrador Hydro

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR DEVELOPMENT



THE HEADWATERS OF THE BAY D'ESPOIR HYDRO ELECTRIC PROJECT BEGIN AT VICTORIA LAKE AT AN APPROXIMATE ELEVATION OF 320 METERS. THROUGH A MAN-MADE ARRAY OF DAMS, DYKES AND CANALS, THIS WATER IS DIRECTED TO GENERATING PLANTS AT UPPER SALMON AND FINALLY, 150 km FROM VICTORIA LAKE, TO ITS FINAL TIDEWATER DESTINATION AT BAY D'ESPOIR. ADDITIONAL WATER IS COLLECTED, STORED AND DIVERTED FROM A NUMBER OF DRAINAGE AREAS BETWEEN VICTORIA LAKE AND LONG POND, WHICH ACTS AS THE FOREBAY FOR THE BAY D'ESPOIR PLANT. HERE SEVEN GENERATING UNITS WITH A TOTAL OUTPUT OF 604 MW PRODUCE MORE THAN 2500 GWh OF ELECTRICAL ENERGY ANNUALLY.

APPROXIMATELY MIDWAY IN THE SYSTEM LIES MEELPAEG LAKE, THE LARGEST RESERVOIR IN THE SYSTEM, AT AN APPROXIMATE ELEVATION OF 265 METERS. THE MEELPAEG CONTROL STRUCTURE (EBBEGUNBAEG) CONTROLS THE MAIN FLOW TO THE UPPER SALMON PLANT WHICH UTILIZES THE ELEVATION DIFFERENCE BETWEEN MEELPAEG AND ROUND POND TO GENERATE 84 MW WITH AN AVERAGE ANNUAL ENERGY OUTPUT OF MORE THAN 500 GWh.

THE TOTAL ENERGY PRODUCED BY THIS SYSTEM ACCOUNTS FOR ALMOST 40% OF NEWFOUNDLAND'S ELECTRICAL NEEDS.

ENERGY CONTROL CENTER
MAY, 1992
J. MORGAN N.T.S.

Appendix B – Reference Monthly Inflow Sequences as Provided by Newfoundland and Labrador Hydro

Table B.1

Victoria Unadjusted Reference Inflow Sequence

Monthly Volumes (m^3 x 10^6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1950	60.60	33.70	32.28	110.72	261.93	79.57	167.35	137.34	18.12	24.64	62.86	76.17	1065
1951	66.83	103.36	73.91	218.89	106.47	70.51	64.85	68.53	55.22	64.85	173.87	88.07	1155
1952	66.26	78.44	43.04	91.18	299.31	133.37	67.11	34.83	16.42	35.40	145.27	59.75	1070
1953	103.07	59.47	43.89	210.68	102.22	107.89	51.54	45.02	60.60	103.92	72.49	95.99	1057
1954	79.29	78.44	138.19	108.74	197.37	61.45	37.38	106.47	21.52	90.05	136.77	145.83	1202
1955	76.74	55.22	37.38	82.40	192.55	97.41	26.90	82.12	98.54	109.87	83.25	55.78	998
1956	168.77	37.10	25.49	92.03	243.52	151.21	47.01	39.36	54.93	44.46	82.12	102.22	1088
1957	76.17	32.28	38.51	39.08	243.52	139.04	79.00	56.63	94.01	133.09	75.04	183.78	1190
1958	94.30	44.46	72.21	111.57	152.34	88.07	81.84	109.59	151.21	121.76	169.33	85.80	1282
1959	37.38	33.98	24.64	100.81	242.96	103.92	31.71	28.60	61.73	72.21	102.22	127.14	967
1960	38.79	59.47	24.92	97.41	268.44	82.40	33.70	11.89	28.88	109.59	93.73	62.30	912
1961	30.30	11.33	12.74	41.34	246.92	167.64	38.79	20.67	30.30	98.83	100.24	71.64	871
1962	43.04	38.23	33.70	182.64	225.12	117.23	77.02	64.00	31.15	85.80	193.40	70.79	1162
1963	128.56	55.78	28.32	104.49	299.31	122.90	84.10	29.45	57.20	59.18	124.88	113.83	1208
1964	26.33	30.30	42.19	144.98	263.63	151.21	103.36	37.66	45.87	86.65	81.55	63.15	1077
1965	49.27	14.16	105.62	32.56	191.42	171.88	39.36	25.49	22.94	93.16	131.67	72.77	950
1966	31.43	22.65	35.68	94.30	184.34	116.67	37.66	54.37	53.24	87.78	123.18	107.04	948
1967	57.77	31.15	26.62	26.05	282.89	68.81	28.60	112.98	35.40	91.75	190.86	156.31	1109
1968	89.48	-97.98	82.69	84.38	115.25	137.34	171.32	60.60	50.40	78.44	158.57	146.40	1077
1969	67.68	242.39	52.67	88.35	287.70	62.86	15.86	37.10	38.79	69.66	195.39	202.47	1361
1970	-151.78	35.11	29.73	66.26	126.29	67.96	67.96	74.47	112.98	73.91	227.38	35.68	766
1971	154.44	120.35	104.77	342.63	171.32	37.38	67.96	104.21	60.60	76.17	179.53	81.84	1501
1972	50.97	37.94	144.70	87.22	293.93	247.77	39.08	20.95	43.61	249.75	158.86	92.31	1467
1973	47.01	89.76	39.08	103.36	284.87	75.61	68.53	116.95	14.44	70.79	111.57	154.61	1177
1974	40.78	37.38	66.26	128.28	239.84	83.53	33.98	44.17	49.27	150.93	82.40	121.76	1079
1975	39.08	17.84	75.32	105.34	271.56	35.11	22.94	18.97	54.65	91.46	142.43	191.14	1066
1976	123.18	98.54	60.03	195.67	189.16	35.96	33.70	25.20	67.11	131.96	115.82	202.18	1279
1977	137.05	57.48	47.57	177.26	291.66	93.45	53.24	88.07	60.60	185.48	180.38	215.21	1587
1978	197.65	36.25	66.26	110.72	284.02	102.22	56.07	21.80	26.33	44.74	45.59	58.62	1050
1979	154.89	64.85	298.18	79.29	105.62	50.12	38.51	39.64	52.39	112.70	127.14	114.40	1238
1980	94.58	20.67	40.78	185.76	199.92	76.46	127.43	74.19	79.57	116.38	158.86	72.21	1247
1981	118.93	103.92	95.76	209.91	202.54	88.24	77.30	87.30	27.81	159.34	156.11	188.14	1515
1982	47.06	37.22	41.80	149.84	391.93	78.11	60.73	30.70	63.40	75.05	67.29	78.77	1122
1983	221.68	79.65	162.82	240.17	92.48	63.93	59.81	189.88	78.48	44.56	131.00	102.22	1467
1984	77.17	117.67	76.57	139.83	280.90	130.45	57.49	107.55	92.92	41.05	57.63	82.01	1261
1985	11.77	2.06	20.32	65.21	292.90	189.22	31.97	28.01	57.63	3.46	28.04	57.25	788
1986	230.10	71.68	32.44	311.63	47.26	78.53	27.00	0.56	53.78	62.90	39.39	42.75	998
1987	59.59	24.20	102.18	335.72	142.48	28.77	5.88	3.53	-12.69	117.34	208.98	66.70	1083
1988	7.18	58.42	150.70	175.36	257.77	122.56	60.43	27.52	36.73	84.66	133.19	66.46	1181
1989	33.79	27.89	34.19	121.49	190.28	29.68	18.08	50.52	71.59	117.82	156.69	38.26	890
1990	40.69	42.00	-6.04	332.05	284.96	60.84	30.10	36.63	22.01	105.30	100.89	214.08	1264
1991	39.73	47.80	71.79	123.88	224.27	76.78	43.54	34.57	68.55	152.16	132.19	54.63	1070
1992	44.79	15.01	59.82	149.74	320.58	122.24	20.85	110.07	62.92	100.48	58.54	79.45	1144
1993	37.97	57.62	55.92	233.77	318.08	71.49	72.16	95.81	36.08	139.01	138.93	246.24	1503
1994	85.23	45.35	85.93	263.65	339.25	86.13	34.81	-3.87	53.28	44.23	136.47	58.83	1229
1995	108.04	38.63	86.15	142.48	194.37	93.23	77.04	78.35	72.49	76.28	168.71	105.65	1241
1996	100.50	238.82	125.06	85.90	119.55	67.70	113.05	37.34	46.23	98.75	63.03	164.75	1261
1997	121.43	99.72	21.96	108.47	314.53	95.51	49.10	41.76	80.78	84.57	104.66	41.25	1164
1998	78.02	99.57	212.24	188.80	186.48	43.38	72.15	56.40	133.35	82.10	107.59	66.87	1327
1999	138.80	171.03	165.37	182.21	180.09	21.52	17.18	119.47	87.75	117.57	111.92	130.72	1444
2000	136.35	79.85	120.04	247.99	179.46	51.42	71.84	55.92	32.31	154.26	142.52	123.29	1395
2001	34.92	37.12	26.86	106.27	235.49	58.53	58.22	25.58	60.99	45.24	118.42	73.42	881
2002	42.02	38.20	142.83	138.61	193.60	61.90	22.40	73.51	109.62	59.16	135.80	58.47	1076

Table B.2

Meelpaeg Unadjusted Reference Inflow Sequence

Monthly Volumes (m^3 x 10^6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1950	109.02	67.39	51.25	206.71	603.43	136.49	148.38	118.65	33.41	37.94	63.15	127.14	1703
1951	175.00	255.13	167.35	381.14	198.22	91.75	81.55	175.85	86.65	84.38	309.22	212.38	2219
1952	197.65	245.79	133.66	201.33	560.67	190.01	99.11	70.23	49.55	50.97	309.22	197.09	2305
1953	152.06	218.89	103.36	412.29	208.70	216.34	83.25	64.00	71.64	184.06	175.28	248.34	2138
1954	147.81	197.37	330.17	203.60	320.55	161.12	99.96	177.83	62.30	107.32	275.24	387.09	2470
1955	251.17	118.65	143.00	163.39	268.16	194.25	81.55	107.04	94.30	146.11	222.57	144.13	1934
1956	351.41	121.76	81.55	242.96	505.17	251.74	123.74	85.23	61.45	64.28	155.46	273.54	2318
1957	190.01	83.25	83.53	123.74	358.21	150.08	64.00	93.16	168.20	203.60	179.81	339.80	2037
1958	224.55	125.73	158.29	165.94	214.64	136.49	148.66	149.51	243.24	217.76	317.43	252.02	2354
1959	78.15	81.84	65.70	238.99	366.14	122.33	60.03	49.27	75.89	75.89	246.36	299.31	1760
1960	111.00	121.76	97.98	140.17	423.90	118.93	67.68	35.40	46.44	121.48	176.98	122.05	1584
1961	96.28	36.81	47.01	139.89	547.93	237.01	59.18	27.18	22.94	82.40	135.92	139.04	1572
1962	91.18	128.56	124.03	441.18	405.78	220.02	131.96	103.92	64.00	158.29	442.03	202.47	2513
1963	424.47	130.82	65.13	196.52	578.23	188.31	103.64	88.63	179.25	165.37	187.46	250.60	2558
1964	81.84	92.31	93.45	348.01	413.99	208.41	185.76	111.29	100.52	268.16	190.57	155.74	2250
1965	135.07	57.48	363.02	103.92	445.42	256.55	86.93	54.37	49.84	148.66	271.28	161.69	2134
1966	76.17	52.95	69.09	194.54	312.33	189.72	94.01	117.23	100.81	164.24	191.99	219.17	1782
1967	130.82	70.51	81.27	87.78	605.41	135.92	52.67	147.25	86.08	178.40	415.69	293.65	2285
1968	156.03	197.65	214.36	219.17	197.65	249.19	233.33	147.81	137.62	138.75	296.19	282.32	2470
1969	154.04	532.07	103.64	169.33	546.23	98.26	24.07	45.87	41.06	134.51	365.00	527.83	2742
1970	77.02	57.48	103.64	113.83	274.96	93.73	143.85	166.22	84.95	65.41	227.67	233.33	1642
1971	97.69	197.65	180.38	670.83	289.12	101.94	23.22	220.59	107.32	177.26	341.50	230.50	2638
1972	99.96	84.95	297.61	210.68	564.64	458.45	168.49	24.07	47.01	314.60	340.37	316.30	2927
1973	184.63	220.59	109.59	163.11	554.44	285.72	144.13	219.74	156.31	128.56	234.18	381.14	2782
1974	202.75	83.53	193.97	354.24	498.66	292.51	53.80	63.71	219.46	254.85	227.38	265.33	2710
1975	118.08	41.06	94.58	296.76	498.94	62.58	113.83	55.50	118.93	156.31	319.98	408.05	2285
1976	309.22	309.50	181.79	506.31	335.55	211.53	15.86	57.20	235.31	256.55	281.75	350.28	3051
1977	324.51	211.53	158.01	387.09	424.19	342.07	138.19	218.89	111.29	401.82	341.78	435.51	3495
1978	471.76	225.97	150.93	264.76	480.54	289.40	214.36	-12.18	25.77	94.01	89.76	121.76	2417
1979	303.56	139.89	507.44	226.53	134.51	99.68	83.82	81.27	152.91	163.67	273.82	211.81	2379
1980	28.60	48.42	149.80	346.03	447.41	287.13	267.31	207.56	66.83	193.12	301.01	183.78	2527
1981	292.80	233.05	189.49	386.52	472.59	201.48	120.53	168.84	148.18	445.36	212.11	334.79	3206
1982	166.00	145.34	183.05	314.14	624.25	260.82	179.28	83.19	91.67	175.09	123.34	186.82	2533
1983	573.61	184.33	348.71	442.70	276.61	173.24	156.82	219.91	128.59	197.39	233.13	187.22	3122
1984	272.67	359.13	211.84	264.16	571.72	294.72	89.51	149.49	163.79	58.64	65.79	190.98	2692
1985	86.96	87.50	66.77	166.68	445.71	513.80	215.63	-20.47	83.51	67.70	-14.53	55.66	1755
1986	304.78	253.29	115.99	500.33	296.54	119.40	59.93	-9.85	118.80	170.89	107.66	129.47	2167
1987	57.95	10.20	103.53	516.80	396.57	151.35	1.61	56.61	31.91	114.72	331.67	285.98	2059
1988	40.78	75.33	323.97	377.81	449.05	290.28	198.60	63.12	35.47	82.71	255.39	100.46	2293
1989	38.76	20.79	70.42	250.88	402.75	159.94	53.47	76.33	117.15	247.47	239.46	104.66	1782
1990	46.42	36.56	43.94	493.89	555.99	323.34	64.16	26.42	67.92	199.08	254.21	354.53	2466
1991	235.23	109.44	180.97	192.87	453.18	192.18	35.33	42.45	140.83	189.12	292.60	102.27	2166
1992	126.82	83.09	232.60	302.14	483.70	341.12	105.28	21.46	40.91	135.20	171.33	179.59	2223
1993	106.81	150.23	192.74	263.44	613.55	270.90	67.74	209.79	26.68	198.40	365.49	501.90	2968
1994	209.19	80.57	240.95	429.65	571.00	258.58	167.18	54.69	62.91	72.07	92.72	171.67	2411
1995	289.17	117.33	105.12	249.08	482.48	228.16	158.42	101.65	139.40	185.71	378.81	260.27	2696
1996	181.95	432.48	368.51	217.18	168.02	98.83	262.45	126.07	91.10	201.52	107.72	289.95	2546
1997	271.66	270.42	90.39	176.19	539.92	291.11	153.37	54.79	233.85	173.59	233.08	61.55	2550
1998	85.19	64.68	440.49	403.51	428.49	100.29	120.67	50.57	209.96	173.20	184.47	153.84	2415
1999	292.52	397.08	412.39	398.90	376.95	182.45	109.37	174.28	193.84	257.47	257.06	361.43	3414
2000	289.17	277.84	367.09	490.60	395.38	250.07	249.84	187.98	34.85	317.18	381.61	246.90	3489
2001	133.19	35.53	106.17	162.57	495.98	290.00	123.06	47.49	76.86	146.45	185.23	198.40	2001
2002	141.63	106.77	315.43	355.01	351.82	207.31	37.60	117.93	201.54	113.73	236.17	158.28	2343

Table B.3

Upper Salmon Unadjusted Reference Inflow Sequence

Monthly Volumes ($m^3 \times 10^6$)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1950	45.87	28.60	18.41	81.55	261.65	54.37	20.67	17.56	9.06	10.19	12.74	48.99	610
1951	85.80	113.55	75.04	134.51	78.44	29.73	24.35	82.40	32.28	26.90	110.15	94.86	888
1952	105.91	119.78	67.68	87.78	203.31	61.16	35.40	28.88	21.52	15.57	125.16	98.54	971
1953	53.24	88.07	47.29	156.03	85.80	88.91	30.58	20.39	19.82	70.79	80.70	111.00	853
1954	60.31	91.46	141.58	80.14	106.19	77.02	49.55	65.98	28.32	32.00	109.59	172.17	1014
1955	121.76	53.80	75.89	67.96	77.87	83.53	39.64	33.98	19.54	45.87	103.36	68.81	792
1956	137.62	65.13	40.49	111.00	196.80	87.22	59.47	37.10	15.57	20.95	64.00	123.74	959
1957	85.80	39.64	36.25	62.58	107.04	35.11	17.84	35.96	65.98	68.53	82.69	124.03	761
1958	97.41	62.86	69.94	57.48	66.26	52.39	60.03	48.14	80.42	73.62	108.74	106.75	884
1959	32.85	37.10	30.87	107.60	105.62	38.23	22.09	21.52	23.79	21.80	121.20	121.20	684
1960	50.40	59.75	52.67	68.81	135.92	45.02	33.41	13.88	7.08	22.37	75.32	55.50	620
1961	44.74	16.71	25.77	85.52	210.96	63.15	18.41	7.36	3.68	6.80	39.93	62.58	586
1962	47.29	78.72	78.44	232.48	127.71	81.55	46.16	35.11	26.90	63.43	173.02	91.75	1083
1963	200.20	63.71	28.88	112.98	210.39	76.46	42.19	34.55	76.17	75.89	67.68	113.83	1103
1964	37.66	53.24	47.01	157.44	149.51	72.49	73.06	43.04	43.89	102.51	107.60	69.94	957
1965	72.21	40.21	91.46	96.28	171.60	99.96	36.53	20.39	17.84	37.38	130.82	75.32	890
1966	37.10	26.05	28.60	114.12	107.89	55.50	43.04	41.06	42.76	52.10	52.39	127.14	728
1967	73.34	35.11	47.86	33.41	254.85	69.38	23.22	11.33	15.86	47.01	162.82	129.69	904
1968	75.32	79.29	115.25	87.22	99.39	82.97	47.86	23.79	63.71	35.96	86.08	118.93	916
1969	48.42	193.69	84.10	108.17	104.49	72.77	11.33	-4.25	32.00	59.47	84.95	201.90	997
1970	75.89	38.79	60.60	127.71	135.92	20.10	62.30	100.81	65.13	-13.88	99.39	155.46	928
1971	7.65	104.21	54.37	258.25	137.90	-7.65	80.42	16.99	58.05	18.41	150.08	75.89	955
1972	49.55	32.00	80.70	103.07	179.53	54.09	83.82	-8.50	21.80	102.79	85.52	67.39	852
1973	20.39	84.95	18.69	129.12	134.79	64.56	29.45	35.68	8.78	86.93	82.40	74.19	770
1974	4.53	19.82	53.52	173.30	110.44	51.82	2.27	-16.99	-3.96	124.88	12.74	136.20	669
1975	-38.79	-3.96	73.62	94.01	197.37	-38.79	-2.27	-2.83	9.34	71.92	144.42	146.11	650
1976	102.79	64.56	48.14	154.89	95.99	27.18	-34.26	-19.26	113.83	124.88	29.45	131.67	840
1977	87.50	54.93	39.93	111.29	105.06	52.67	9.91	27.47	32.00	116.10	30.58	138.75	806
1978	118.93	14.16	45.02	133.09	82.40	80.14	-24.35	-17.27	-11.33	56.63	-35.96	82.69	524
1979	113.27	13.03	206.71	-30.87	64.28	-16.14	17.84	39.36	43.89	75.89	77.31	35.11	640
1980	65.41	20.39	60.60	183.78	122.61	73.91	65.70	38.51	83.53	58.90	82.69	48.42	904
1981	109.59	84.67	110.15	62.58	169.33	20.39	18.69	32.00	77.87	105.34	88.07	40.21	919
1982	34.26	-2.27	31.43	167.64	167.07	15.86	47.86	-12.18	49.84	18.69	126.29	95.71	740
1983	178.11	31.15	148.95	137.05	53.24	14.72	65.41	120.35	58.05	3.68	68.24	22.65	902
1984	63.15	114.12	48.14	117.23	231.35	48.42	32.28	98.26	83.53	8.78	60.88	30.58	937
1985	-8.50	14.72	89.20	105.62	161.69	176.98	1.13	18.12	7.93	-24.64	90.05	120.63	753
1986	157.72	45.87	20.67	262.50	13.59	13.31	2.83	46.72	4.53	73.34	56.07	54.09	751
1987	35.73	43.09	47.20	266.85	56.52	6.45	0.65	-42.12	7.48	39.91	145.27	40.07	647
1988	48.27	166.60	141.37	174.13	91.39	78.57	23.11	18.60	-7.18	62.91	132.14	131.96	1062
1989	124.74	112.90	71.61	115.95	113.23	20.43	5.94	35.85	42.61	48.50	66.84	64.82	823
1990	115.77	78.31	65.19	252.40	144.33	-53.27	33.16	-32.27	-20.19	60.34	91.45	126.47	862
1991	-1.28	45.75	85.73	153.65	172.86	92.24	19.52	-7.63	100.05	115.35	156.56	55.02	988
1992	40.22	58.65	154.38	114.56	194.92	105.82	65.68	61.37	85.76	126.22	53.38	83.49	1144
1993	37.70	65.39	44.10	216.66	187.42	36.00	147.97	56.47	36.31	124.53	98.09	199.71	1250
1994	154.24	58.84	129.15	208.29	145.56	51.99	37.19	38.54	74.51	36.34	131.40	-30.88	1035
1995	77.45	1.71	88.44	159.31	108.45	30.18	-0.27	13.82	46.77	38.79	125.85	59.27	750
1996	51.46	131.41	70.73	46.62	60.42	26.57	93.85	11.71	80.68	74.22	50.81	145.56	844
1997	101.18	43.14	6.34	92.12	205.08	58.75	17.29	35.55	100.78	69.76	72.61	93.81	896
1998	36.55	87.98	115.27	218.67	98.28	49.85	77.62	36.23	113.83	36.20	89.29	82.08	1042
1999	123.63	156.88	104.22	78.04	-0.69	-28.03	-30.69	31.75	59.77	63.62	25.28	24.62	608
2000	87.82	56.58	50.77	65.50	46.27	-34.65	-13.67	-42.22	0.12	146.88	97.90	55.08	516
2001	37.11	29.21	16.37	109.19	161.35	55.15	9.94	-13.35	25.45	7.88	78.28	22.08	539
2002	9.97	34.07	83.41	100.30	45.53	1.33	-8.15	-7.13	37.49	19.55	88.45	35.57	440

Table B.4
Lower Salmon Unadjusted Reference Inflow Sequence
Monthly Volumes ($m^3 \times 10^6$)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1950	91.46	56.35	36.81	162.26	519.61	107.89	41.06	34.55	18.12	19.82	25.49	97.41	1211
1951	170.47	225.40	148.66	267.03	156.03	59.18	48.14	163.39	64.00	53.52	218.61	188.02	1762
1952	210.39	237.86	133.94	174.15	403.52	121.48	69.94	56.92	43.04	30.58	248.34	195.67	1926
1953	105.34	175.00	93.73	310.07	170.47	176.13	60.31	40.21	39.64	140.17	159.99	220.31	1691
1954	120.06	181.23	280.90	159.14	210.96	152.63	98.26	131.11	56.07	63.43	217.76	342.07	2014
1955	241.54	106.47	150.93	134.51	154.89	165.94	78.72	67.68	38.51	91.46	205.58	136.77	1573
1956	273.54	129.41	80.14	220.59	391.06	173.30	118.08	73.62	30.58	41.63	126.86	245.51	1904
1957	170.47	79.00	72.21	124.59	212.38	69.94	35.11	71.08	131.39	136.20	163.95	246.07	1512
1958	193.69	124.88	138.47	114.12	131.67	103.92	118.93	95.14	159.71	146.40	215.77	211.81	1755
1959	65.13	73.91	60.88	213.79	209.26	76.17	44.17	43.04	47.29	43.61	244.37	240.69	1362
1960	99.68	118.93	104.21	136.77	269.86	89.20	65.98	27.18	14.16	44.17	149.23	109.87	1229
1961	88.63	32.85	50.97	169.90	418.52	125.44	36.53	14.44	7.36	13.59	79.57	124.03	1162
1962	93.73	156.31	156.03	461.85	253.72	162.26	91.75	69.66	53.80	126.29	343.77	182.08	2151
1963	397.57	126.86	56.92	224.55	417.67	151.78	83.82	68.53	151.50	150.93	134.22	225.97	2190
1964	74.47	105.62	93.45	312.33	296.48	144.13	145.27	85.80	87.50	203.88	213.79	138.75	1901
1965	143.28	79.57	181.51	191.42	340.37	198.78	72.77	40.21	35.68	74.19	259.67	149.80	1767
1966	73.62	52.10	56.35	226.53	214.36	110.44	85.23	81.84	84.95	104.21	103.92	252.02	1446
1967	145.83	69.66	94.86	66.54	505.74	137.34	46.44	22.65	31.43	93.45	323.10	257.12	1794
1968	149.80	157.16	228.80	173.30	197.09	165.09	94.86	47.01	126.29	71.08	170.47	235.88	1817
1969	95.99	384.83	166.79	214.36	207.28	144.13	22.37	-8.21	63.71	118.08	169.05	400.97	1979
1970	150.65	77.02	120.63	253.44	270.14	39.64	123.46	200.20	129.69	-27.18	197.37	308.65	1844
1971	15.01	207.00	108.17	512.25	273.54	-15.01	159.99	33.70	115.53	36.81	297.89	150.36	1895
1972	97.98	63.43	160.27	204.45	356.79	107.32	166.79	-16.99	43.32	204.45	169.33	133.37	1691
1973	40.78	169.05	37.38	256.55	267.59	127.99	58.33	70.79	17.84	172.45	163.67	147.25	1530
1974	9.34	39.36	106.47	344.33	218.89	102.79	4.81	-33.70	-8.21	248.06	25.20	270.71	1328
1975	-77.02	-7.65	145.83	186.61	391.91	-76.74	-4.25	-5.95	18.69	143.00	286.28	289.96	1291
1976	204.45	128.56	95.14	307.52	190.57	54.09	-67.68	-37.94	226.25	247.49	58.62	261.65	1669
1977	173.87	109.30	79.29	220.59	208.41	104.21	19.82	54.93	63.71	230.22	60.88	275.24	1600
1978	236.16	28.32	89.76	263.91	163.67	159.42	-48.42	-34.26	-22.37	112.70	-71.08	164.24	1042
1979	225.12	25.77	410.03	-60.88	127.43	-32.00	35.11	77.87	87.22	150.93	153.48	69.38	1269
1980	129.97	40.21	120.06	364.72	243.81	146.40	130.82	76.17	165.65	116.67	164.52	95.99	1795
1981	217.76	168.49	218.32	124.31	336.12	40.49	37.38	63.43	154.61	208.70	174.43	79.57	1824
1982	68.24	-4.81	62.01	333.01	331.31	31.43	94.58	-24.07	99.11	37.38	250.32	190.29	1469
1983	492.71	65.41	365.00	236.73	138.19	55.78	117.23	272.69	74.19	17.84	137.62	124.88	2098
1984	209.54	286.28	136.49	246.64	413.14	130.26	38.23	188.31	126.86	39.93	34.55	134.22	1984
1985	27.75	17.56	74.47	154.04	351.98	301.29	161.97	-26.05	84.38	-14.44	33.98	77.59	1245
1986	283.17	122.90	65.41	560.11	27.18	65.70	54.09	-13.31	65.41	96.56	88.63	71.36	1487
1987	60.70	81.42	139.81	500.44	116.78	20.01	11.52	-62.09	-12.07	87.50	301.92	116.08	1362
1988	43.50	161.22	315.83	357.08	176.46	156.83	63.86	8.10	-3.06	84.91	200.99	54.42	1620
1989	80.37	56.38	87.05	294.06	182.43	31.18	29.58	53.49	123.94	119.39	144.14	30.66	1233
1990	77.42	92.63	60.71	566.28	240.04	75.15	52.45	-49.21	29.14	178.99	181.07	275.38	1780
1991	25.82	118.99	230.18	239.86	268.74	37.27	-3.03	-25.36	107.70	204.99	270.10	27.68	1503
1992	79.50	19.33	321.65	231.22	330.19	174.39	46.88	-36.00	91.67	155.84	61.19	129.77	1606
1993	52.56	189.28	137.58	455.24	315.41	71.78	106.16	108.84	25.03	192.84	243.96	370.75	2269
1994	138.39	83.24	253.59	436.27	320.75	96.23	35.51	-4.44	66.22	75.94	173.48	50.52	1726
1995	206.72	62.97	231.74	349.36	191.38	78.60	43.83	60.04	153.49	143.76	288.89	184.46	1995
1996	127.23	324.36	198.54	131.50	119.99	58.60	214.44	31.28	117.37	143.94	127.31	239.60	1834
1997	232.97	75.13	48.33	226.18	377.05	98.39	48.14	72.58	200.50	80.37	183.23	92.36	1735
1998	97.07	120.17	249.76	453.28	180.03	74.23	88.35	49.09	188.93	88.42	142.60	155.48	1887
1999	219.72	368.37	307.68	279.14	176.02	70.09	22.67	62.25	117.54	188.62	150.35	149.72	2112
2000	260.39	134.51	247.33	251.89	168.48	56.22	193.62	88.95	42.89	339.41	232.46	204.46	2221
2001	25.32	22.56	65.91	315.24	320.28	95.73	96.70	-3.60	66.68	12.03	225.02	111.13	1353
2002	90.14	146.24	252.82	222.50	129.01	37.35	22.22	47.59	34.98	67.91	215.00	111.94	1378

Table B.5
Combined Meelpaeg and Salmon Basin Unadjusted Reference Inflow Sequence
Monthly Volumes (m^3 x 10^6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1950	246	152	106	451	1385	299	210	171	61	68	101	274	3523
1951	431	594	391	783	433	181	154	422	183	165	638	495	4869
1952	514	603	335	463	1168	373	204	156	114	97	683	491	5202
1953	311	482	244	878	465	481	174	125	131	395	416	580	4682
1954	328	470	753	443	638	391	248	375	147	203	603	901	5498
1955	614	279	370	366	501	444	200	209	152	283	532	350	4299
1956	763	316	202	575	1093	512	301	196	108	127	346	643	5182
1957	446	202	192	311	678	255	117	200	366	408	426	710	4311
1958	516	313	367	338	413	293	328	293	483	438	642	571	4993
1959	176	193	157	560	681	237	126	114	147	141	612	661	3806
1960	261	300	255	346	830	253	167	76	68	188	402	287	3433
1961	230	86	124	395	1177	426	114	49	34	103	255	326	3319
1962	232	364	359	1136	787	464	270	209	145	348	959	476	5747
1963	1022	321	151	534	1206	417	230	192	407	392	389	590	5852
1964	194	251	234	818	860	425	404	240	232	575	512	364	5109
1965	351	177	636	392	957	555	196	115	103	260	662	387	4791
1966	187	131	154	535	635	356	222	240	229	321	348	598	3956
1967	350	175	224	188	1366	343	122	181	133	319	902	680	4983
1968	381	434	558	480	494	497	376	219	328	246	553	637	5203
1969	298	1111	355	492	858	315	58	33	137	312	619	1131	5718
1970	304	173	285	495	681	153	330	467	280	24	524	697	4414
1971	120	509	343	1441	701	79	264	271	281	232	789	457	5488
1972	247	180	539	518	1101	620	419	-1	112	622	595	517	5469
1973	246	475	166	549	957	478	232	326	183	388	480	603	5082
1974	217	143	354	872	828	447	61	13	207	628	265	672	4707
1975	2	29	314	577	1088	-53	107	47	147	371	751	844	4225
1976	616	503	325	969	622	293	-86	0	575	629	370	744	5559
1977	586	376	277	719	738	499	168	301	207	748	433	850	5902
1978	827	268	286	662	727	529	142	-64	-8	263	-17	369	3983
1979	642	179	1124	135	326	52	137	199	284	390	505	316	4288
1980	224	109	330	895	814	507	464	322	316	369	548	328	5226
1981	620	486	518	573	978	262	177	264	381	759	475	455	5948
1982	269	138	276	815	1123	308	322	47	241	231	500	473	4742
1983	1244	281	863	816	468	244	339	613	261	219	439	335	6122
1984	545	760	396	628	1216	473	160	436	374	107	161	356	5614
1985	106	120	230	426	959	992	379	-28	176	29	110	254	3752
1986	746	422	202	1323	337	198	117	24	189	341	252	255	4406
1987	154	135	291	1284	570	178	14	-48	27	242	779	442	4068
1988	133	403	781	909	717	526	286	90	25	231	589	287	4975
1989	244	190	229	661	698	212	89	166	284	415	450	200	3838
1990	240	208	170	1313	940	345	150	-55	77	438	527	756	5108
1991	260	274	497	586	895	322	52	9	349	509	719	185	4657
1992	247	161	709	648	1009	621	218	47	218	417	286	393	4973
1993	197	405	374	935	1116	379	322	375	88	516	708	1072	6487
1994	502	223	624	1074	1037	407	240	89	204	184	398	191	5172
1995	573	182	425	758	782	337	202	176	340	368	794	504	5441
1996	361	888	638	395	348	184	571	169	289	420	286	675	5224
1997	606	389	145	494	1122	448	219	163	535	324	489	248	5182
1998	219	273	806	1075	707	224	287	136	513	298	416	391	5345
1999	636	922	824	756	552	225	101	268	371	510	433	536	6134
2000	637	469	665	808	610	272	430	235	78	803	712	506	6226
2001	196	87	188	587	978	441	230	31	169	166	489	332	3893
2002	242	287	652	678	526	246	52	158	274	201	540	306	4161

Table B.6
Total Bay d'Espoir System Unadjusted Reference Inflow Sequence
Monthly Volumes ($m^3 \times 10^6$)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1950	307	186	139	561	1647	378	377	308	79	93	164	350	4589
1951	498	697	465	1002	539	251	219	490	238	230	812	583	6024
1952	580	682	378	554	1467	506	272	191	131	133	828	551	6272
1953	414	541	288	1089	567	589	226	170	192	499	488	676	5739
1954	407	549	891	552	835	452	285	481	168	293	739	1047	6700
1955	691	334	407	448	693	541	227	291	251	393	615	405	5297
1956	931	353	228	667	1337	663	348	235	163	171	428	745	6270
1957	522	234	231	350	921	394	196	257	460	541	501	894	5501
1958	610	358	439	449	565	381	409	402	635	560	811	656	6275
1959	214	227	182	661	924	341	158	142	209	214	714	788	4773
1960	300	360	280	443	1098	336	201	88	97	298	495	350	4345
1961	260	98	136	437	1424	593	153	70	64	202	356	397	4190
1962	275	402	392	1318	1012	581	347	273	176	434	1152	547	6909
1963	1151	377	179	639	1506	539	314	221	464	451	514	704	7060
1964	220	281	276	963	1124	576	507	278	278	661	594	428	6186
1965	400	191	742	424	1149	727	236	140	126	353	793	460	5742
1966	218	154	190	629	819	472	260	295	282	408	471	705	4904
1967	408	206	251	214	1649	411	151	294	169	411	1092	837	6093
1968	471	336	641	564	609	635	547	279	378	324	711	784	6280
1969	366	1353	407	580	1146	378	74	71	176	382	814	1333	7079
1970	152	208	315	561	807	221	398	542	393	98	752	733	5180
1971	275	629	448	1784	872	117	332	375	342	309	969	539	6989
1972	298	218	683	605	1395	868	458	20	156	872	754	609	6936
1973	293	564	205	652	1242	554	300	443	197	459	592	757	6258
1974	257	180	420	1000	1068	531	95	57	257	779	348	794	5785
1975	41	47	389	683	1360	-18	130	66	202	463	893	1035	5291
1976	740	601	385	1164	811	329	-52	25	643	761	486	946	6838
1977	723	433	325	896	1029	592	221	389	268	934	614	1065	7489
1978	1025	305	352	772	1011	631	198	-42	18	308	28	427	5033
1979	797	244	1422	214	432	102	175	238	336	503	632	431	5526
1980	319	130	371	1080	1014	584	591	396	396	485	707	400	6473
1981	739	590	614	783	1181	351	254	352	408	919	631	643	7464
1982	316	175	318	965	1515	386	382	78	304	306	567	552	5864
1983	1466	361	1025	1057	561	308	399	803	339	263	570	437	7589
1984	623	877	473	768	1497	604	218	544	467	148	219	438	6875
1985	118	122	251	492	1252	1181	411	0	233	32	138	311	4540
1986	976	494	235	1635	385	277	144	24	243	404	292	298	5404
1987	214	159	393	1620	712	207	20	-44	15	359	988	509	5151
1988	140	462	932	1084	975	648	346	117	62	315	722	353	6156
1989	278	218	263	782	889	241	107	216	355	533	607	238	4728
1990	280	250	164	1645	1225	406	180	-18	99	544	628	970	6372
1991	300	322	569	710	1119	398	95	44	417	662	851	240	5727
1992	291	176	768	798	1329	744	239	157	281	518	344	472	6118
1993	235	463	430	1169	1434	450	394	471	124	655	846	1319	7991
1994	587	268	710	1338	1377	493	275	85	257	229	534	250	6401
1995	681	221	511	900	977	430	279	254	412	445	962	610	6682
1996	461	1127	763	481	468	252	684	206	335	518	349	840	6485
1997	727	488	167	603	1437	544	268	205	616	408	594	289	6345
1998	297	372	1018	1264	893	268	359	192	646	380	524	458	6672
1999	775	1093	990	938	732	246	119	388	459	627	545	666	7578
2000	774	549	785	1056	790	323	502	291	110	958	854	630	7621
2001	231	124	215	693	1213	499	288	56	230	212	607	405	4774
2002	284	325	794	816	720	308	74	232	384	260	675	364	5237

Appendix C – Mean Annual Runoff Data

Table C.1
Victoria Unadjusted Reference Inflow Sequence
Annual Volume, Flow, and Runoff

Length of Record: 53 years
Plants in Service: 1967 (Bay d'Espoir), 1983 (Upper Salmon)
Area (km^2): 1058

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1950	1065	33.8	1007
1951	1155	36.6	1092
1952	1070	33.9	1012
1953	1057	33.5	999
1954	1202	38.1	1136
1955	998	31.6	943
1956	1088	34.5	1029
1957	1190	37.7	1125
1958	1282	40.6	1212
1959	967	30.7	914
1960	912	28.9	862
1961	871	27.6	823
1962	1162	36.8	1098
1963	1208	38.3	1142
1964	1077	34.1	1018
1965	950	30.1	898
1966	948	30.1	896
1967	1109	35.1	1048
1968	1077	34.1	1018
1969	1361	43.1	1286
1970	766	24.3	724
1971	1501	47.6	1419
1972	1467	46.5	1387
1973	1177	37.3	1112
1974	1079	34.2	1019
1975	1066	33.8	1007
1976	1279	40.5	1208
1977	1587	50.3	1500
1978	1050	33.3	993
1979	1238	39.2	1170
1980	1247	39.5	1178
1981	1515	48.0	1432
1982	1122	35.6	1060
1983	1467	46.5	1386
1984	1261	40.0	1192
1985	788	25.0	745
1986	998	31.6	943
1987	1083	34.3	1023
1988	1181	37.4	1116
1989	890	28.2	841
1990	1264	40.0	1194
1991	1070	33.9	1011
1992	1144	36.3	1082
1993	1503	47.6	1421
1994	1229	39.0	1162
1995	1241	39.3	1173
1996	1261	39.9	1192
1997	1164	36.9	1100
1998	1327	42.0	1254
1999	1444	45.7	1364
2000	1395	44.2	1319
2001	881	27.9	833
2002	1076	34.1	1017
Mean	1161	36.8	1097

Source: Newfoundland and Labrador Hydro, as volumes (m^3 x 10^6).

Table C.2
Meelpaeg Unadjusted Reference Inflow Sequence
Annual Volume, Flow, and Runoff

Length of Record: 53 years
Plants in Service: 1967 (Bay d'Espoir), 1983 (Upper Salmon)
Area (km^2): 2152

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1950	1703	54.0	791
1951	2219	70.3	1031
1952	2305	73.0	1071
1953	2138	67.8	994
1954	2470	78.3	1148
1955	1934	61.3	899
1956	2318	73.5	1077
1957	2037	64.6	947
1958	2354	74.6	1094
1959	1760	55.8	818
1960	1584	50.2	736
1961	1572	49.8	730
1962	2513	79.6	1168
1963	2558	81.1	1189
1964	2250	71.3	1046
1965	2134	67.6	992
1966	1782	56.5	828
1967	2285	72.4	1062
1968	2470	78.3	1148
1969	2742	86.9	1274
1970	1642	52.0	763
1971	2638	83.6	1226
1972	2927	92.8	1360
1973	2782	88.2	1293
1974	2710	85.9	1259
1975	2285	72.4	1062
1976	3051	96.7	1418
1977	3495	110.7	1624
1978	2417	76.6	1123
1979	2379	75.4	1105
1980	2527	80.1	1174
1981	3206	101.6	1490
1982	2533	80.3	1177
1983	3122	98.9	1451
1984	2692	85.3	1251
1985	1755	55.6	815
1986	2167	68.7	1007
1987	2059	65.2	957

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1988	2293	72.7	1066
1989	1782	56.5	828
1990	2466	78.2	1146
1991	2166	68.7	1007
1992	2223	70.5	1033
1993	2968	94.0	1379
1994	2411	76.4	1120
1995	2696	85.4	1253
1996	2546	80.7	1183
1997	2550	80.8	1185
1998	2415	76.5	1122
1999	3414	108.2	1586
2000	3489	110.5	1621
2001	2001	63.4	930
2002	2343	74.3	1089
Mean	2402	76.1	1116

Source: Newfoundland and Labrador Hydro, as volumes ($m^3 \times 10^6$).

Table C.3
Upper Salmon Unadjusted Reference Inflow Sequence
Annual Volume, Flow, and Runoff

Length of Record: 53 years
Plants in Service: 1967 (Bay d'Espoir), 1983 (Upper Salmon)
Area (km^2): 902

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1950	610	19.3	676
1951	888	28.1	984
1952	971	30.8	1076
1953	853	27.0	945
1954	1014	32.1	1125
1955	792	25.1	878
1956	959	30.4	1063
1957	761	24.1	844
1958	884	28.0	980
1959	684	21.7	758
1960	620	19.7	688
1961	586	18.6	649
1962	1083	34.3	1200
1963	1103	34.9	1223
1964	957	30.3	1061
1965	890	28.2	987
1966	728	23.1	807
1967	904	28.6	1002
1968	916	29.0	1015
1969	997	31.6	1105
1970	928	29.4	1029
1971	955	30.2	1058
1972	852	27.0	944
1973	770	24.4	854
1974	669	21.2	741
1975	650	20.6	721
1976	840	26.6	931
1977	806	25.5	894
1978	524	16.6	581
1979	640	20.3	709
1980	904	28.7	1003
1981	919	29.1	1019
1982	740	23.5	821
1983	902	28.6	1000
1984	937	29.7	1038
1985	753	23.9	835
1986	751	23.8	833
1987	647	20.5	717

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1988	1062	33.6	1177
1989	823	26.1	913
1990	862	27.3	955
1991	988	31.3	1095
1992	1144	36.3	1269
1993	1250	39.6	1386
1994	1035	32.8	1148
1995	750	23.8	831
1996	844	26.7	936
1997	896	28.4	994
1998	1042	33.0	1155
1999	608	19.3	675
2000	516	16.4	572
2001	539	17.1	597
2002	440	14.0	488
Mean	834	26.4	924

Source: Newfoundland and Labrador Hydro, as volumes ($m^3 \times 10^6$).

Table C.4
Lower Salmon Unadjusted Reference Inflow Sequence
Annual Volume, Flow, and Runoff

Length of Record: 53 years
Plants in Service: 1967 (Bay d'Espoir), 1983 (Upper Salmon)
Area (km^2): 1792

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1950	1211	38.4	676
1951	1762	55.8	984
1952	1926	61.0	1075
1953	1691	53.6	944
1954	2014	63.8	1124
1955	1573	49.8	878
1956	1904	60.3	1063
1957	1512	47.9	844
1958	1755	55.6	979
1959	1362	43.2	760
1960	1229	39.0	686
1961	1162	36.8	648
1962	2151	68.2	1200
1963	2190	69.4	1222
1964	1901	60.3	1061
1965	1767	56.0	986
1966	1446	45.8	807
1967	1794	56.9	1001
1968	1817	57.6	1014
1969	1979	62.7	1105
1970	1844	58.4	1029
1971	1895	60.1	1058
1972	1691	53.6	943
1973	1530	48.5	854
1974	1328	42.1	741
1975	1291	40.9	720
1976	1669	52.9	931
1977	1600	50.7	893
1978	1042	33.0	582
1979	1269	40.2	708
1980	1795	56.9	1002
1981	1824	57.8	1018
1982	1469	46.5	820
1983	2098	66.5	1171
1984	1984	62.9	1107
1985	1245	39.4	694
1986	1487	47.1	830
1987	1362	43.2	760

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1988	1620	51.3	904
1989	1233	39.1	688
1990	1780	56.4	993
1991	1503	47.6	839
1992	1606	50.9	896
1993	2269	71.9	1266
1994	1726	54.7	963
1995	1995	63.2	1113
1996	1834	58.1	1024
1997	1735	55.0	968
1998	1887	59.8	1053
1999	2112	66.9	1179
2000	2221	70.4	1239
2001	1353	42.9	755
2002	1378	43.7	769
Mean	1676	53.1	935

Source: Newfoundland and Labrador Hydro, as volumes ($m^3 \times 10^6$).

Table C.5

Combined Meelpaeg and Salmon Basin Unadjusted Reference Inflow Sequence
Annual Volume, Flow, and Runoff

Length of Record: 53 years
Plants in Service: 1967 (Bay d'Espoir), 1983 (Upper Salmon)
Area (km^2): 4846

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1950	3523	112	727
1951	4869	154	1005
1952	5202	165	1073
1953	4682	148	966
1954	5498	174	1135
1955	4299	136	887
1956	5182	164	1069
1957	4311	137	890
1958	4993	158	1030
1959	3806	121	785
1960	3433	109	708
1961	3319	105	685
1962	5747	182	1186
1963	5852	185	1208
1964	5109	162	1054
1965	4791	152	989
1966	3956	125	816
1967	4983	158	1028
1968	5203	165	1074
1969	5718	181	1180
1970	4414	140	911
1971	5488	174	1132
1972	5469	173	1129
1973	5082	161	1049
1974	4707	149	971
1975	4225	134	872
1976	5559	176	1147
1977	5902	187	1218
1978	3983	126	822
1979	4288	136	885
1980	5226	166	1079
1981	5948	188	1227
1982	4742	150	979
1983	6122	194	1263
1984	5614	178	1158
1985	3752	119	774
1986	4406	140	909
1987	4068	129	839

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1988	4975	158	1027
1989	3838	122	792
1990	5108	162	1054
1991	4657	148	961
1992	4973	158	1026
1993	6487	206	1339
1994	5172	164	1067
1995	5441	172	1123
1996	5224	166	1078
1997	5182	164	1069
1998	5345	169	1103
1999	6134	194	1266
2000	6226	197	1285
2001	3893	123	803
2002	4161	132	859
Mean	4911	155.6	1013

Source: Newfoundland and Labrador Hydro, as volumes (m^3 x 10^6).

Table C.6

Total Bay d'Espoir System Unadjusted Reference Inflow Sequence
Annual Volume, Flow, and Runoff

Length of Record: 53 years
Plants in Service: 1967 (Bay d'Espoir), 1983 (Upper Salmon)
Area (km^2): 5904

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1950	4589	145	777
1951	6024	191	1020
1952	6272	199	1062
1953	5739	182	972
1954	6700	212	1135
1955	5297	168	897
1956	6270	199	1062
1957	5501	174	932
1958	6275	199	1063
1959	4773	151	808
1960	4345	138	736
1961	4190	133	710
1962	6909	219	1170
1963	7060	224	1196
1964	6186	196	1048
1965	5742	182	973
1966	4904	155	831
1967	6093	193	1032
1968	6280	199	1064
1969	7079	224	1199
1970	5180	164	877
1971	6989	221	1184
1972	6936	220	1175
1973	6258	198	1060
1974	5785	183	980
1975	5291	168	896
1976	6838	217	1158
1977	7489	237	1268
1978	5033	159	853
1979	5526	175	936
1980	6473	205	1096
1981	7464	237	1264
1982	5864	186	993
1983	7589	240	1285
1984	6875	218	1164
1985	4540	144	769
1986	5404	171	915
1987	5151	163	872

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1988	6156	195	1043
1989	4728	150	801
1990	6372	202	1079
1991	5727	181	970
1992	6118	194	1036
1993	7991	253	1353
1994	6401	203	1084
1995	6682	212	1132
1996	6485	205	1098
1997	6345	201	1075
1998	6672	211	1130
1999	7578	240	1284
2000	7621	241	1291
2001	4774	151	809
2002	5237	166	887
Mean	6072	192.4	1028

Source: Newfoundland and Labrador Hydro, as volumes (m^3 x 10^6).

Table C.7

Bay du Nord River at Big Falls
Environment Canada Streamflow Record

ID Number: 02ZF001
Length of Record: 51 years
Area (km^2): 1170

Year	Flow m^3/s	Runoff mm
1952	44.7	1206
1953	39.5	1065
1954	44.7	1206
1955	37.1	1001
1956	46.3	1249
1957	35.5	958
1958	35.9	968
1959	37.1	1001
1960	25.6	690
1961	24.1	650
1962	43.9	1184
1963	45.6	1230
1964	40.0	1079
1965	39.3	1060
1966	31.4	847
1967	39.3	1060
1968	46.6	1257
1969	44.9	1211
1970	42.2	1138
1971	45.5	1227
1972	44.7	1206
1973	47.9	1292
1974	35.4	955
1975	34.8	939
1976	47.2	1273
1977	42.2	1138
1978	37.2	1003
1979	34.3	925
1980*	48.4	1305
1981	50.2	1354
1982	37.2	1003
1983	51.8	1397
1984	48.2	1300
1985	28.5	769
1986	37.2	1003
1987	33.9	914
1988	44.3	1195
1989	31.1	839

Year	Flow m^3/s	Runoff mm
1990	44.4	1198
1991	36.8	993
1992	37.4	1009
1993	52.4	1413
1994	43.1	1163
1995	43.8	1181
1996	36.7	990
1997	36.8	993
1998	37.0	998
1999	44.2	1192
2000	42.0	1133
2001	33.0	890
2002	32.1	866
Mean	40.1	1081

* Includes 2 estimated monthly inflows as described in Appendix D.
Source: Environment Canada HYDAT database, as flows (m^3/s).

Table C.8
Pipers Hole River at Mothers Brook
Environment Canada Streamflow Record

ID Number: 02ZH001
Length of Record: 50 years
Area (km^2): 764

Year	Flow m^3/s	Runoff mm
1953	24.0	991
1954	26.3	1086
1955	27.4	1132
1956	28.0	1157
1957	23.3	962
1958	22.1	913
1959	21.6	892
1960	18.3	756
1961	16.3	673
1962	30.8	1272
1963	29.7	1227
1964	24.5	1012
1965	22.2	917
1966	21.9	905
1967	24.0	991
1968	27.5	1136
1969	27.6	1140
1970	28.3	1169
1971	27.0	1115
1972	22.5	929
1973	28.6	1181
1974	21.8	900
1975	20.8	859
1976	24.0	991
1977	22.6	934
1978	21.5	888
1979	21.9	905
1980	32.8	1355
1981	31.9	1318
1982	25.1	1037
1983	28.4	1173
1984	29.9	1235
1985	18.5	764
1986	24.6	1016
1987	20.8	859
1988	31.2	1289
1989	17.0	702
1990	26.5	1095

Year	Flow m^3/s	Runoff mm
1991	25.1	1037
1992	22.3	921
1993	35.1	1450
1994	25.2	1041
1995	28.9	1194
1996	29.1	1202
1997	21.3	880
1998	24.8	1024
1999	29.9	1235
2000	28.2	1165
2001	23.0	950
2002	19.9	822
Mean	25.1	1036

Source: Environment Canada HYDAT database, as flows (m^3/s).

Table C.9
Gander River at Big Chute
Environment Canada Streamflow Record

ID Number: 02YQ001
Length of Record: 53 years
Area (km^2): 4450

Year	Flow m^3/s	Runoff mm
1950	78.7	558
1951	114	808
1952	123	872
1953	112	794
1954	132	936
1955	117	830
1956	124	879
1957	111	787
1958	102	723
1959	91.5	649
1960	95.4	677
1961	71.4	506
1962	158.0	1120
1963	142	1007
1964	129	915
1965	121	858
1966	106	752
1967	110	780
1968	132	936
1969	134	950
1970	142	1007
1971	119	844
1972	121	858
1973	139	986
1974	116	823
1975	104	738
1976	129	915
1977	128	908
1978	93.3	662
1979	120	851
1980	142	1007
1981	146	1035
1982	105	745
1983	131	929
1984	155	1099
1985	82.1	582
1986	105	745
1987	98.3	697

Year	Flow m^3/s	Runoff mm
1988	118	837
1989	85.6	607
1990	119	844
1991	130	922
1992	125	886
1993	148	1050
1994	138	979
1995	137	972
1996	124	879
1997	118	837
1998	121	858
1999	129	915
2000	127	901
2001	100	712
2002	96.9	687
Mean	118.8	843

Source: Environment Canada HYDAT database, as flows (m^3/s).

Table C.10
Upper Humber River near Reidville
Environment Canada Streamflow Record

ID Number: 02YL001
Length of Record: 50 years
Area (km^2): 2110

Year	Flow m^3/s	Runoff mm
1953	74.2	1110
1954	90.1	1348
1955	62.8	939
1956	75.0	1122
1957	77.1	1153
1958	71.7	1072
1959	71.6	1071
1960	61.0	912
1961	72.2	1080
1962	88.9	1330
1963	88.6	1325
1964	79.8	1194
1965	75.5	1129
1966	77.5	1159
1967	69.6	1041
1968	75.0	1122
1969	96.3	1440
1970	69.6	1041
1971	77.4	1158
1972	94.1	1407
1973	91.4	1367
1974	73.0	1092
1975	75.7	1132
1976	91.6	1370
1977	111	1660
1978	76.3	1141
1979	85.3	1276
1980	92.5	1383
1981	88.2	1319
1982	92.8	1388
1983	76.5	1144
1984	86.2	1289
1985	68.5	1025
1986	64.3	962
1987	68.1	1019
1988	83.3	1246
1989	63.2	945
1990	86.6	1295

Year	Flow m^3/s	Runoff mm
1991	72.6	1086
1992	66.4	993
1993	86.4	1292
1994	93.2	1394
1995	85.2	1274
1996	74.2	1110
1997	76.5	1144
1998	79.7	1192
1999	92.0	1376
2000	88.0	1316
2001	65.4	978
2002	79.0	1182
Mean	79.6	1191

Source: Environment Canada HYDAT database, as flows (m^3/s).

Table C.11
Humber River at Deer Lake
Deer Lake Power Inflow Sequence

ID Number: n/a
Length of Record: 78 years
Area (km^2): 5020

Year	Flow m^3/s	Runoff mm	Year	Flow m^3/s	Runoff mm
1925	146	916	1965	134	845
1926	184	1154	1966	121	762
1927	186	1171	1967	129	814
1928	136	855	1968	142	890
1929	158	996	1969	177	1116
1930	152	956	1970	131	824
1931	141	885	1971	146	916
1932	150	944	1972	152	957
1933	193	1212	1973	155	973
1934	153	963	1974	135	850
1935	177	1112	1975	134	845
1936	163	1026	1976	147	925
1937	127	796	1977	186	1172
1938	117	734	1978	121	763
1939	158	995	1979	152	957
1940	131	824	1980	151	950
1941	164	1030	1981	167	1047
1942	156	982	1982	161	1010
1943	128	806	1983	165	1037
1944	182	1145	1984	157	988
1945	166	1045	1985	106	668
1946	114	715	1986	121	760
1947	130	814	1987	121	760
1948	127	795	1988	154	967
1949	166	1041	1989	115	725
1950	113	709	1990	155	971
1951	152	956	1991	139	875
1952	147	924	1992	129	809
1953	136	856	1993	168	1055
1954	154	970	1994	175	1102
1955	137	864	1995	173	1088
1956	146	915	1996	148	933
1957	154	969	1997	155	972
1958	141	886	1998	179	1128
1959	123	771	1999	162	1016
1960	114	718	2000	167	1051
1961	130	819	2001	122	767
1962	168	1059	2002	155	977
1963	153	959			
1964	141	888	Mean	148	929

Source: Natural Inflows backrouted by Deer Lake Power.

Table C.12
Hinds Brook near Grand Lake
Environment Canada Streamflow Record

ID Number: 02YK004
Length of Record: 22 years
Area (km^2): 529

Year	Flow m^3/s	Runoff mm
1957	15.4	919
1958	16.2	966
1959	14.1	841
1960	13.5	805
1961	13.3	793
1962	18.9	1127
1963	17.1	1020
1964	16.9	1008
1965	16.2	966
1966	13.4	799
1967	14.6	871
1968	15.9	949
1969	19.1	1139
1970	15.8	943
1971	18.0	1074
1972	18.9	1127
1973	18.7	1116
1974	15.7	937
1975	15.6	931
1976	17.4	1038
1977	21.0	1253
1978	*	*
1979	16.2	966
Mean	16.5	981

* Missing data
Source: Environment Canada HYDAT database, as flows (m^3/s).

Table C.13
Lewaseechjeech Brook at Little Grand Lake
Environment Canada Streamflow Record

ID Number: 02YK002
Length of Record: 40 years
Area (km^2): 470

Year	Flow m^3/s	Runoff mm
1956	17.0	1141
1957	18.2	1222
1958	20.0	1343
1959	14.7	987
1960	13.1	880
1961	13.5	906
1962	18.2	1222
1963	17.8	1195
1964	16.7	1121
1965	14.8	994
1966	14.0	940
1967	*	*
1968	*	*
1969	*	*
1970	*	*
1971	*	*
1972	*	*
1973	19.3	1296
1974	17.5	1175
1975	17.0	1141
1976	16.6	1115
1977	23.0	1544
1978	15.1	1014
1979	18.4	1235
1980	19.0	1276
1981	*	*
1982	20.7	1390
1983	21.4	1437
1984	19.9	1336
1985	13.6	913
1986	16.4	1101
1987	14.8	994
1988	19.2	1289
1989	16.8	1128
1990	20.0	1343
1991	17.1	1148

Year	Flow m^3/s	Runoff mm
1992	17.0	1141
1993	22.6	1517
1994	19.0	1276
1995	19.8	1329
1996	18.6	1249
1997	19.3	1296
1998	21.4	1437
1999	21.7	1457
2000	21.2	1423
2001	14.7	987
2002	21.4	1437
Mean	18.0	1209

* Missing data
Source: Environment Canada HYDAT database, as flows (m^3/s).
Note: The Lewaseechjeech Brook at Little Grand Lake record was not considered in this analysis because it did not meet the Environment Canada criteria for inclusion in the Reference Hydrometric Basin Network.

Table C.14
Isle aux Morts River below Highway Bridge
Environment Canada Streamflow Record

ID Number: 02ZB001
Length of Record: 40 years
Area (km^2): 205

Year	Flow m^3/s	Runoff mm
1963	12.1	1863
1964	13.1	2017
1965	13.6	2094
1966	13.6	2094
1967	15.3	2355
1968	15.4	2371
1969	15.7	2417
1970	11.6	1786
1971	14.1	2171
1972	16.4	2525
1973	14.1	2171
1974	12.5	1924
1975	10.7	1647
1976	13.4	2063
1977	15.7	2417
1978	12.7	1955
1979	14.8	2278
1980	12.2	1878
1981	15.3	2355
1982	15.8	2432
1983	15.2	2340
1984	13.3	2047
1985	11.9	1832
1986	10.3	1586
1987	11.8	1816
1988	13.4	2063
1989	11.9	1832
1990	16.8	2586
1991	10.4	1601
1992	10.4	1601
1993	14.7	2263
1994	16.0	2463
1995	13.4	2063
1996	16.5	2540
1997	14.5	2232
1998	18.3	2817
1999	15.8	2432
2000	14.0	2155
2001	10.1	1555
2002	13.7	2109
Mean	13.8	2119

Source: Environment Canada HYDAT database, as flows (m^3/s).

Table C.15
Salmon River at Long Pond
Environment Canada Streamflow Record

ID Number: 02ZE001
Length of Record: 21 years
Area (km^2): 2640

Year	Flow m^3/s	Runoff mm
1944	141	1685
1945	128	1530
1946	93.1	1113
1947	63.7	761
1948	114	1363
1949	77.8	930
1950	56.1	671
1951	82.4	985
1952	89.7	1072
1953	79.1	946
1954	94.2	1126
1955	73.5	879
1956	88.8	1061
1957	70.8	846
1958	82.0	980
1959	63.5	759
1960	57.4	686
1961	54.4	650
1962	101	1207
1963	102	1219
1964	88.7	1060
Mean	85.8	1025

Source: Environment Canada HYDAT database, as flows (m^3/s).

Table C.16
Grey River near Pudops Lake
Environment Canada Streamflow Record

ID Number: 02ZD001
Length of Record: 8 years
Area (km^2): 982

Year	Flow m^3/s	Runoff mm
1959	24.0	772
1960	22.2	712
1961	21.0	675
1962	32.7	1052
1963	34.4	1105
1964	29.2	937
1965	27.4	881
1966	22.0	708
Mean	26.6	855

Source: Environment Canada HYDAT database, as flows (m^3/s).

Table C.17
White Bear River at White Bear Lake
Environment Canada Streamflow Record

ID Number: 02ZC001
Length of Record: 4 years
Area (km^2): 798

Year	Flow m^3/s	Runoff mm
1965	32.3	1277
1966	24.9	985
1967	28.3	1119
1968	31.8	1258
Mean	29.3	1160

Source: Environment Canada HYDAT database, as flows (m^3/s).

Appendix D – Minor Record Adjustments

Appendix D
Minor Record Adjustments

D1 Bay du Nord River: Fill-in of two missing months

In the EC Bay du Nord hydrometric sequence, April and May 1980 flows were missing and thus the annual average could not be calculated for that year.[1] In order to allow the Bay du Nord record to be used in the comparison of mean annual runoffs, the Bay du Nord combined April and May flows in 1980 were estimated. Since only the average annual value for 1980 was required, there was no need to separate the two months.

The 1980 April/May flow was calculated as a fraction of the 1953 to 2002 April/May average, without 1980, from the Gander River at Big Chute and Piper's Hole at Mother's Brook records. Of the basins with long records, these two are most similar to Bay du Nord. The average ratio of the April/May 1980 flow to April/May 1953 to 2003 without 1980 was 1.356. Applying this value to the April/May Bay du Nord average of 63.9 m^3/s for 1953 to 2003 without 1980 leads to an April/May 1980 value of 86.7 m^3/s. An alternative ratio, determined by weighting the Gander River and Piper's Hole ratios by their correlation with the Bay du Nord record (correlation of April/May flows), is 1.345. This ratio leads to a Bay du Nord April/May 1980 flow of 86.0 m^3/s, similar to the value calculated taking the average of the two ratios. To obtain the 1980 annual Bay du Nord flow, the April and May flows were assumed to be 86 m^3/s. The resulting estimated 1980 annual average Bay du Nord flow is 48.4 m^3/s (1305 mm).

D2 Victoria Monthly Adjustments During Reservoir Filling

Two large negative inflows were noticed in the Victoria monthly reference inflow sequence during the reservoir filling period: -39.1 m^3/s in February 1968, and –56.7 m^3/s in January 1970. The monthly runoff sequence from January 1968 to January 1971 was compared to several surrounding natural basins and it was apparent that there were other months with unusually high inflows. Hence, water was transferred among months so the Victoria sequence more closely resembled that of the natural basins. The monthly inflow sequence during reservoir filling before and after the adjustments compared to the Gander and Upper Humber River basins is shown in Figure D.1. There are other possibilities for redistribution during this period, but slight changes will make little difference for Hydro's purposes.

Table D.1 summarizes the monthly adjustments made to the Victoria Reservoir sequence.

[1] See main text for stations numbers of Environment Canada gauged basins used in this Appendix.

Table D.1
Victoria Reservoir Filling Period Monthly Adjustments

Month	Unadjusted Flow (m^3/s)	Adjusted Flow (m^3/s)	Change in Volume (m^3 x 10^6)
February 1968	-39.1	35.2	+186.2
July 1968	64.0	17.7	-123.8
November 1968	61.2	37.1	-62.4
February 1969	100.2	56.5	-105.8
January 1970	-56.7	22.3	+211.6
May 1970	47.2	86.7	+105.8
November 1970	87.7	46.9	-105.8
January 1971	57.7	18.2	-105.8
		Total Change in Volume =	0.0

The corresponding changes in mean annual runoff for the Victoria Reservoir sequence are summarized in Table D.2.

Table D.2
Victoria Reservoir Filling Period Mean Annual Runoffs after Monthly Volume Transfers

Year	Mean Annual Runoff (mm)		
	Unadjusted	Adjusted)	Difference
1968	1018	1018	0
1969	1286	1186	-100
1970	724	924	+200
1971	1419	1319	-100
		Total Change in Mean Annual Runoff =	0

D3 Victoria and Meelpaeg Reservoirs: July/August 1950 Monthly Adjustments

A review of the records showed that estimated inflows to Victoria and Meelpaeg Reservoirs for July and August of 1950 in the Hydro sequence were much higher than the natural gauged basins for which records were available (Gander River at Big Chute, Rocky River near Colinet, and Salmon River at Long Pond.). Since these basins are all to the east of the Victoria and Meelpaeg basins, Environment Canada precipitation records for Stephenville, Buchans, and Deer Lake were checked. The review confirmed that those months were not unusually wet in the west.

In order to adjust the flow in these two months, the average of the July/August flow for each year between 1950 and 1965 was computed. This period was chosen since it was the longest period for which data were available for the Salmon River gauge. The ratio of the 1950 average July/August flow to the 1951 to 1965 average July/August flow was computed for the Salmon River record. Since the correlation between the Salmon River record and both the Victoria and Meelpaeg Reservoir sequences was better than the Gander basins, the only other gauged basin in the region in this period, this ratio was used to estimate the 1950 July and August average inflows to Victoria and Meelpaeg Reservoirs.

The resulting estimated July and August 1950 flows are 10.3 m^3/s and 18.3 m^3/s for Victoria and Meelpaeg Reservoirs, respectively. These adjustments reduced the 1950 mean annual runoffs for the Victoria and Meelpaeg Reservoirs from 1007 mm and 791 mm to 771 mm and 713 mm, respectively.

As a check, the annual average Victoria and Meelpaeg Reservoir 1950 flows were also computed using ratios of mean annual runoffs, without estimating the July/August flows separately. The 1950 runoff value as a fraction of the average mean annual runoff from 1951 to 1964 was calculated for the natural basins. The estimated 1950 runoff for Victoria and Meelpaeg Reservoirs by the monthly analysis described above was within the range of estimates produced under this annual analysis.

The monthly inflows to Victoria and Meelpaeg Reservoirs before and after this minor adjustment are shown in Figure D.2, along with the monthly inflows from the Salmon River gauge record.

D4 Reservoir Filling Period Overall Adjustments

Reservoir filling in Victoria and Meelpaeg Reservoirs took place between 1968 and 1970. In addition to the large negative inflows in the Victoria sequence during this period, flows are low relative to natural gauged basins, possibly due to the difficulties of monitoring and recording outflows. Upward adjustment factors were thus determined separately for this period.

The overall pattern of Victoria and Meelpaeg inflows is reasonable (after the monthly volume transfers within the Victoria sequence), as shown by Figure D.3, which compares the unadjusted monthly runoff with that of natural basins. The mean annual runoff for 1968 to 1970 was compared to that of 1971 to 2002 for a number of gauged basins, as shown in Table D.3 below. The time series plots and a correlation analysis indicated that the four gauges listed below are all suitable for the analysis. The fact that two are generally eastern basins and two are western accounts for possible east-west variations in weather patterns.

Table D.3
Mean Annual Runoff Data to Calculate Victoria and Meelpaeg Reservoir Filling Period Adjustment Factors

	1968 to 1970	1971 to 2002	(1968-1970): (1971-2002) Ratio
Hydro Basins			
Victoria Reservoir Basin	1043	1149	0.908
Combined Meelpaeg and Salmon Basin	1055	1041	1.013
Natural Basins			
Gander River at Big Chute	964	853	1.130
Upper Humber River near Reidville	1201	1217	0.987
Bay du Nord River at Big Falls	1202	1095	1.097
Humber River at Deer Lake[1]	943	938	1.006
Average (1968-1970):(1971-2002) Ratio =			1.055

1 Natural inflows backrouted by Deer Lake Power

The average ratio of the 1968 to 1970 period to the 1971 to 2002 period for the four natural basins is 1.055. To achieve this ratio in the Victoria Reservoir sequence, a 1.162 adjustment factor was applied to each of the three years.

Table D.4 summarizes the mean annual runoffs of the Victoria Reservoir sequence during the reservoir filling period after the monthly volume transfers and after the 16.2 percent increase.

Table D.4
Victoria Reservoir Filling Period Overall Adjustment

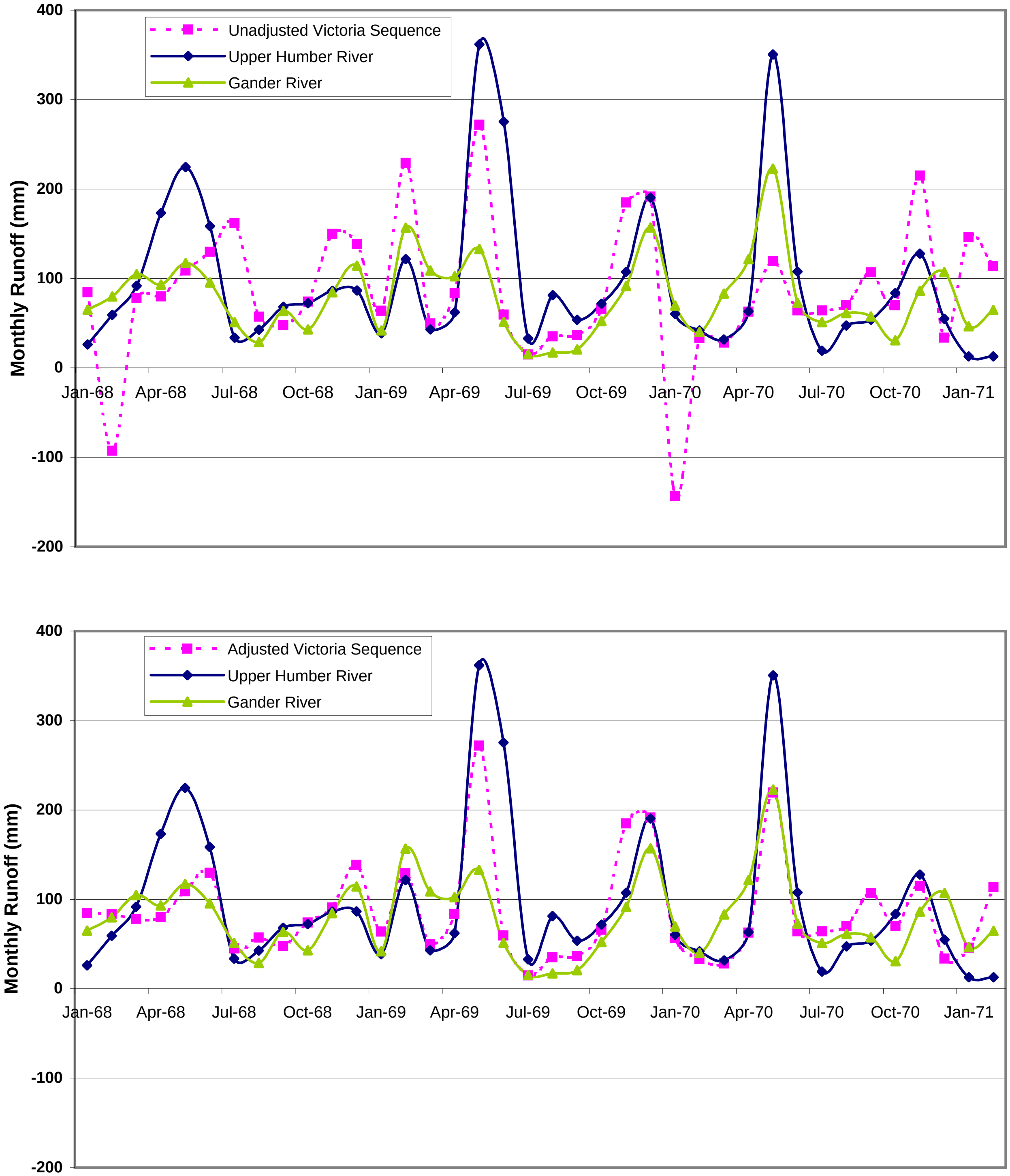
Year	Mean Annual Runoff (mm)		
	Original Hydro Sequence	After Monthly Volume Transfers	After Overall Adjustment
1968	1018	1018	1183
1969	1286	1186	1378
1970	724	924	1074
1971	1419	1319	1319

A slightly different approach was required for the Meelpaeg Reservoir since the Meelpaeg post-project sequence was not accepted and so could not be used directly to calculate ratios. The combined Meelpaeg and Salmon Basin post-project sequence, however, was accepted in this period, as was the post-project Salmon River sequence. Hence, the required Meelpaeg adjustment factor could be determined. A mean annual runoff comparison of Meelpaeg Reservoir with natural basins indicated that 1968 and 1969 were reasonable without any adjustment; however, the 1970 Meelpaeg runoff was lower than expected and thus the adjustment was applied only to this year. A review of the monthly runoff during this period indicated that it was reasonable to apply the same adjustment factor to each month in 1970. The 1970 Meelpaeg adjustment, which results in the desired ratio of the reservoir filling period to the post-project period, is 1.382.

Table D.5 summarizes the mean annual runoffs of the Meelpaeg Reservoir sequence during the reservoir filling period after the 38.2 percent increase to 1970.

Table D.5
Meelpaeg Reservoir Filling Period Overall Adjustment

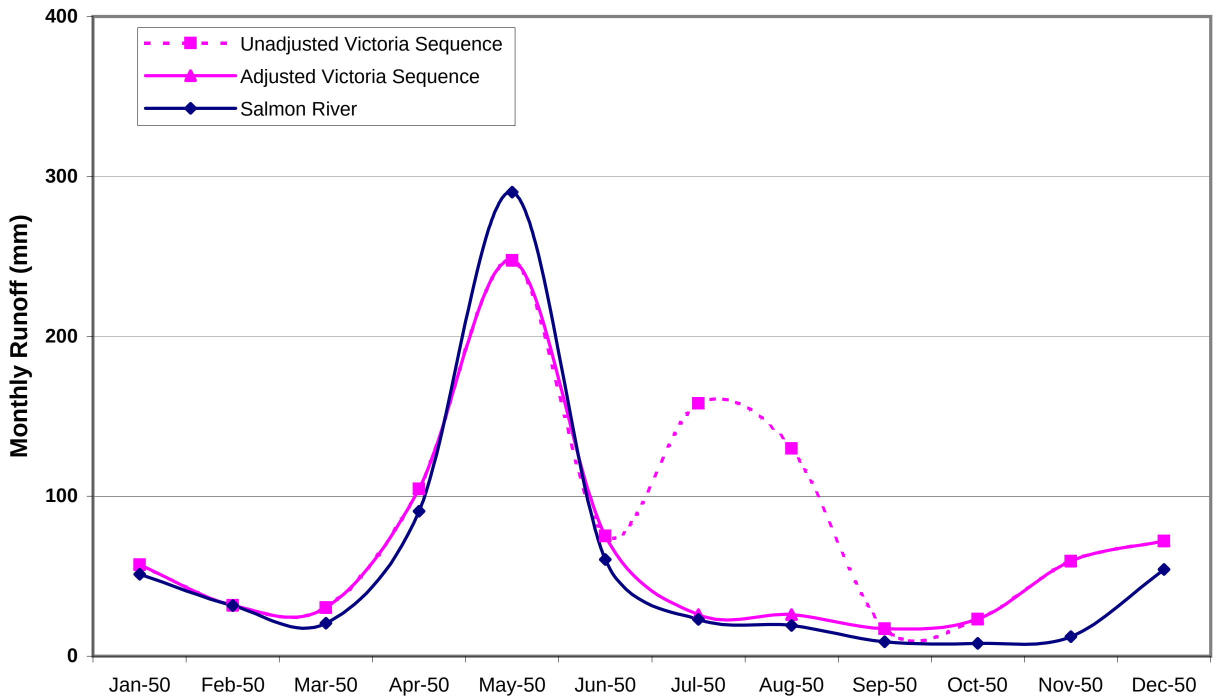
	Mean Annual Runoff (mm)	
Year	Unadjusted	Adjusted
1968	1148	1148
1969	1274	1274
1970	763	1055

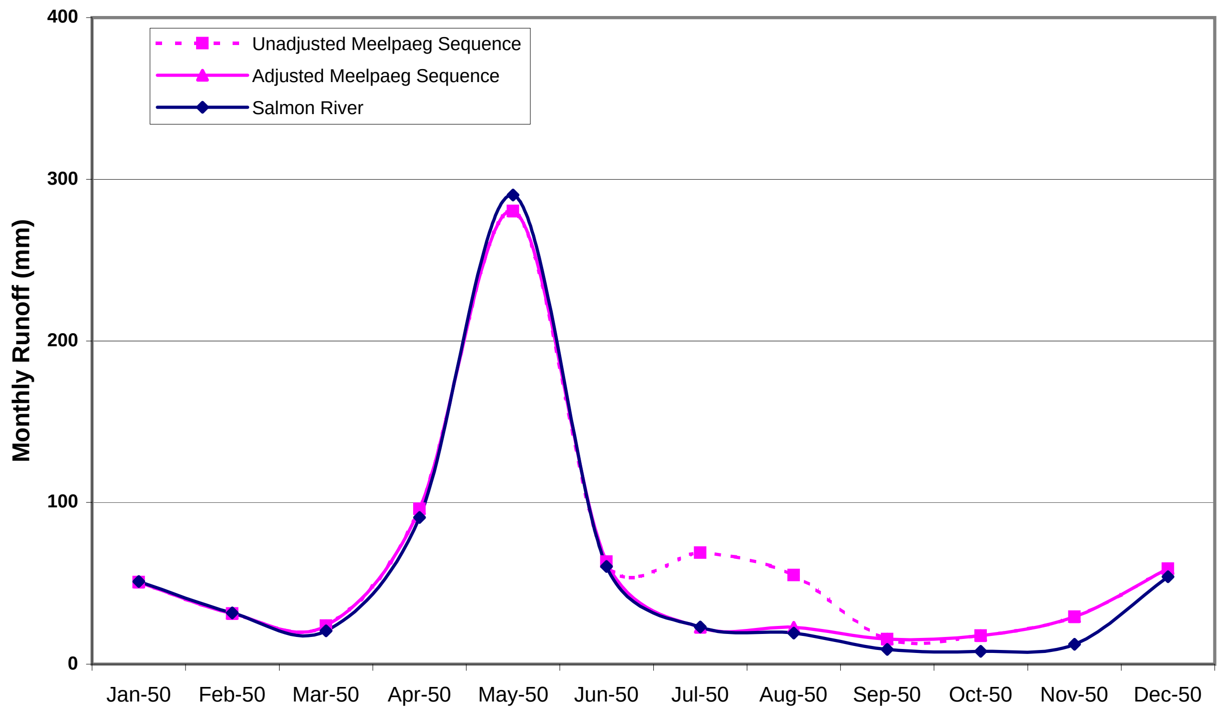


Note: Points connected and lines rounded for graphical clarity.

Figure D.1
Monthly Runoff Curves: Reservoir Filling Period
Unadjusted and Adjusted Victoria Reservoir Inflows
Adjustment of Bay d'Espoir Reference Inflow Sequences
Newfoundland and Labrador Hydro

SGE Acres



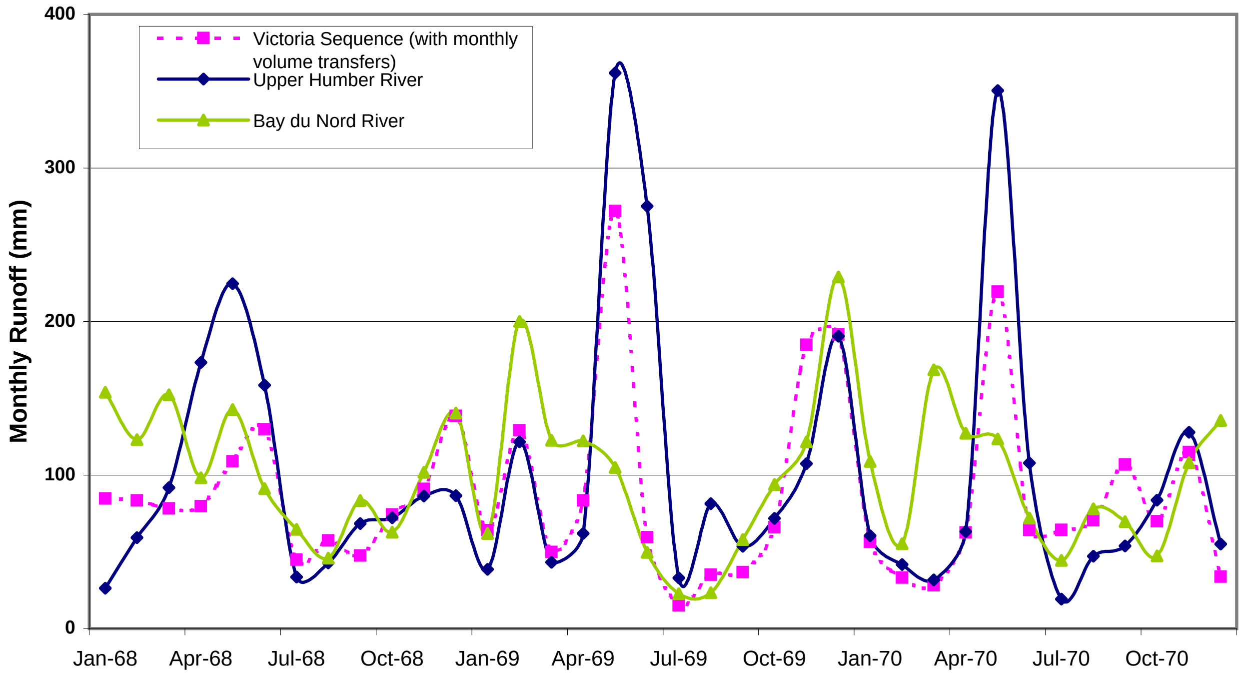


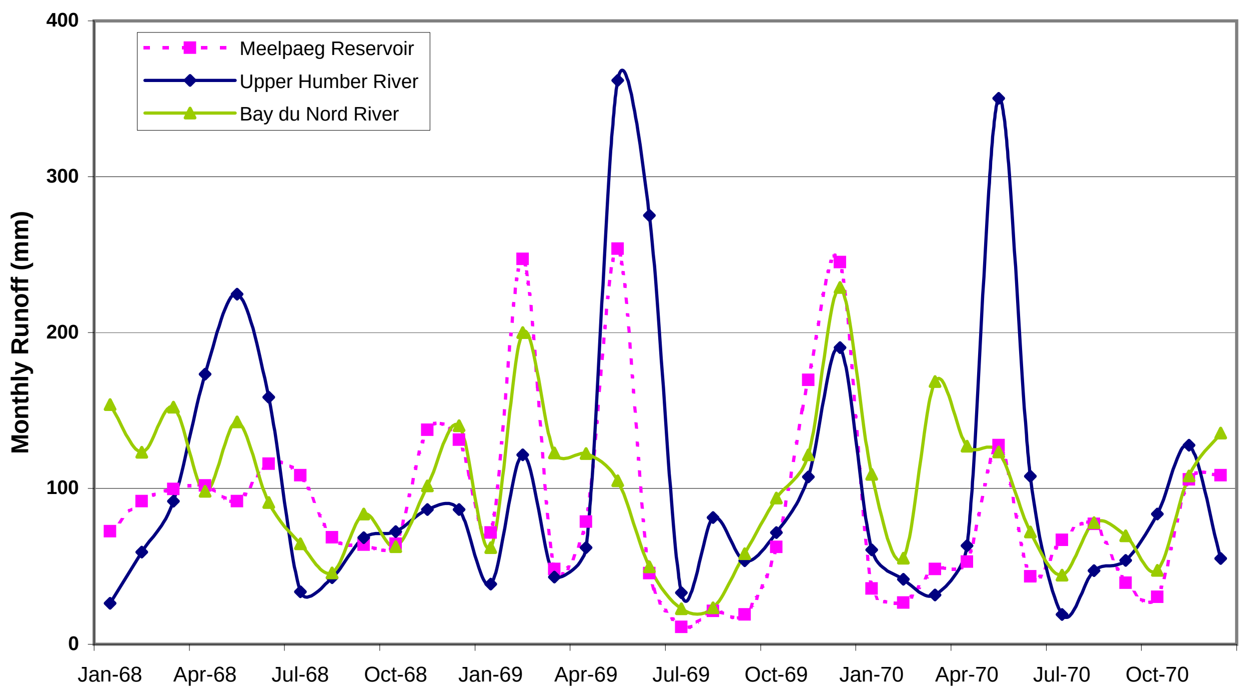
Note: Points connected and lines rounded for graphical clarity.

Figure D.2
Monthly Runoff Curves: 1950
Unadjusted and Adjusted Victoria and Meelpaeg Reservoir

SGE Acres

Adjustment of Bay d'Espoir Reference Inflow Sequences
Newfoundland and Labrador Hydro





Note: Points connected and lines rounded for graphical clarity.

Figure D.3
Monthly Runoff Curves: Reservoir Filling Period
Unadjusted Victoria and Meelpaeg Reservoir Runoff

SGE Acres

Adjustment of Bay d'Espoir Reference Inflow Sequences
Newfoundland and Labrador Hydro

Appendix E – Adjusted Mean Annual Runoff Data, Bay d’Espoir Basins

Table E.1
Victoria Adjusted Reference Inflow Sequence
Annual Volume, Flow, and Runoff

Length of Record: 53 years
Plants in Service: 1967 (Bay d'Espoir), 1983 (Upper Salmon)
Area (km^2): 1058

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1950	872	27.6	824
1951	1235	39.1	1167
1952	1144	36.3	1082
1953	1130	35.8	1068
1954	1284	40.7	1214
1955	1067	33.8	1009
1956	1163	36.9	1100
1957	1272	40.3	1203
1958	1371	43.4	1296
1959	1034	32.8	977
1960	974	30.9	921
1961	931	29.5	880
1962	1242	39.4	1174
1963	1291	40.9	1221
1964	1151	36.5	1088
1965	1016	32.2	960
1966	992	31.4	937
1967	1139	36.1	1077
1968	1251	39.7	1183
1969	1458	46.2	1378
1970	1136	36.0	1074
1971	1395	44.2	1319
1972	1467	46.5	1387
1973	1177	37.3	1112
1974	1079	34.2	1019
1975	1066	33.8	1007
1976	1279	40.5	1208
1977	1587	50.3	1500
1978	1050	33.3	993
1979	1238	39.2	1170
1980	1247	39.5	1178
1981	1515	48.0	1432
1982	1122	35.6	1060
1983	1467	46.5	1386
1984	1261	40.0	1192
1985	788	25.0	745
1986	998	31.6	943
1987	1083	34.3	1023

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1988	1181	37.4	1116
1989	890	28.2	841
1990	1264	40.0	1194
1991	1070	33.9	1011
1992	1144	36.3	1082
1993	1503	47.6	1421
1994	1229	39.0	1162
1995	1241	39.3	1173
1996	1261	39.9	1192
1997	1164	36.9	1100
1998	1327	42.0	1254
1999	1444	45.7	1364
2000	1395	44.2	1319
2001	881	27.9	833
2002	1076	34.1	1017
Mean	1190	37.7	1124

Includes all adjustments as described in Section 7 and Appendix D.

Table E.2
Meelpaeg Adjusted Reference Inflow Sequence
Annual Volume, Flow, and Runoff

Length of Record: 53 years
Plants in Service: 1967 (Bay d'Espoir), 1983 (Upper Salmon)
Area (km^2): 2152

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1950	1575	49.9	732
1951	2279	72.2	1059
1952	2368	75.0	1100
1953	2196	69.6	1020
1954	2537	80.4	1179
1955	1987	62.9	923
1956	2381	75.4	1106
1957	2092	66.3	972
1958	2418	76.6	1124
1959	1807	57.3	840
1960	1627	51.5	756
1961	1614	51.1	750
1962	2581	81.8	1199
1963	2628	83.3	1221
1964	2311	73.2	1074
1965	2192	69.5	1019
1966	1830	58.0	851
1967	2347	74.4	1091
1968	2470	78.3	1148
1969	2742	86.9	1274
1970	2269	71.9	1055
1971	2524	80.0	1173
1972	2516	79.7	1169
1973	2338	74.1	1086
1974	2165	68.6	1006
1975	1944	61.6	903
1976	2557	81.0	1188
1977	2715	86.0	1261
1978	1832	58.1	851
1979	1973	62.5	917
1980	2404	76.2	1117
1981	2736	86.7	1271
1982	2181	69.1	1014
1983	2816	89.2	1309
1984	2582	81.8	1200
1985	1726	54.7	802
1986	2027	64.2	942
1987	1871	59.3	870

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1988	2288	72.5	1063
1989	1766	55.9	820
1990	2350	74.5	1092
1991	2142	67.9	996
1992	2288	72.5	1063
1993	2984	94.6	1387
1994	2379	75.4	1106
1995	2503	79.3	1163
1996	2403	76.1	1117
1997	2384	75.5	1108
1998	2459	77.9	1142
1999	2822	89.4	1311
2000	2864	90.7	1331
2001	1791	56.7	832
2002	1914	60.7	889
Mean	2273	72.0	1056

Includes all adjustments as described in Section 7 and Appendix D.

Table E.3
Upper Salmon Adjusted Reference Inflow Sequence
Annual Volume, Flow, and Runoff

Length of Record: 53 years
Plants in Service: 1967 (Bay d'Espoir), 1983 (Upper Salmon)
Area (km^2): 902

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1950	674	21.3	747
1951	981	31.1	1087
1952	1072	34.0	1188
1953	941	29.8	1044
1954	1120	35.5	1242
1955	875	27.7	970
1956	1059	33.6	1175
1957	841	26.7	933
1958	976	30.9	1082
1959	757	24.0	839
1960	684	21.7	759
1961	647	20.5	717
1962	1197	37.9	1327
1963	1219	38.6	1351
1964	1058	33.5	1173
1965	983	31.2	1090
1966	804	25.5	891
1967	998	31.6	1107
1968	1011	32.0	1121
1969	1101	34.9	1221
1970	1026	32.5	1137
1971	1096	34.7	1216
1972	1093	34.6	1212
1973	1015	32.2	1126
1974	940	29.8	1043
1975	844	26.8	936
1976	1111	35.2	1231
1977	1179	37.4	1307
1978	796	25.2	882
1979	857	27.1	950
1980	1044	33.1	1158
1981	1188	37.7	1318
1982	947	30.0	1050
1983	1208	38.3	1339
1984	1047	33.2	1161
1985	782	24.8	867
1986	892	28.3	989
1987	835	26.5	925
1988	1066	33.8	1182
1989	840	26.6	931
1990	978	31.0	1085
1991	1012	32.1	1122
1992	1080	34.2	1197
1993	1234	39.1	1368
1994	1067	33.8	1183
1995	943	29.9	1045
1996	987	31.3	1094
1997	1063	33.7	1178
1998	999	31.6	1107
1999	1200	38.0	1331
2000	1141	36.2	1265
2001	749	23.7	830
2002	869	27.5	964
Mean	984	31.2	1090

Includes all adjustments as described in Section 7 and Appendix D.

Table E.4
Lower Salmon Adjusted Reference Inflow Sequence
Annual Volume, Flow, and Runoff

Length of Record: 53 years
Plants in Service: 1967 (Bay d'Espoir), 1983 (Upper Salmon)
Area (km^2): 1792

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1950	1147	36.3	640
1951	1670	52.9	932
1952	1825	57.8	1018
1953	1603	50.8	894
1954	1908	60.4	1065
1955	1490	47.2	831
1956	1804	57.2	1007
1957	1433	45.4	799
1958	1662	52.7	928
1959	1289	40.8	719
1960	1165	36.9	650
1961	1101	34.9	614
1962	2037	64.6	1137
1963	2075	65.7	1158
1964	1801	57.1	1005
1965	1674	53.0	934
1966	1369	43.4	764
1967	1700	53.9	949
1968	1722	54.6	961
1969	1875	59.4	1046
1970	1746	55.3	975
1971	1867	59.2	1042
1972	1861	59.0	1038
1973	1729	54.8	965
1974	1601	50.7	894
1975	1437	45.6	802
1976	1891	59.9	1055
1977	2008	63.6	1120
1978	1355	42.9	756
1979	1459	46.2	814
1980	1778	56.3	992
1981	2024	64.1	1129
1982	1613	51.1	900
1983	2098	66.5	1171
1984	1984	62.9	1107
1985	1245	39.4	694
1986	1487	47.1	830
1987	1362	43.2	760
1988	1620	51.3	904
1989	1233	39.1	688
1990	1780	56.4	993
1991	1503	47.6	839
1992	1606	50.9	896
1993	2269	71.9	1266
1994	1726	54.7	963
1995	1995	63.2	1113
1996	1834	58.1	1024
1997	1735	55.0	968
1998	1887	59.8	1053
1999	2112	66.9	1179
2000	2221	70.4	1239
2001	1353	42.9	755
2002	1378	43.7	769
Mean	1682	53.3	939

Includes all adjustments as described in Section 7 and Appendix D.

Table E.5
Combined Meelpaeg and Salmon Basin Adjusted Reference Inflow Sequence Annual Volume, Flow, and Runoff

Length of Record: 53 years
Plants in Service: 1967 (Bay d'Espoir), 1983 (Upper Salmon)
Area (km^2): 4846

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1950	3396	108	701
1951	4929	156	1017
1952	5264	167	1086
1953	4740	150	978
1954	5565	176	1148
1955	4352	138	898
1956	5244	166	1082
1957	4366	138	901
1958	5056	160	1043
1959	3854	122	795
1960	3476	110	717
1961	3361	107	694
1962	5815	184	1200
1963	5921	188	1222
1964	5170	164	1067
1965	4849	154	1001
1966	4004	127	826
1967	5045	160	1041
1968	5203	165	1074
1969	5718	181	1180
1970	5041	160	1040
1971	5488	174	1132
1972	5469	173	1129
1973	5082	161	1049
1974	4707	149	971
1975	4225	134	872
1976	5559	176	1147
1977	5902	187	1218
1978	3983	126	822
1979	4288	136	885
1980	5226	166	1079
1981	5948	188	1227
1982	4742	150	979
1983	6122	194	1263
1984	5614	178	1158
1985	3752	119	774
1986	4406	140	909
1987	4068	129	839

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1988	4975	158	1027
1989	3838	122	792
1990	5108	162	1054
1991	4657	148	961
1992	4973	158	1026
1993	6487	206	1339
1994	5172	164	1067
1995	5441	172	1123
1996	5224	166	1078
1997	5182	164	1069
1998	5345	169	1103
1999	6134	194	1266
2000	6226	197	1285
2001	3893	123	803
2002	4161	132	859
Mean	4939	157	1019

Includes all adjustments as described in Section 7 and Appendix D.

Table E.6

Total Bay d'Espoir System Adjusted Reference Inflow Sequence
Annual Volume, Flow, and Runoff

Length of Record: 53 years
Plants in Service: 1967 (Bay d'Espoir), 1983 (Upper Salmon)
Area (km^2): 5904

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1950	4268	135	723
1951	6164	195	1044
1952	6408	203	1085
1953	5870	186	994
1954	6849	217	1160
1955	5419	172	918
1956	6408	203	1085
1957	5639	179	955
1958	6427	204	1089
1959	4888	155	828
1960	4450	141	754
1961	4292	136	727
1962	7057	224	1195
1963	7212	229	1222
1964	6321	200	1071
1965	5865	186	993
1966	4996	158	846
1967	6185	196	1048
1968	6454	205	1093
1969	7177	227	1216
1970	6177	196	1046
1971	6883	218	1166
1972	6936	220	1175
1973	6258	198	1060
1974	5785	183	980
1975	5291	168	896
1976	6838	217	1158
1977	7489	237	1268
1978	5033	159	853
1979	5526	175	936
1980	6473	205	1096
1981	7464	237	1264
1982	5864	186	993
1983	7589	240	1285
1984	6875	218	1164
1985	4540	144	769
1986	5404	171	915
1987	5151	163	872

Year	Volume 10^6 m^3	Flow m^3/s	Runoff mm
1988	6156	195	1043
1989	4728	150	801
1990	6372	202	1079
1991	5727	181	970
1992	6118	194	1036
1993	7991	253	1353
1994	6401	203	1084
1995	6682	212	1132
1996	6485	205	1098
1997	6345	201	1075
1998	6672	211	1130
1999	7578	240	1284
2000	7621	241	1291
2001	4774	151	809
2002	5237	166	887
Mean	6129	194	1038

Includes all adjustments as described in Section 7 and Appendix D.

Appendix F – Adjusted Reference Monthly Inflow Sequences

Table F.1

Victoria Adjusted Reference Inflow Sequence

Monthly Volumes ($m^3 \times 10^6$)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1950	64.78	36.03	34.51	118.36	280.00	85.06	29.49	29.49	19.37	26.34	67.20	81.43	872
1951	71.44	110.49	79.01	233.99	113.82	75.38	69.32	73.26	59.03	69.32	185.87	94.15	1235
1952	70.83	83.85	46.01	97.47	319.96	142.57	71.74	37.23	17.55	37.84	155.29	63.87	1144
1953	110.18	63.57	46.92	225.22	109.27	115.33	55.10	48.13	64.78	111.09	77.49	102.61	1130
1954	84.76	83.85	147.73	116.24	210.99	65.69	39.96	113.82	23.00	96.26	146.21	155.89	1284
1955	82.04	59.03	39.96	88.09	205.84	104.13	28.76	87.79	105.34	117.45	88.99	59.63	1067
1956	180.42	39.66	27.25	98.38	260.32	161.64	50.25	42.08	58.72	47.53	87.79	109.27	1163
1957	81.43	34.51	41.17	41.78	260.32	148.63	84.45	60.54	100.50	142.27	80.22	196.46	1272
1958	100.81	47.53	77.19	119.27	162.85	94.15	87.49	117.15	161.64	130.16	181.01	91.72	1371
1959	39.96	36.32	26.34	107.77	259.72	111.09	33.90	30.57	65.99	77.19	109.27	135.91	1034
1960	41.47	63.57	26.64	104.13	286.96	88.09	36.03	12.71	30.87	117.15	100.20	66.60	974
1961	32.39	12.11	13.62	44.19	263.96	179.21	41.47	22.10	32.39	105.65	107.16	76.58	931
1962	46.01	40.87	36.03	195.24	240.65	125.32	82.33	68.42	33.30	91.72	206.74	75.67	1242
1963	137.43	59.63	30.27	111.70	319.96	131.38	89.90	31.48	61.15	63.26	133.50	121.68	1291
1964	28.15	32.39	45.10	154.98	281.82	161.64	110.49	40.26	49.04	92.63	87.18	67.51	1151
1965	52.67	15.14	112.91	34.81	204.63	183.74	42.08	27.25	24.52	99.59	140.76	77.79	1016
1966	33.60	24.21	38.14	100.81	197.06	124.72	40.26	58.12	56.91	87.78	123.18	107.04	992
1967	57.77	31.15	26.62	26.05	282.89	68.81	28.60	112.98	35.40	98.08	204.03	167.10	1139
1968	103.98	102.52	96.09	98.05	133.92	159.59	55.23	70.42	58.56	91.15	111.72	170.12	1251
1969	78.64	158.72	61.20	102.66	334.31	73.04	18.43	43.11	45.07	80.94	227.04	235.27	1458
1970	69.51	40.80	34.55	76.99	269.69	78.97	78.97	86.53	131.28	85.88	141.28	41.46	1136
1971	48.64	120.35	104.77	342.63	171.32	37.38	67.96	104.21	60.60	76.17	179.53	81.84	1395
1972	50.97	37.94	144.70	87.22	293.93	247.77	39.08	20.95	43.61	249.75	158.86	92.31	1467
1973	47.01	89.76	39.08	103.36	284.87	75.61	68.53	116.95	14.44	70.79	111.57	154.61	1177
1974	40.78	37.38	66.26	128.28	239.84	83.53	33.98	44.17	49.27	150.93	82.40	121.76	1079
1975	39.08	17.84	75.32	105.34	271.56	35.11	22.94	18.97	54.65	91.46	142.43	191.14	1066
1976	123.18	98.54	60.03	195.67	189.16	35.96	33.70	25.20	67.11	131.96	115.82	202.18	1279
1977	137.05	57.48	47.57	177.26	291.66	93.45	53.24	88.07	60.60	185.48	180.38	215.21	1587
1978	197.65	36.25	66.26	110.72	284.02	102.22	56.07	21.80	26.33	44.74	45.59	58.62	1050
1979	154.89	64.85	298.18	79.29	105.62	50.12	38.51	39.64	52.39	112.70	127.14	114.40	1238
1980	94.58	20.67	40.78	185.76	199.92	76.46	127.43	74.19	79.57	116.38	158.86	72.21	1247
1981	118.93	103.92	95.76	209.91	202.54	88.24	77.30	87.30	27.81	159.34	156.11	188.14	1515
1982	47.06	37.22	41.80	149.84	391.93	78.11	60.73	30.70	63.40	75.05	67.29	78.77	1122
1983	221.68	79.65	162.82	240.17	92.48	63.93	59.81	189.88	78.48	44.56	131.00	102.22	1467
1984	77.17	117.67	76.57	139.83	280.90	130.45	57.49	107.55	92.92	41.05	57.63	82.01	1261
1985	11.77	2.06	20.32	65.21	292.90	189.22	31.97	28.01	57.63	3.46	28.04	57.25	788
1986	230.10	71.68	32.44	311.63	47.26	78.53	27.00	0.56	53.78	62.90	39.39	42.75	998
1987	59.59	24.20	102.18	335.72	142.48	28.77	5.88	3.53	-12.69	117.34	208.98	66.70	1083
1988	7.18	58.42	150.70	175.36	257.77	122.56	60.43	27.52	36.73	84.66	133.19	66.46	1181
1989	33.79	27.89	34.19	121.49	190.28	29.68	18.08	50.52	71.59	117.82	156.69	38.26	890
1990	40.69	42.00	-6.04	332.05	284.96	60.84	30.10	36.63	22.01	105.30	100.89	214.08	1264
1991	39.73	47.80	71.79	123.88	224.27	76.78	43.54	34.57	68.55	152.16	132.19	54.63	1070
1992	44.79	15.01	59.82	149.74	320.58	122.24	20.85	110.07	62.92	100.48	58.54	79.45	1144
1993	37.97	57.62	55.92	233.77	318.08	71.49	72.16	95.81	36.08	139.01	138.93	246.24	1503
1994	85.23	45.35	85.93	263.65	339.25	86.13	34.81	-3.87	53.28	44.23	136.47	58.83	1229
1995	108.04	38.63	86.15	142.48	194.37	93.23	77.04	78.35	72.49	76.28	168.71	105.65	1241
1996	100.50	238.82	125.06	85.90	119.55	67.70	113.05	37.34	46.23	98.75	63.03	164.75	1261
1997	121.43	99.72	21.96	108.47	314.53	95.51	49.10	41.76	80.78	84.57	104.66	41.25	1164
1998	78.02	99.57	212.24	188.80	186.48	43.38	72.15	56.40	133.35	82.10	107.59	66.87	1327
1999	138.80	171.03	165.37	182.21	180.09	21.52	17.18	119.47	87.75	117.57	111.92	130.72	1444
2000	136.35	79.85	120.04	247.99	179.46	51.42	71.84	55.92	32.31	154.26	142.52	123.29	1395
2001	34.92	37.12	26.86	106.27	235.49	58.53	58.22	25.58	60.99	45.24	118.42	73.42	881
2002	42.02	38.20	142.83	138.61	193.60	61.90	22.40	73.51	109.62	59.16	135.80	58.47	1076

Includes all adjustments as described in Section 7 and Appendix D.

Table F.2
Meelpaeg Adjusted Reference Inflow Sequence
Monthly Volumes ($m^3 \times 10^6$)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1950	111.96	69.21	52.63	212.29	619.72	140.18	50.34	50.34	34.31	38.96	64.86	130.57	1575
1951	179.73	262.02	171.87	391.43	203.57	94.23	83.75	180.60	88.99	86.66	317.57	218.11	2279
1952	202.99	252.43	137.27	206.77	575.81	195.14	101.79	72.13	50.89	52.35	317.57	202.41	2368
1953	156.17	224.80	106.15	423.42	214.33	222.18	85.50	65.73	73.57	189.03	180.01	255.05	2196
1954	151.80	202.70	339.08	209.10	329.20	165.47	102.66	182.63	63.98	110.22	282.67	397.54	2537
1955	257.95	121.85	146.86	167.80	275.40	199.49	83.75	109.93	96.85	150.05	228.58	148.02	1987
1956	360.90	125.05	83.75	249.52	518.81	258.54	127.08	87.53	63.11	66.02	159.66	280.93	2381
1957	195.14	85.50	85.79	127.08	367.88	154.13	65.73	95.68	172.74	209.10	184.66	348.97	2092
1958	230.61	129.12	162.56	170.42	220.44	140.18	152.67	153.55	249.81	223.64	326.00	258.82	2418
1959	80.26	84.05	67.47	245.44	376.03	125.63	61.65	50.60	77.94	77.94	253.01	307.39	1807
1960	114.00	125.05	100.63	143.95	435.35	122.14	69.51	36.36	47.69	124.76	181.76	125.35	1627
1961	98.88	37.80	48.28	143.67	562.72	243.41	60.78	27.91	23.56	84.62	139.59	142.79	1614
1962	93.64	132.03	127.38	453.09	416.74	225.96	135.52	106.73	65.73	162.56	453.96	207.94	2581
1963	435.93	134.35	66.89	201.83	593.84	193.39	106.44	91.02	184.09	169.83	192.52	257.37	2628
1964	84.05	94.80	95.97	357.41	425.17	214.04	190.78	114.29	103.23	275.40	195.72	159.94	2311
1965	138.72	59.03	372.82	106.73	457.45	263.48	89.28	55.84	51.19	152.67	278.60	166.06	2192
1966	78.23	54.38	70.96	199.79	320.76	194.84	96.55	120.40	103.53	168.67	197.17	225.09	1830
1967	134.35	72.41	83.46	90.15	621.76	139.59	54.09	151.23	88.40	183.22	426.91	301.58	2347
1968	156.03	197.65	214.36	219.17	197.65	249.19	233.33	147.81	137.62	138.75	296.19	282.32	2470
1969	154.04	532.07	103.64	169.33	546.23	98.26	24.07	45.87	41.06	134.51	365.00	527.83	2742
1970	106.44	79.44	143.23	157.31	379.99	129.53	198.80	229.72	117.40	90.40	314.64	322.46	2269
1971	55.36	234.08	157.74	663.01	322.26	36.47	121.27	124.79	129.21	106.94	363.16	210.11	2524
1972	113.85	82.97	247.75	238.37	506.44	285.14	192.79	-0.65	51.58	286.05	273.80	237.85	2516
1973	113.07	218.31	76.20	252.44	440.14	220.00	106.68	150.06	84.15	178.45	220.92	277.19	2338
1974	99.65	65.65	162.82	401.06	380.88	205.68	28.00	5.99	95.35	288.78	122.05	309.23	2165
1975	1.04	13.55	144.45	265.59	500.58	-24.36	49.36	21.49	67.60	170.77	345.31	388.30	1944
1976	283.57	231.21	149.53	445.61	286.17	134.69	-39.60	0.00	264.68	289.30	170.12	342.06	2557
1977	269.50	172.85	127.53	330.73	339.32	229.52	77.24	138.59	95.22	344.14	199.29	390.77	2715
1978	380.35	123.49	131.43	304.41	334.24	243.32	65.13	-29.31	-3.65	121.14	-7.95	169.60	1832
1979	295.30	82.20	517.12	62.00	150.06	23.71	62.91	91.31	130.65	179.63	232.12	145.50	1973
1980	103.03	50.15	152.01	411.48	374.36	233.42	213.36	148.23	145.36	169.60	252.18	150.97	2404
1981	285.27	223.66	238.26	263.77	449.90	120.69	81.24	121.56	175.10	349.32	218.32	209.10	2736
1982	123.51	63.60	127.19	374.80	516.41	141.73	147.99	21.59	110.69	106.33	229.98	217.50	2181
1983	572.44	129.21	396.82	375.58	215.30	112.12	156.15	281.96	119.98	100.70	201.94	153.99	2816
1984	250.87	349.38	182.38	288.89	559.46	217.76	73.61	200.59	172.12	49.38	74.16	163.66	2582
1985	48.86	55.10	106.00	196.12	441.31	456.35	174.22	-13.06	80.88	13.17	50.37	116.78	1726
1986	343.01	194.15	92.95	608.55	155.16	91.27	53.75	10.84	86.82	156.76	116.09	117.26	2027
1987	71.01	61.97	133.65	590.68	262.14	81.79	6.34	-21.90	12.57	111.38	358.28	203.38	1871
1988	60.97	185.45	359.34	418.15	329.77	241.81	131.36	41.32	11.61	106.04	270.72	131.95	2288
1989	112.18	87.43	105.38	304.01	321.27	97.31	40.94	76.21	130.50	191.07	207.20	92.06	1766
1990	110.22	95.45	78.13	603.78	432.57	158.80	68.89	-25.33	35.36	201.67	242.30	347.93	2350
1991	119.49	126.12	228.56	269.73	411.60	147.98	23.84	4.35	160.35	234.35	330.86	85.09	2142
1992	113.41	74.09	325.97	298.04	464.05	285.81	100.21	21.54	100.44	191.94	131.51	180.71	2288
1993	90.65	186.25	172.23	430.26	513.53	174.19	148.06	172.55	40.49	237.25	325.47	493.29	2984
1994	230.84	102.42	286.90	494.14	477.16	187.13	110.34	40.84	93.67	84.80	182.90	88.00	2379
1995	263.74	83.72	195.64	348.57	359.86	154.99	92.91	80.73	156.24	169.40	365.03	231.84	2503
1996	165.89	408.60	293.38	181.84	160.28	84.64	262.54	77.77	133.01	193.05	131.49	310.55	2403
1997	278.67	178.80	66.73	227.47	516.14	206.20	100.65	74.94	246.16	148.91	224.90	113.95	2384
1998	100.65	125.50	370.54	494.71	325.13	103.21	131.85	62.51	235.85	137.00	191.53	180.04	2459
1999	292.50	424.27	379.17	347.80	254.05	103.27	46.62	123.41	170.73	234.47	199.04	246.45	2822
2000	293.19	215.71	305.99	371.68	280.66	124.95	197.70	107.97	35.82	369.60	327.51	232.96	2864
2001	89.99	40.16	86.69	270.02	449.70	202.80	105.66	14.05	77.74	76.53	224.72	152.54	1791
2002	111.20	132.06	299.76	311.79	242.13	113.16	23.77	72.86	126.04	92.55	248.23	140.66	1914

Includes all adjustments as described in Section 7 and Appendix D.

Table F.3

Upper Salmon Adjusted Reference Inflow Sequence

Monthly Volumes (m^3 x 10^6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1950	50.81	31.43	20.43	90.21	289.07	60.04	22.84	19.28	10.06	11.10	14.15	54.17	674
1951	94.82	125.41	82.77	148.57	86.75	32.90	26.82	90.94	35.62	29.76	121.64	104.67	981
1952	117.03	132.33	74.60	96.91	224.53	67.58	38.98	31.75	23.89	17.08	138.20	108.86	1072
1953	58.67	97.34	52.18	172.46	94.82	98.06	33.63	22.42	22.00	78.06	89.06	122.58	941
1954	66.74	100.90	156.32	88.53	117.35	84.97	54.69	72.92	31.22	35.31	121.12	190.27	1120
1955	134.42	59.30	83.92	74.91	86.12	92.30	43.79	37.61	21.48	50.81	114.31	76.06	875
1956	152.13	71.98	44.63	122.69	217.51	96.39	65.69	40.97	17.08	23.15	70.62	136.62	1059
1957	94.82	43.90	40.13	69.25	118.19	38.87	19.59	39.60	73.03	75.75	91.26	136.94	841
1958	107.71	69.46	77.11	63.49	73.23	57.83	66.22	53.01	88.85	81.41	120.07	117.87	976
1959	36.25	41.07	33.95	118.91	116.51	42.33	24.52	23.89	26.30	24.20	135.26	133.90	757
1960	55.53	66.11	58.05	76.06	150.14	49.66	36.77	15.19	7.86	24.62	83.08	61.19	684
1961	49.35	18.34	28.39	94.51	232.91	69.78	20.33	8.07	4.08	7.54	44.22	69.05	647
1962	52.18	86.96	86.75	256.90	141.13	90.21	51.03	38.76	29.86	70.20	191.21	101.32	1197
1963	221.17	70.51	31.75	124.89	232.38	84.45	46.62	38.14	84.24	83.92	74.70	125.73	1219
1964	41.49	58.78	51.97	173.81	165.02	80.15	80.78	47.67	48.61	113.36	118.91	77.22	1058
1965	79.73	44.32	101.00	106.45	189.43	110.53	40.44	22.42	19.80	41.28	144.48	83.29	983
1966	40.97	28.92	31.43	126.04	119.23	61.40	47.46	45.47	47.25	57.83	57.83	140.29	804
1967	81.09	38.76	52.81	36.98	281.42	76.49	25.77	12.57	17.50	51.97	179.79	143.12	998
1968	83.29	87.49	127.30	96.39	109.70	91.78	52.81	26.20	70.30	39.60	94.92	131.28	1011
1969	53.43	214.05	92.83	119.34	115.35	80.25	12.47	-4.61	35.41	65.69	93.98	223.06	1101
1970	83.82	42.85	67.06	141.03	150.24	22.10	68.73	111.37	72.08	-15.19	109.80	171.72	1026
1971	24.05	101.67	68.52	287.98	139.97	15.84	52.67	54.20	56.12	46.45	157.74	91.26	1096
1972	49.45	36.04	107.61	103.54	219.97	123.85	83.74	-0.28	22.40	124.24	118.92	103.31	1093
1973	49.11	94.82	33.10	109.65	191.17	95.56	46.34	65.18	36.55	77.51	95.95	120.40	1015
1974	43.28	28.51	70.72	174.20	165.43	89.33	12.16	2.60	41.42	125.43	53.01	134.31	940
1975	0.45	5.88	62.74	115.36	217.43	-10.58	21.44	9.33	29.36	74.17	149.99	168.66	844
1976	123.17	100.42	64.95	193.55	124.30	58.50	-17.20	0.00	114.96	125.66	73.89	148.57	1111
1977	117.06	75.08	55.39	143.65	147.38	99.69	33.55	60.20	41.36	149.48	86.56	169.73	1179
1978	165.20	53.64	57.08	132.22	145.18	105.69	28.29	-12.73	-1.58	52.62	-3.45	73.66	796
1979	128.26	35.70	224.61	26.93	65.18	10.30	27.33	39.66	56.75	78.02	100.82	63.20	857
1980	44.75	21.78	66.03	178.73	162.60	101.39	92.67	64.38	63.14	73.66	109.53	65.57	1044
1981	123.91	97.14	103.49	114.57	195.41	52.42	35.28	52.80	76.06	151.73	94.83	90.82	1188
1982	53.65	27.62	55.24	162.80	224.30	61.56	64.28	9.38	48.08	46.19	99.89	94.47	947
1983	179.28	86.27	100.84	204.17	114.55	75.84	66.08	58.30	66.66	100.37	99.43	55.89	1208
1984	84.95	123.87	77.60	92.50	243.61	125.38	48.18	47.16	75.20	18.04	52.51	57.90	1047
1985	29.60	47.12	49.97	76.18	166.09	234.43	42.54	10.71	10.56	29.89	25.15	59.51	782
1986	119.49	105.01	43.71	154.28	154.97	41.44	9.01	26.03	36.51	87.47	47.64	66.30	892
1987	22.67	-8.68	17.08	192.97	190.95	76.01	-4.08	36.39	26.82	43.25	118.66	122.67	835
1988	28.08	56.48	106.00	133.79	210.67	127.04	90.35	40.40	16.68	39.58	116.81	100.47	1066
1989	51.32	46.26	36.65	62.82	194.71	83.06	18.47	35.97	29.26	104.90	99.10	77.42	840
1990	51.97	19.42	31.00	142.51	267.75	111.27	28.43	19.48	12.37	57.75	103.36	133.07	978
1991	114.46	29.07	38.14	76.79	214.44	136.44	31.01	30.47	80.53	70.12	118.30	72.20	1012
1992	53.63	67.65	61.01	118.66	214.57	161.13	70.75	61.29	26.23	69.48	93.20	82.37	1080
1993	53.86	29.37	64.61	49.84	287.44	132.71	67.65	93.71	22.50	85.68	138.11	208.32	1234
1994	132.59	36.99	83.20	143.80	239.40	123.44	94.03	52.39	43.75	23.61	41.22	52.79	1067
1995	102.88	35.32	-2.08	59.83	231.07	103.35	65.24	34.74	29.93	55.10	139.63	87.70	943
1996	67.52	155.30	145.86	81.96	68.16	40.76	93.76	60.01	38.77	82.69	27.04	124.96	987
1997	94.17	134.76	30.00	40.84	228.86	143.67	70.01	15.40	88.47	94.44	80.79	41.41	1063
1998	21.09	27.16	185.22	127.47	201.64	46.93	66.44	24.29	87.94	72.40	82.23	55.88	999
1999	123.65	129.69	137.44	129.14	122.21	51.15	32.06	82.62	82.88	86.62	83.30	139.60	1200
2000	83.80	118.71	111.87	184.42	160.99	90.47	38.47	37.79	-0.85	94.46	152.00	69.02	1141
2001	80.31	24.58	35.85	1.74	207.63	142.35	27.34	20.09	24.57	77.80	38.79	67.94	749
2002	40.40	8.78	99.08	143.52	155.22	95.48	5.68	37.94	112.99	40.73	76.39	53.19	869

Includes all adjustments as described in Section 7 and Appendix D.

Table F.4

Lower Salmon Adjusted Reference Inflow Sequence

Monthly Volumes ($m^3 \times 10^6$)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1950	86.52	53.52	34.79	153.60	492.19	102.22	38.89	32.83	17.12	18.91	24.08	92.23	1147
1951	161.45	213.54	140.93	252.97	147.72	56.01	45.67	154.85	60.66	50.66	207.12	178.21	1670
1952	199.27	225.31	127.02	165.02	382.30	115.06	66.36	54.05	40.67	29.07	235.31	185.35	1825
1953	99.91	165.73	88.84	293.64	161.45	166.98	57.26	38.18	37.46	132.90	151.63	208.73	1603
1954	113.63	171.79	266.16	150.75	199.80	144.68	93.12	124.17	53.17	60.12	206.23	323.97	1908
1955	228.88	100.97	142.90	127.56	146.64	157.17	74.57	64.05	36.57	86.52	194.63	129.52	1490
1956	259.03	122.56	76.00	208.90	370.35	164.13	111.86	69.75	29.07	39.43	120.24	232.63	1804
1957	161.45	74.74	68.33	117.92	201.23	66.18	33.36	67.44	124.34	128.98	155.38	233.16	1433
1958	183.39	118.28	131.30	108.11	124.70	98.48	112.74	90.27	151.28	138.61	204.44	200.69	1662
1959	61.73	69.94	57.80	202.48	198.37	72.07	41.74	40.67	44.78	41.21	230.31	227.99	1289
1960	94.55	112.57	98.83	129.52	255.64	84.56	62.62	25.87	13.38	41.92	141.47	104.18	1165
1961	84.02	31.22	48.35	160.91	396.57	118.81	34.61	13.73	6.96	12.85	75.29	117.56	1101
1962	88.84	148.07	147.72	437.43	240.30	153.60	86.88	66.01	50.84	119.52	325.58	172.51	2037
1963	376.60	120.06	54.05	212.64	395.68	143.79	79.39	64.94	143.43	142.90	127.20	214.07	2075
1964	70.64	100.08	88.49	295.96	280.97	136.47	137.55	81.17	82.78	193.03	202.48	131.47	1801
1965	135.76	75.46	171.97	181.25	322.54	188.21	68.86	38.18	33.72	70.29	246.01	141.83	1674
1966	69.75	49.23	53.52	214.61	203.02	104.54	80.81	77.43	80.46	98.48	98.48	238.87	1369
1967	138.08	66.01	89.91	62.97	479.17	130.23	43.89	21.41	29.79	88.49	306.13	243.69	1700
1968	141.83	148.96	216.75	164.13	186.78	156.28	89.91	44.60	119.70	67.44	161.63	223.53	1722
1969	90.98	364.47	158.06	203.19	196.42	136.65	21.23	-7.85	60.30	111.86	160.02	379.81	1875
1970	142.72	72.96	114.17	240.12	255.82	37.64	117.03	189.64	122.74	-25.87	186.96	292.39	1746
1971	40.94	173.11	116.66	490.34	238.33	26.97	89.69	92.29	95.56	79.09	268.58	155.39	1867
1972	84.20	61.37	183.22	176.29	374.55	210.88	142.58	-0.48	38.15	211.55	202.49	175.90	1861
1973	83.62	161.46	56.36	186.69	325.51	162.71	78.90	110.98	62.23	131.98	163.38	205.00	1729
1974	73.69	48.55	120.42	296.61	281.68	152.11	20.71	4.43	70.52	213.57	90.26	228.70	1601
1975	0.77	10.02	106.83	196.42	370.21	-18.01	36.51	15.89	50.00	126.29	255.38	287.17	1437
1976	209.72	170.99	110.59	329.56	211.64	99.61	-29.28	0.00	195.75	213.96	125.81	252.97	1891
1977	199.32	127.83	94.31	244.59	250.95	169.74	57.13	102.50	70.42	254.52	147.39	289.00	2008
1978	281.29	91.33	97.20	225.13	247.19	179.95	48.17	-21.67	-2.70	89.59	-5.88	125.43	1355
1979	218.39	60.79	382.45	45.85	110.98	17.53	46.53	67.53	96.62	132.84	171.67	107.61	1459
1980	76.20	37.09	112.42	304.32	276.86	172.63	157.79	109.63	107.51	125.43	186.50	111.65	1778
1981	210.98	165.41	176.21	195.07	332.73	89.25	60.08	89.90	129.50	258.35	161.46	154.64	2024
1982	91.34	47.04	94.06	277.19	381.92	104.82	109.45	15.97	81.86	78.64	170.08	160.85	1613
1983	492.71	65.41	365.00	236.73	138.19	55.78	117.23	272.69	74.19	17.84	137.62	124.88	2098
1984	209.54	286.28	136.49	246.64	413.14	130.26	38.23	188.31	126.86	39.93	34.55	134.22	1984
1985	27.75	17.56	74.47	154.04	351.98	301.29	161.97	-26.05	84.38	-14.44	33.98	77.59	1245
1986	283.17	122.90	65.41	560.11	27.18	65.70	54.09	-13.31	65.41	96.56	88.63	71.36	1487
1987	60.70	81.42	139.81	500.44	116.78	20.01	11.52	-62.09	-12.07	87.50	301.92	116.08	1362
1988	43.50	161.22	315.83	357.08	176.46	156.83	63.86	8.10	-3.06	84.91	200.99	54.42	1620
1989	80.37	56.38	87.05	294.06	182.43	31.18	29.58	53.49	123.94	119.39	144.14	30.66	1233
1990	77.42	92.63	60.71	566.28	240.04	75.15	52.45	-49.21	29.14	178.99	181.07	275.38	1780
1991	25.82	118.99	230.18	239.86	268.74	37.27	-3.03	-25.36	107.70	204.99	270.10	27.68	1503
1992	79.50	19.33	321.65	231.22	330.19	174.39	46.88	-36.00	91.67	155.84	61.19	129.77	1606
1993	52.56	189.28	137.58	455.24	315.41	71.78	106.16	108.84	25.03	192.84	243.96	370.75	2269
1994	138.39	83.24	253.59	436.27	320.75	96.23	35.51	-4.44	66.22	75.94	173.48	50.52	1726
1995	206.72	62.97	231.74	349.36	191.38	78.60	43.83	60.04	153.49	143.76	288.89	184.46	1995
1996	127.23	324.36	198.54	131.50	119.99	58.60	214.44	31.28	117.37	143.94	127.31	239.60	1834
1997	232.97	75.13	48.33	226.18	377.05	98.39	48.14	72.58	200.50	80.37	183.23	92.36	1735
1998	97.07	120.17	249.76	453.28	180.03	74.23	88.35	49.09	188.93	88.42	142.60	155.48	1887
1999	219.72	368.37	307.68	279.14	176.02	70.09	22.67	62.25	117.54	188.62	150.35	149.72	2112
2000	260.39	134.51	247.33	251.89	168.48	56.22	193.62	88.95	42.89	339.41	232.46	204.46	2221
2001	25.32	22.56	65.91	315.24	320.28	95.73	96.70	-3.60	66.68	12.03	225.02	111.13	1353
2002	90.14	146.24	252.82	222.50	129.01	37.35	22.22	47.59	34.98	67.91	215.00	111.94	1378

Includes all adjustments as described in Section 7 and Appendix D.

Table F.5

Combined Meelpaeg and Salmon Basin Adjusted Reference Inflow Sequence

Monthly Volumes ($m^3 \times 10^6$)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1950	249	154	108	456	1401	302	112	102	61	69	103	277	3396
1951	436	601	396	793	438	183	156	426	185	167	646	501	4929
1952	519	610	339	469	1183	378	207	158	115	98	691	497	5264
1953	315	488	247	890	471	487	176	126	133	400	421	586	4740
1954	332	475	762	448	646	395	250	380	148	206	610	912	5565
1955	621	282	374	370	508	449	202	212	155	287	538	354	4352
1956	772	320	204	581	1107	519	305	198	109	129	351	650	5244
1957	451	204	194	314	687	259	119	203	370	414	431	719	4366
1958	522	317	371	342	418	296	332	297	490	444	651	577	5056
1959	178	195	159	567	691	240	128	115	149	143	619	669	3854
1960	264	304	258	350	841	256	169	77	69	191	406	291	3476
1961	232	87	125	399	1192	432	116	50	35	105	259	329	3361
1962	235	367	362	1147	798	470	273	211	146	352	971	482	5815
1963	1034	325	153	539	1222	422	232	194	412	397	394	597	5921
1964	196	254	236	827	871	431	409	243	235	582	517	369	5170
1965	354	179	646	394	969	562	199	116	105	264	669	391	4849
1966	189	133	156	540	643	361	225	243	231	325	353	604	4004
1967	354	177	226	190	1382	346	124	185	136	324	913	688	5045
1968	381	434	558	480	494	497	376	219	328	246	553	637	5203
1969	298	1111	355	492	858	315	58	33	137	312	619	1131	5718
1970	333	195	324	538	786	189	385	531	312	49	611	787	5041
1971	120	509	343	1441	701	79	264	271	281	232	789	457	5488
1972	247	180	539	518	1101	620	419	-1	112	622	595	517	5469
1973	246	475	166	549	957	478	232	326	183	388	480	603	5082
1974	217	143	354	872	828	447	61	13	207	628	265	672	4707
1975	2	29	314	577	1088	-53	107	47	147	371	751	844	4225
1976	616	503	325	969	622	293	-86	0	575	629	370	744	5559
1977	586	376	277	719	738	499	168	301	207	748	433	850	5902
1978	827	268	286	662	727	529	142	-64	-8	263	-17	369	3983
1979	642	179	1124	135	326	52	137	199	284	390	505	316	4288
1980	224	109	330	895	814	507	464	322	316	369	548	328	5226
1981	620	486	518	573	978	262	177	264	381	759	475	455	5948
1982	269	138	276	815	1123	308	322	47	241	231	500	473	4742
1983	1244	281	863	816	468	244	339	613	261	219	439	335	6122
1984	545	760	396	628	1216	473	160	436	374	107	161	356	5614
1985	106	120	230	426	959	992	379	-28	176	29	110	254	3752
1986	746	422	202	1323	337	198	117	24	189	341	252	255	4406
1987	154	135	291	1284	570	178	14	-48	27	242	779	442	4068
1988	133	403	781	909	717	526	286	90	25	231	589	287	4975
1989	244	190	229	661	698	212	89	166	284	415	450	200	3838
1990	240	208	170	1313	940	345	150	-55	77	438	527	756	5108
1991	260	274	497	586	895	322	52	9	349	509	719	185	4657
1992	247	161	709	648	1009	621	218	47	218	417	286	393	4973
1993	197	405	374	935	1116	379	322	375	88	516	708	1072	6487
1994	502	223	624	1074	1037	407	240	89	204	184	398	191	5172
1995	573	182	425	758	782	337	202	176	340	368	794	504	5441
1996	361	888	638	395	348	184	571	169	289	420	286	675	5224
1997	606	389	145	494	1122	448	219	163	535	324	489	248	5182
1998	219	273	806	1075	707	224	287	136	513	298	416	391	5345
1999	636	922	824	756	552	225	101	268	371	510	433	536	6134
2000	637	469	665	808	610	272	430	235	78	803	712	506	6226
2001	196	87	188	587	978	441	230	31	169	166	489	332	3893
2002	242	287	652	678	526	246	52	158	274	201	540	306	4161

Includes all adjustments as described in Section 7 and Appendix D.

Table F.6

Total Bay d'Espoir System Adjusted Reference Inflow Sequence

Monthly Volumes (m^3 x 10^6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1950	314	190	142	574	1681	387	142	132	81	95	170	358	4268
1951	507	711	475	1027	552	259	226	500	244	236	832	595	6164
1952	590	694	385	566	1503	520	279	195	133	136	846	560	6408
1953	425	551	294	1115	580	603	231	174	198	511	498	689	5870
1954	417	559	909	565	857	461	290	494	171	302	756	1068	6849
1955	703	341	414	458	714	553	231	299	260	405	627	413	5419
1956	952	359	232	679	1367	681	355	240	168	176	438	759	6408
1957	533	239	235	356	948	408	203	263	471	556	512	916	5639
1958	623	364	448	461	581	391	419	414	652	574	832	669	6427
1959	218	231	186	675	951	351	162	146	215	221	728	805	4888
1960	306	367	284	454	1128	344	205	90	100	308	507	357	4450
1961	265	99	139	443	1456	611	157	72	67	211	366	406	4292
1962	281	408	398	1343	1039	595	356	280	180	444	1177	557	7057
1963	1171	385	183	651	1542	553	322	226	473	460	528	719	7212
1964	224	286	282	982	1153	592	520	283	284	674	604	436	6321
1965	407	194	759	429	1174	746	241	144	129	364	810	469	5865
1966	223	157	194	641	840	486	265	301	288	413	477	711	4996
1967	411	208	253	216	1665	415	152	298	171	422	1117	855	6185
1968	485	537	654	578	628	657	431	289	386	337	664	807	6454
1969	377	1269	416	595	1192	388	76	77	182	393	846	1366	7177
1970	402	236	359	615	1056	268	464	617	444	135	753	828	6177
1971	169	629	448	1784	872	117	332	375	342	309	969	539	6883
1972	298	218	683	605	1395	868	458	20	156	872	754	609	6936
1973	293	564	205	652	1242	554	300	443	197	459	592	757	6258
1974	257	180	420	1000	1068	531	95	57	257	779	348	794	5785
1975	41	47	389	683	1360	-18	130	66	202	463	893	1035	5291
1976	740	601	385	1164	811	329	-52	25	643	761	486	946	6838
1977	723	433	325	896	1029	592	221	389	268	934	614	1065	7489
1978	1025	305	352	772	1011	631	198	-42	18	308	28	427	5033
1979	797	244	1422	214	432	102	175	238	336	503	632	431	5526
1980	319	130	371	1080	1014	584	591	396	396	485	707	400	6473
1981	739	590	614	783	1181	351	254	352	408	919	631	643	7464
1982	316	175	318	965	1515	386	382	78	304	306	567	552	5864
1983	1466	361	1025	1057	561	308	399	803	339	263	570	437	7589
1984	623	877	473	768	1497	604	218	544	467	148	219	438	6875
1985	118	122	251	492	1252	1181	411	0	233	32	138	311	4540
1986	976	494	235	1635	385	277	144	24	243	404	292	298	5404
1987	214	159	393	1620	712	207	20	-44	15	359	988	509	5151
1988	140	462	932	1084	975	648	346	117	62	315	722	353	6156
1989	278	218	263	782	889	241	107	216	355	533	607	238	4728
1990	280	250	164	1645	1225	406	180	-18	99	544	628	970	6372
1991	300	322	569	710	1119	398	95	44	417	662	851	240	5727
1992	291	176	768	798	1329	744	239	157	281	518	344	472	6118
1993	235	463	430	1169	1434	450	394	471	124	655	846	1319	7991
1994	587	268	710	1338	1377	493	275	85	257	229	534	250	6401
1995	681	221	511	900	977	430	279	254	412	445	962	610	6682
1996	461	1127	763	481	468	252	684	206	335	518	349	840	6485
1997	727	488	167	603	1437	544	268	205	616	408	594	289	6345
1998	297	372	1018	1264	893	268	359	192	646	380	524	458	6672
1999	775	1093	990	938	732	246	119	388	459	627	545	666	7578
2000	774	549	785	1056	790	323	502	291	110	958	854	630	7621
2001	231	124	215	693	1213	499	288	56	230	212	607	405	4774
2002	284	325	794	816	720	308	74	232	384	260	675	364	5237

Includes all adjustments as described in Section 7 and Appendix D.

Appendix G – Statistical Tests (Victoria)

Table G3: Step Trend Tests (2-sample t-test, 2-tailed): Victoria River comparison with Rivers Nearby

River	Pre-Project	Post-Project	n_1, n_2	p-value	Remarks
Upper Humber River	1953-1970	1971-2002	18,32	0.102	Post- is higher but n.s.
Gander River	1950-1970	1971-2002	21,32	0.495	Post- is higher but n.s.
Bay du Nord River	1952-1970	1971-2002	19,32	0.441	Post- is higher but n.s.
Grand Lake	1950-1070	1971-2002	21,32	0.081	Post- is higher and significant at 10% level
Victoria River (Adjusted)	***1950-1970***	1971-2002	***21,32***	***0.177***	***Post- is higher but n.s.***
Victoria River (Unadjusted)	1950-1970	1971-2002	21,32	0.001	Post- is higher and significant at 5% level

All assumptions of the t-test are met. Before and After data are both approximately normally distributed.

Table G4: Homogeneity of Variance Tests (Levene's 2-tailed test): Victoria River comparison with Rivers Nearby

River	Pre-Project	Post-Project	n_1, n_2	p-value	Remarks
Upper Humber River	1953-1970	1971-2002	18,32	0.197	Post- is higher but n.s.
Gander River	1950-1970	1971-2002	21,32	0.469	Pre- is higher but n.s.
Bay du Nord River	1952-1970	1971-2002	19,32	0.482	About equal
Grand Lake	1950-1070	1971-2002	21,32	0.413	Post- is higher but n.s.
Victoria River (Adjusted)	***1950-1970***	1971-2002	***21,32***	***0.227***	***Post- is higher but n.s.***
Victoria River (Unadjusted)	1950-1970	1971-2002	21,32	0.063	Post- is higher but n.s.

Pre/Post period = Period before and after plant came into operation at Victoria River

Red = significant at 5% level

G1. Descriptive Statistics: UnVic, Adj Vic, Gander, BayDN, UH, Grand

Variable	N	Mean	StDev	CoefVar	Minimum	Q1	Median	Q3	Maximum
UnVic	53	1092.5	173.0	15.83	745.0	1002.5	1092.0	1192.0	1500.0
Adj Vic	53	1124.3	169.4	15.06	745.0	1010.0	1112.0	1211.0	1500.0
Gander	53	842.5	136.8	16.24	506.0	745.0	858.0	932.5	1120.0
BayDN	51	1080.7	174.5	16.15	650.0	968.0	1065.0	1206.0	1413.0
UH	50	1190.9	158.3	13.29	912.0	1078.0	1155.5	1320.5	1660.0
Grand	53	915.6	119.4	13.05	668.0	821.5	925.0	982.5	1172.0

Variable	Range	IQR	Skewness
UnVic	755.0	189.5	0.27
Adj Vic	755.0	201.0	0.07
Gander	614.0	187.5	-0.34
BayDN	763.0	238.0	-0.30
UH	748.0	242.5	0.42
Grand	504.0	161.0	-0.04

Legend:

UnVic = Unadjusted Victoria River
AdjVic = Adjusted Victoria River
Gander = Gander River
BayDN = Bay du Nord River
UH = Upper River River
Grand = Grand Lake River

G2. Descriptive Statistics: UnVic, Adj Vic, Gander, BayDN, UH, Grand by Pre/Post

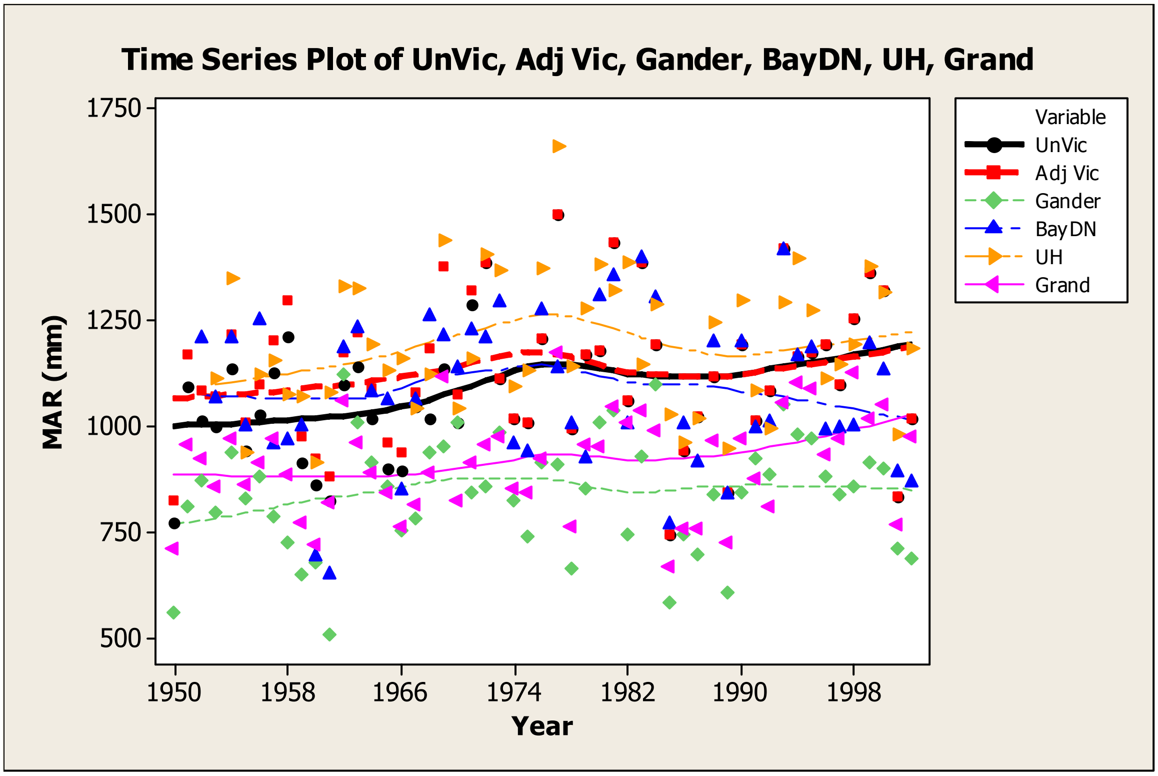
Variable	Pre/Post	N	Mean	StDev	CoefVar	Minimum	Q1	Median	Q3
UnVic	0	21	1008.6	116.9	11.59	771.0	906.0	1018.0	1111.5
	1	32	1147.5	182.9	15.94	745.0	1017.5	1166.0	1278.0
Adj Vic	0	21	1087.3	140.8	12.95	824.0	968.5	1082.0	1193.0
	1	32	1148.5	183.8	16.01	745.0	1017.5	1166.0	1302.8
Gander	0	21	825.9	150.7	18.25	506.0	737.5	830.0	936.0
	1	32	853.4	128.2	15.02	582.0	745.0	858.0	927.3
BayDN	0	19	1055.8	177.4	16.80	650.0	968.0	1065.0	1206.0
	1	32	1095.5	173.9	15.87	769.0	963.8	1071.0	1221.8
UH	0	18	1143.8	140.0	12.24	912.0	1063.5	1122.0	1226.8
	1	32	1217.3	163.8	13.46	945.0	1096.5	1219.0	1355.0
Grand	0	21	881.6	103.4	11.72	709.0	816.5	886.0	957.5
	1	32	937.9	125.5	13.38	668.0	846.3	962.0	1031.8

Variable	Pre/Post	Maximum	Range	IQR	Skewness
UnVic	0	1212.0	441.0	205.5	-0.31
	1	1500.0	755.0	260.5	-0.09
Adj Vic	0	1378.0	554.0	224.5	0.05
	1	1500.0	755.0	285.3	-0.09
Gander	0	1120.0	614.0	198.5	-0.32
	1	1099.0	517.0	182.3	-0.29
BayDN	0	1257.0	607.0	238.0	-1.03
	1	1413.0	644.0	258.0	0.12
UH	0	1440.0	528.0	163.3	0.55
	1	1660.0	715.0	258.5	0.30
Grand	0	1116.0	407.0	141.0	0.37
	1	1172.0	504.0	185.5	-0.36

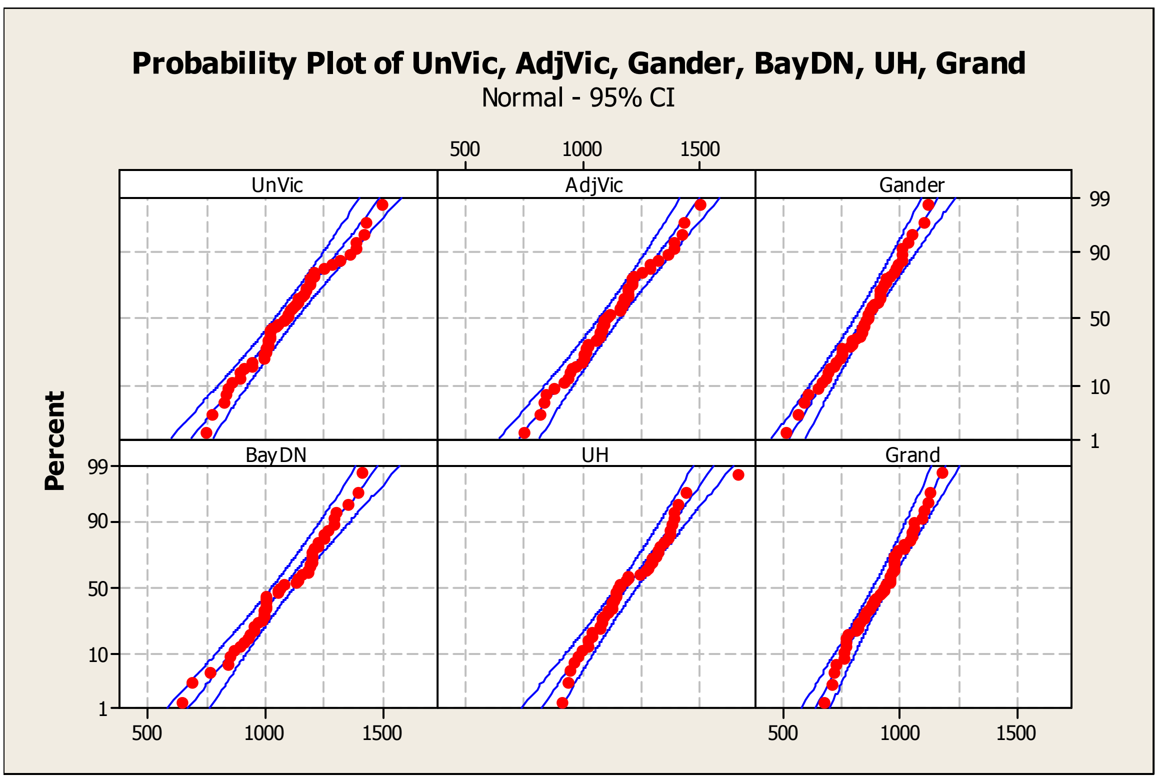
Legend:

0 = Pre-project (to 1970)
1 = Post-project (1971-2002)

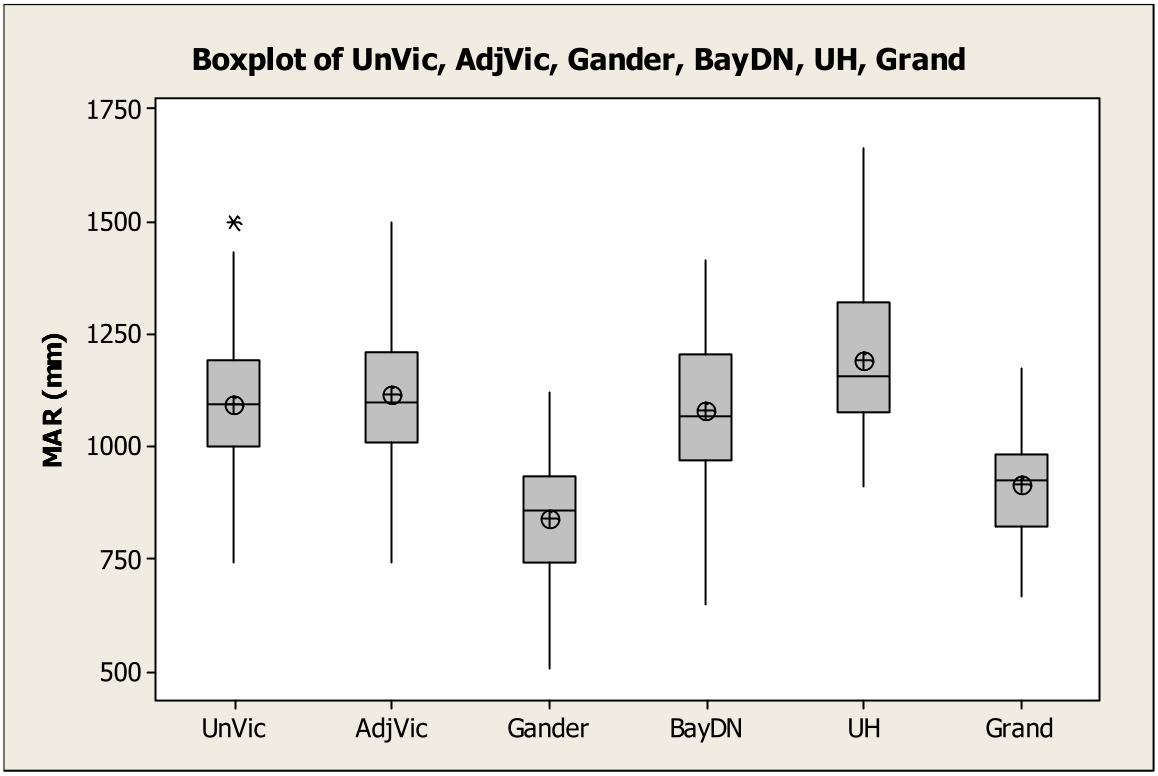
G3. Time Series Plots of all 6 series.



G4. Normal Probability Plots of all 6 Series



G5. Boxplots of all 6 series



G6. Boxplots of all 6 series by pre/post project

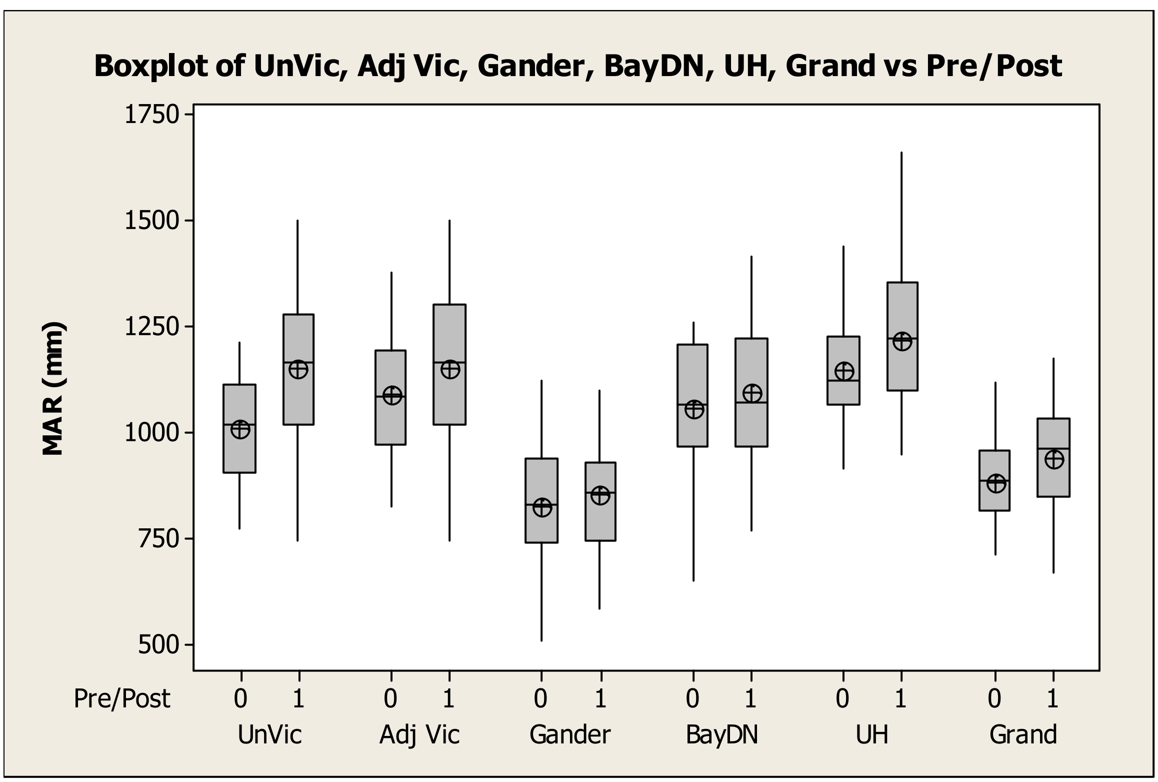


Table G1: Summary of Trend Analysis - Adjusted Victoria River and Nearby Rivers

			Mann-Kendall using resampling				Linear Regression				
Name of Series	**Years**	**n**	**S**	**Z**	**p-value1**	**Sen's β**	**Reg b_1**	**R^2**	**p-value2**	**Category**	**Remarks**
MAR (mm)											
Upper Humber River	1953-2002	50	89	0.752	0.452	1.031	1.125	1.1	0.474	3	Weak upward trend
Gander River	1950-2002	53	102	0.753	0.452	1.018	1.157	1.7	0.351	3	Weak upward trend
Bay du Nord River	1952-2003	51	-55	-0.423	0.672	-0.357	0.072	0.0	0.966	3	Practically horizontal
Grand Lake	1950-2002	53	281	2.144	0.032	2.338	2.002	6.7	0.061	2	mild to strong upward trend
Victoria River (adjusted)	1950-2002	***53***	***132***	***0.967***	***0.334***	***1.57***	***1.349***	***1.5***	***0.380***	***3***	***Weak upward trend***
Victoria River (Unadjusted)	1950-2002	53	301	2.308	0.021	3.500	3.346	8.9	0.030	1	Significant upward trend

All data sets are normally distributed with p-values > 0.1 using the Anderson-Darling test.

Categories: 1=SI (p1<0.05), 2=MI (0.05 <p1<0.10), 3 = Weak or No trend, 4 = MD (0.05 <p1<0.1), 5 = SD (p1< 0.05)

Table G2: Summary of Runs Analysis: Victoria River and Nearby Rivers

			Runs above and below the median					Length of runs				
Name of Series	**Years**	**n**	**RAB**	**E(RAB)**	**LRABM**	**p-value 1**	**p-value 2**	**NRUD**	**E(NR)**	**LRUD**	**p-value 3**	**p-value 4**
MAR (mm)												
Upper Humber River	1953-2002	50	26	26.00	7	0.500	0.500	29	33.00	3	0.086	0.914
Gander River	1950-2002	53	23	27.26	6	0.116	0.884	30	35.00	4	0.049	0.951
Bay du Nord River	1952-2002	51	24	26.49	6	0.240	0.760	33	33.67	3	0.411	0.589
Grand Lake	1950-2002	53	24	27.49	8	0.166	0.834	33	35.00	4	0.254	0.746
Victoria River (adjusted)	***1950-2002***	***53***	***27***	***27.49***	***4***	***0.446***	0.554	***29***	***35.00***	***3***	***0.023***	0.977
Victoria River (Unadjusted)	1950-2002	53	23	27.49	8	0.106	0.894	31	35.00	3	0.092	0.908

All data sets are normally distributed with p-values > 0.1 using the Anderson-Darling test.

RAB = Number of runs about the median, E(RAB) = Expected number of runs, LRABM = Longest run about the median, p-value 1 = p-value for clustering

p-value 2 = p-value for mixtures, NRUD = Number of runs up and down, E(NR) = Expected number of runs, LRUD = Longest run up or down

p-value 3 = p-value for trends, p-value 4 = p-value for oscillation. Red = statistically significant at the 5% level

Appendix H – Statistical Tests (Meelpaeg and Salmon River)

H1. Descriptive Statistics: UnGS, AdjGS, AdjVic, Gander, BayDN, Pipers

Variable	N	Mean	StDev	CoefVar	Minimum	Q1	Median	Q3	Maximum
UnGS	53	1012.8	161.4	15.94	685.0	886.0	1030.0	1130.5	1339.0
AdjGS	53	1019.2	160.0	15.70	694.0	891.5	1043.0	1130.5	1339.0
AdjVic	53	1124.3	169.4	15.06	745.0	1010.0	1112.0	1211.0	1500.0
Gander	53	842.5	136.8	16.24	506.0	745.0	858.0	932.5	1120.0
BayDN	51	1080.7	174.5	16.15	650.0	968.0	1065.0	1206.0	1413.0
Pipers	50	1035.9	173.8	16.78	673.0	905.0	1020.0	1170.0	1450.0

Variable	Range	IQR	Skewness
UnGS	654.0	244.5	-0.19
AdjGS	645.0	239.0	-0.24
AdjVic	755.0	201.0	0.07
Gander	614.0	187.5	-0.34
BayDN	763.0	238.0	-0.30
Pipers	777.0	265.0	0.12

Legend:
UnGS = Unadjusted Grey + Salmon River
AdjGS = Adjusted Grey + Salmon River
AdjVic = Adjusted Victoria River
Gander = Gander River
BayDN = Bay du Nord River
Pipers = Pipers Hole River

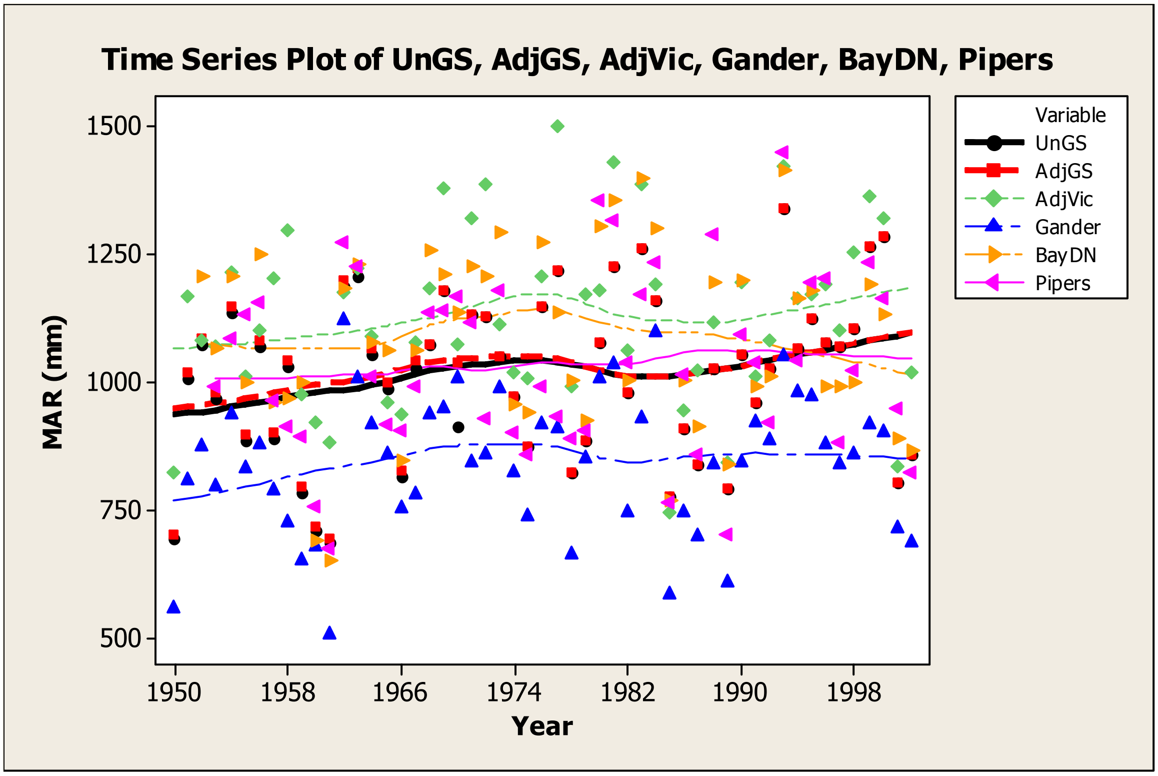
H2. Descriptive Statistics: UnGS, AdjGS, AdjVic, Gander, BayDN, Pipers

Variable	Pre/Post	N	Mean	StDev	CoefVar	Minimum	Q1	Median	Q3
UnGS	0	21	970.0	161.8	16.68	685.0	851.5	1005.0	1073.5
	1	32	1040.8	157.4	15.12	774.0	891.0	1060.5	1143.3
AdjGS	0	21	986.2	162.1	16.43	694.0	862.0	1040.0	1084.0
	1	32	1040.8	157.4	15.12	774.0	891.0	1060.5	1143.3
AdjVic	0	21	1087.3	140.8	12.95	824.0	968.5	1082.0	1193.0
	1	32	1148.5	183.8	16.01	745.0	1017.5	1166.0	1302.8
Gander	0	21	825.9	150.7	18.25	506.0	737.5	830.0	936.0
	1	32	853.4	128.2	15.02	582.0	745.0	858.0	927.3
BayDN	0	19	1055.8	177.4	16.80	650.0	968.0	1065.0	1206.0
	1	32	1095.5	173.9	15.87	769.0	963.8	1071.0	1221.8
Pipers	0	18	1018.4	160.7	15.78	673.0	911.0	1001.5	1144.3
	1	32	1045.8	182.5	17.45	702.0	901.3	1030.5	1190.8

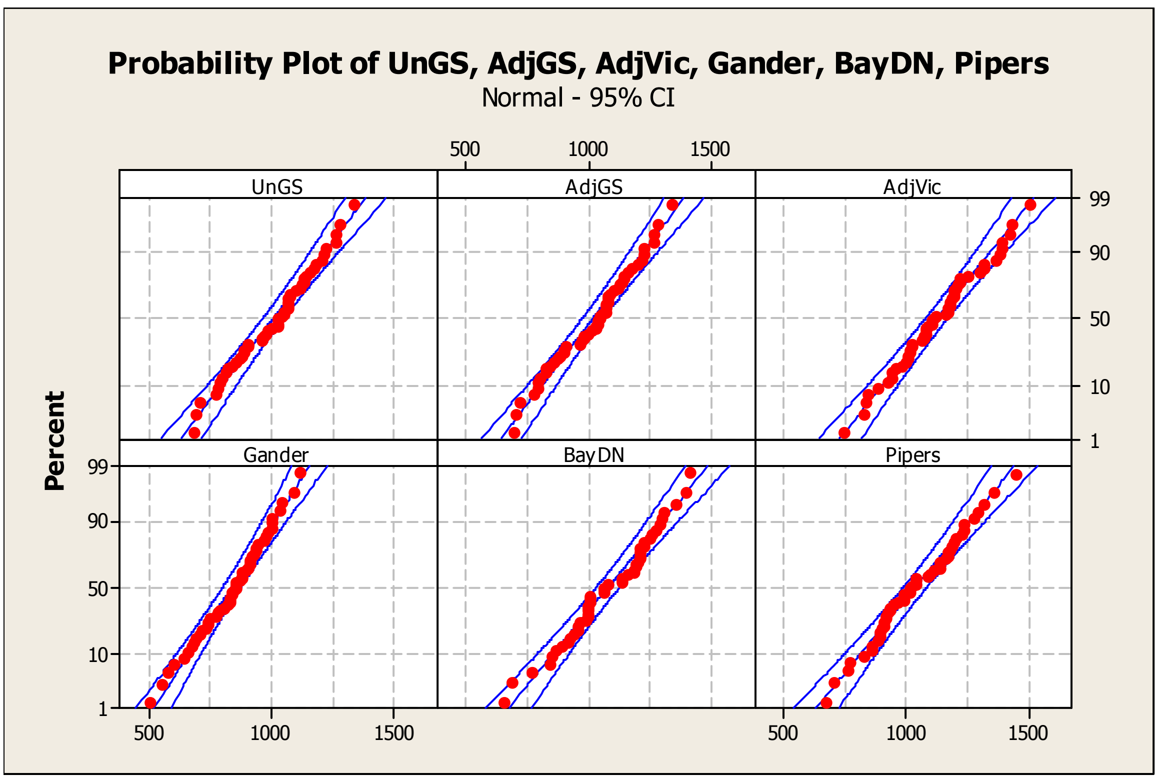
Variable	Pre/Post	Maximum	Range	IQR	Skewness
UnGS	0	1208.0	523.0	222.0	-0.42
	1	1339.0	565.0	252.3	-0.03
AdjGS	0	1222.0	528.0	222.0	-0.55
	1	1339.0	565.0	252.3	-0.03
AdjVic	0	1378.0	554.0	224.5	0.05
	1	1500.0	755.0	285.3	-0.09
Gander	0	1120.0	614.0	198.5	-0.32
	1	1099.0	517.0	182.3	-0.29
BayDN	0	1257.0	607.0	238.0	-1.03
	1	1413.0	644.0	258.0	0.12
Pipers	0	1272.0	599.0	233.3	-0.45
	1	1450.0	748.0	289.5	0.28

Legend:
0 = Pre-Project (up to 1970)
1 = Post-Project (1971-2002)

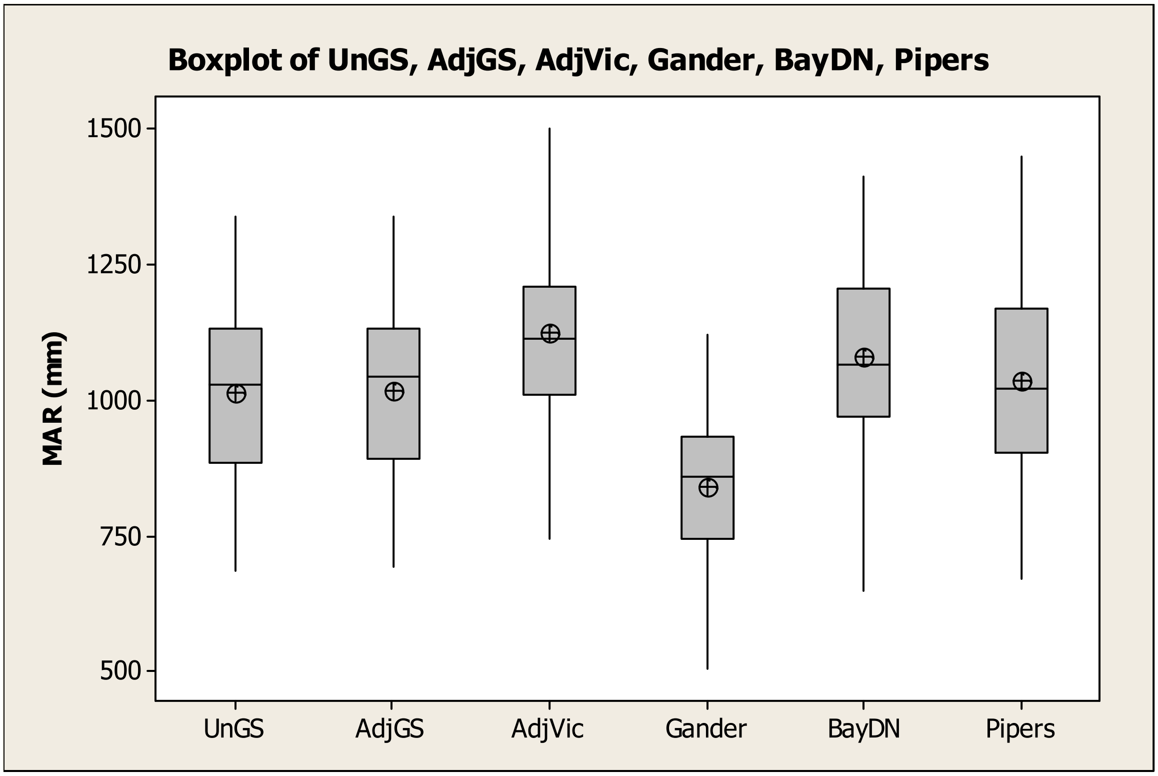
H3. Time Series Plots of all 6 series.



H4. Normal Probability Plots of all 6 Series



H5. Boxplots of all 6 series



6. Boxplots of all 6 series by pre/post project

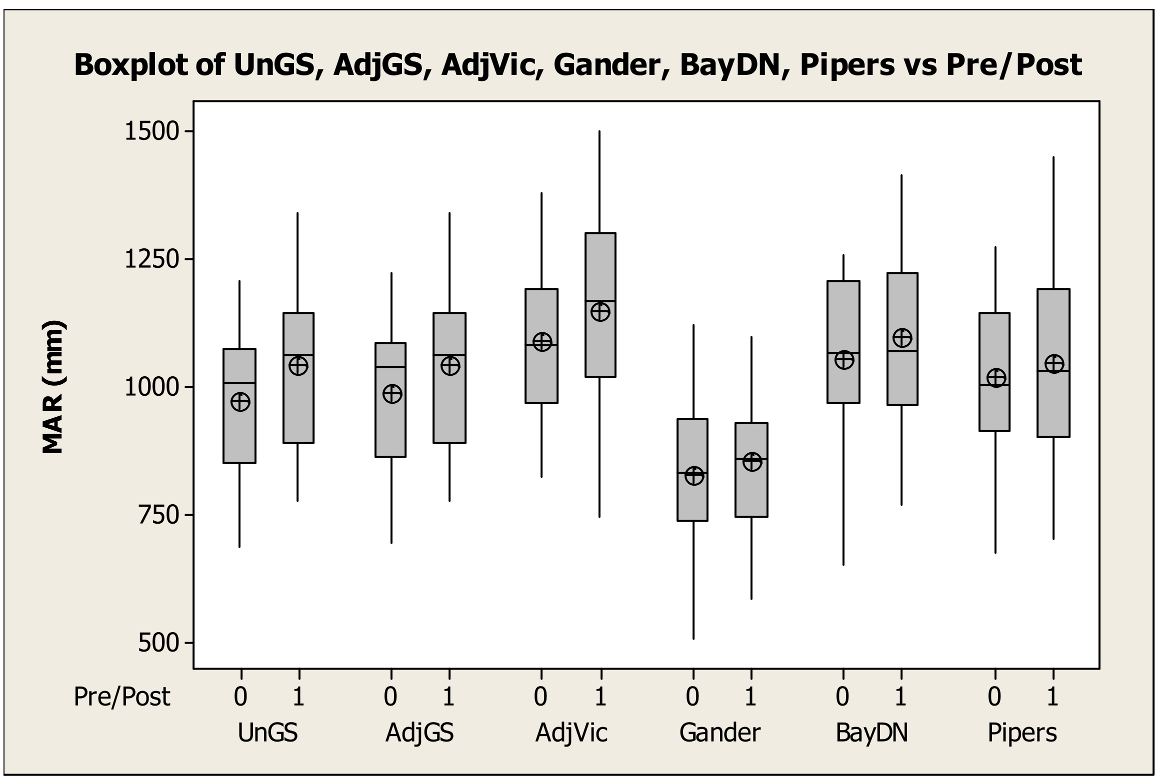


Table H1: Summary of Trend Analysis - Adjusted Grey + Salmon and Nearby Rivers

Name of Series	Years	n	Mann-Kendall using resampling S	Z	p-value1	Sen's β	Linear Regression Reg b_1	R^2	p-value2	Category	Remarks
MAR (mm)											
Victoria River (Adjusted)	1950-2002	53	132	0.967	0.334	1.57	1.349	1.5	0.380	3	Weak upward trend
Gander River	1950-2002	53	102	0.753	0.452	1.018	1.157	1.7	0.351	3	Weak upward trend
Bay du Nord River	1952-2003	51	-55	-0.423	0.672	-0.357	0.072	0.0	0.966	3	Practically horizontal
Pipers Hole River	1953-2002	50	80	0.664	0.507	0.967	1.360	1.3	0.430	3	Weak upward trend
Grey + Salmon River (Adjusted)	1950-2002	***53***	***163***	***1.244***	***0.214***	***2***	***1.998***	***3.7***	***0.167***	***3***	***Weak upward trend***
Grey + Salmon River (Unadjusted)	1950-2002	53	186	1.401	0.161	2.250	2.280	4.7	0.120	3	Weak upward trend

All data sets are normally distributed with p-values > 0.1 using the Anderson-Darling test.

Categories: 1=SI (p1<0.05), 2=MI (0.05 <p1<0.10), 3 = Weak or No trend, 4 = MD (0.05 <p1<0.1), 5 = SD (p1< 0.05)

Table H2: Summary of Runs Analysis: Grey + Salmon and Nearby Rivers

			Runs above and below the median					Length of runs				
Name of Series	**Years**	**n**	**RAB**	**E(RAB)**	**LRABM**	**p-value 1**	**p-value 2**	**NRUD**	**E(NR)**	**LRUD**	**p-value 3**	**p-value 4**
MAR (mm)												
Victoria River (Adjusted)	***1950-2002***	***53***	***27***	***27.49***	***4***	***0.446***	0.554	***29***	***35.00***	***3***	***0.023***	0.977
Gander River	1950-2002	53	23	27.26	6	0.116	0.884	30	35.00	4	0.049	0.951
Bay du Nord River	1952-2002	51	24	26.49	6	0.240	0.760	33	33.67	3	0.411	0.589
Pipers Hole River	1953-2002	50	19	26.00	6	0.023	0.977	26	33.00	5	0.008	0.992
Grey + Salmon River (Adjusted)	***1950-2002***	***53***	***23***	***27.49***	***8***	***0.106***	0.894	***33***	***35.00***	***4***	***0.254***	0.746
Grey + Salmon River (Unadjusted)	1950-2002	53	23	24.49	8	0.106	0.894	33	35.00	4	0.254	0.746

All data sets are normally distributed with p-values > 0.1 using the Anderson-Darling test.
RAB = Number of runs about the median, E(RAB) = Expected number of runs, LRABM = Longest run about the median, p-value 1 = p-value for clustering
p-value 2 = p-value for mixtures, NRUD = Number of runs up and down, E(NR) = Expected number of runs, LRUD = Longest run up or down
p-value 3 = p-value for trends, p-value 4 = p-value for oscillation. Red = statistically significant at the 5% level

Table H3: Step Trend Tests (2-sample t-test, 2-tailed): Grey + Salmon comparison with Rivers Nearby

River	Pre-Project	Post-Project	n_1, n_2	p-value	Remarks
Victoria River (Adjusted)	1950-1970	1971-2002	21,32	0.078	Post- is higher but n.s.
Gander River	1950-1970	1971-2002	21,32	0.495	Post- is higher but n.s.
Bay du Nord River	1952-1970	1971-2002	19,32	0.441	Post- is higher but n.s.
Pipers Hole River	1953-1970	1971-2002	18,32	0.585	Post is higher but n.s.
Grey + Salmon River (Adjusted)	***1950-1970***	1971-2002	***21,32***	***0.232***	***Post- is higher but n.s.***
Grey + Salmon River (Unadjusted)	1950-1970	1971-2002	21,32	0.123	Post is higher but n.s.

All assumptions of the t-test are met. Before and After data are both approximately normally distributed.

Table H4: Homogeneity of Variance Tests (Levene's 2-tailed test): Grey + Salmon comparison with Rivers Nearby

River	Pre-Project	Post-Project	n_1, n_2	p-value	Remarks
Victoria River (Adjusted)	1950-1970	1971-2002	21,32	0.105	Post- is higher but n.s.
Gander River	1950-1970	1971-2002	21,32	0.469	Pre- is higher but n.s.
Bay du Nord River	1952-1970	1971-2002	19,32	0.482	About equal
Pipers Hole River	1953-1070	1971-2002	18,32	0.499	Post- is higher but n.s.
Grey + Salmon River (Adjusted)	***1950-1970***	1971-2002	***21,32***	***0.934***	***About equal***
Grey + Salmon River (Unadjusted)	1950-1970	1971-2002	21,32	0.939	About equal

Pre/Post period = Period before and after plant came into operation

Red = significant at 5% level

Appendix I – Statistical Tests (Bay d'Espoir Total Basin)

I1. Descriptive Statistics: UnTot, AdjTot, Gander, BayDN, UH, Pipers

Variable	N	Mean	StDev	CoefVar	Minimum	Q1	Median	Q3	Maximum
UnTot	53	1028.4	159.0	15.46	710.0	896.5	1048.0	1146.5	1353.0
AdjTot	53	1038.0	158.4	15.26	723.0	916.5	1060.0	1159.0	1353.0
Gander	53	842.5	136.8	16.24	506.0	745.0	858.0	932.5	1120.0
BayDN	51	1080.7	174.5	16.15	650.0	968.0	1065.0	1206.0	1413.0
UH	50	1190.9	158.3	13.29	912.0	1078.0	1155.5	1320.5	1660.0
Pipers	50	1035.9	173.8	16.78	673.0	905.0	1020.0	1170.0	1450.0

Variable	Range	IQR	Skewness
UnTot	643.0	250.0	-0.07
AdjTot	630.0	242.5	-0.19
Gander	614.0	187.5	-0.34
BayDN	763.0	238.0	-0.30
UH	748.0	242.5	0.42
Pipers	777.0	265.0	0.12

Legend:
UnTot = Unadjusted Total System
AdjTot = Adjusted Total System
Gander = Gander River
BayDN = Bay du Nord River
UH = Upper Humber River
Pipers = Pipers Hole River

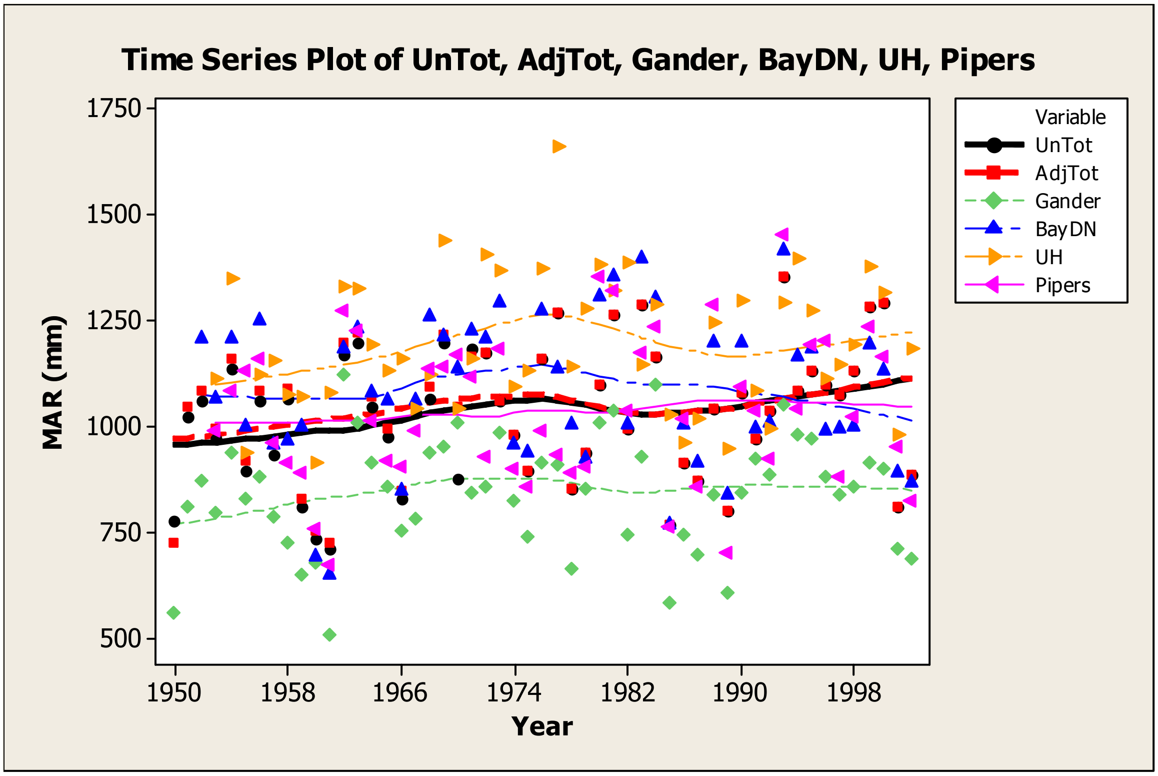
I2. Descriptive Statistics: UnTot, AdjTot, Gander, BayDN, UH, Pipers

Variable	Pre/Post	N	Mean	StDev	CoefVar	Minimum	Q1	Median	Q3
UnTot	0	21	979.2	147.7	15.08	710.0	854.0	1020.0	1063.5
	1	32	1060.6	160.0	15.09	769.0	920.3	1077.0	1172.3
AdjTot	0	21	1004.4	154.2	15.35	723.0	882.0	1046.0	1091.0
	1	32	1060.1	159.6	15.06	769.0	920.3	1077.0	1165.5
Gander	0	21	825.9	150.7	18.25	506.0	737.5	830.0	936.0
	1	32	853.4	128.2	15.02	582.0	745.0	858.0	927.3
BayDN	0	19	1055.8	177.4	16.80	650.0	968.0	1065.0	1206.0
	1	32	1095.5	173.9	15.87	769.0	963.8	1071.0	1221.8
UH	0	18	1143.8	140.0	12.24	912.0	1063.5	1122.0	1226.8
	1	32	1217.3	163.8	13.46	945.0	1096.5	1219.0	1355.0
Pipers	0	18	1018.4	160.7	15.78	673.0	911.0	1001.5	1144.3
	1	32	1045.8	182.5	17.45	702.0	901.3	1030.5	1190.8

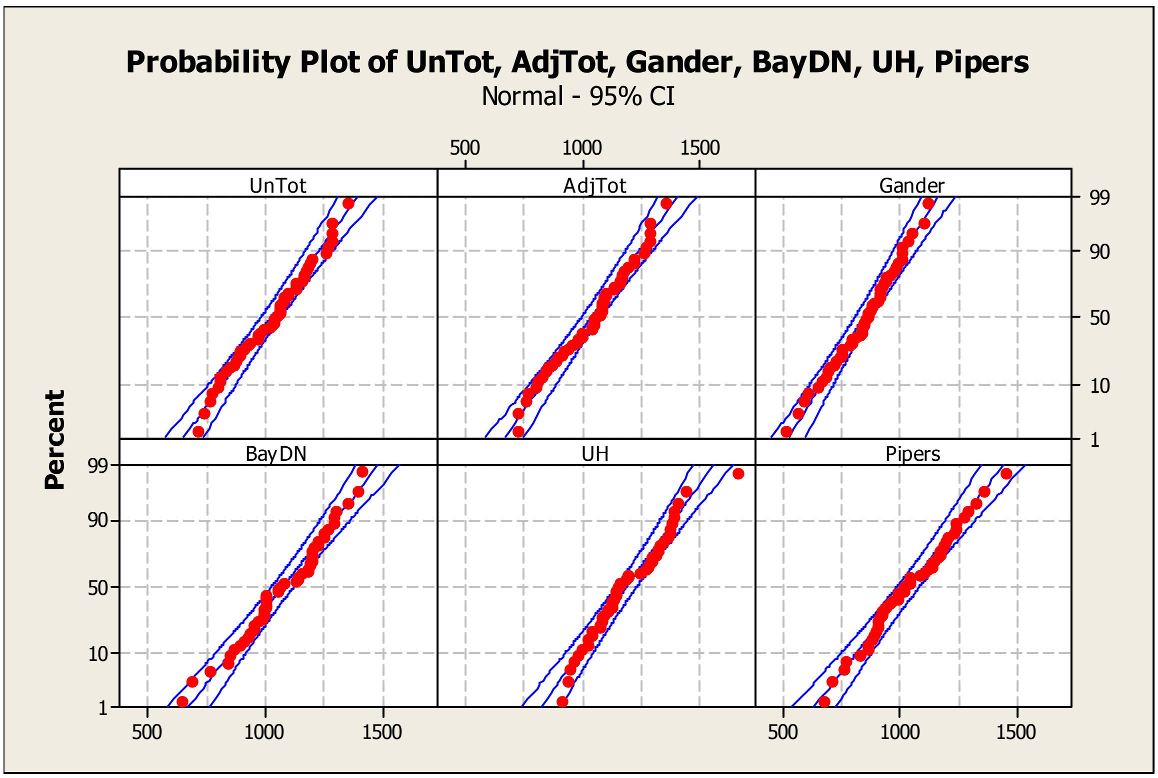
Variable	Pre/Post	Maximum	Range	IQR	Skewness
UnTot	0	1199.0	489.0	209.5	-0.31
	1	1353.0	584.0	252.0	-0.06
AdjTot	0	1222.0	499.0	209.0	-0.55
	1	1353.0	584.0	245.3	-0.05
Gander	0	1120.0	614.0	198.5	-0.32
	1	1099.0	517.0	182.3	-0.29
BayDN	0	1257.0	607.0	238.0	-1.03
	1	1413.0	644.0	258.0	0.12
UH	0	1440.0	528.0	163.3	0.55
	1	1660.0	715.0	258.5	0.30
Pipers	0	1272.0	599.0	233.3	-0.45
	1	1450.0	748.0	289.5	0.28

Legend:
0 = Pre-Project (up to 1970)
1 = Post-Project (1971-2002)

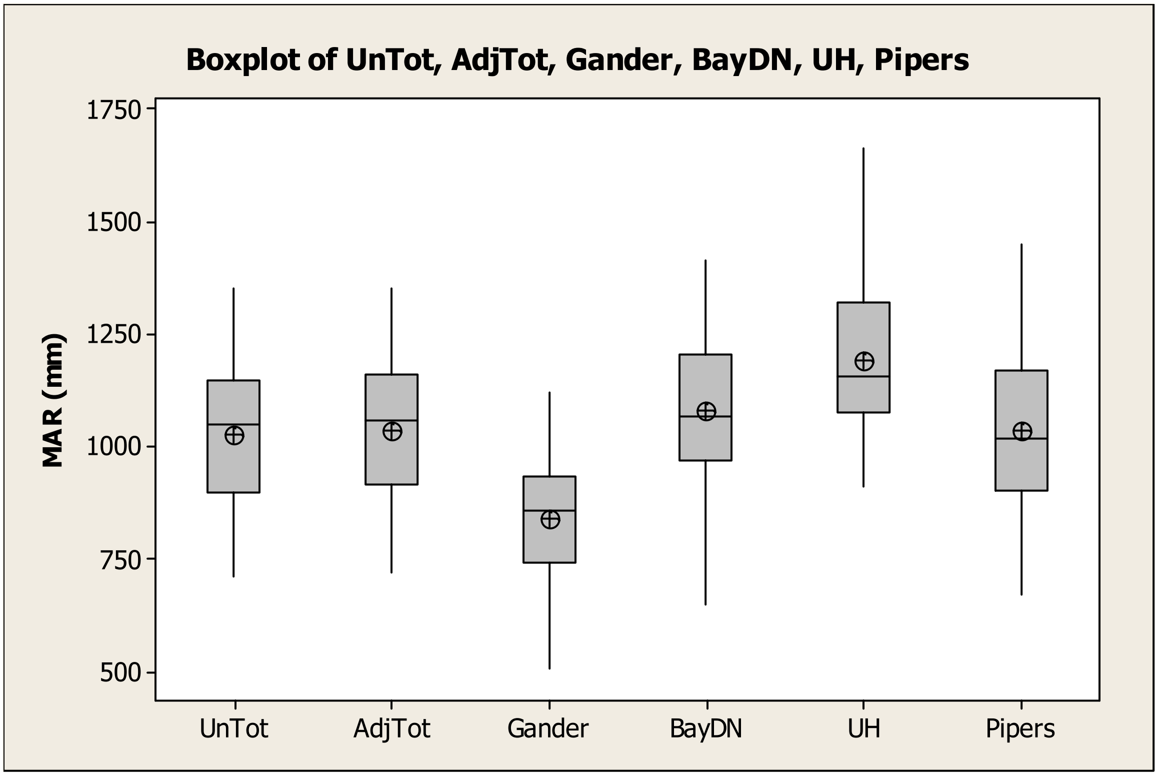
I3. Time Series Plots of all 6 series.



I4. Normal Probability Plots of all 6 Series



I5. Boxplots of all 6 series



I6. Boxplots of all 6 series by pre/post project

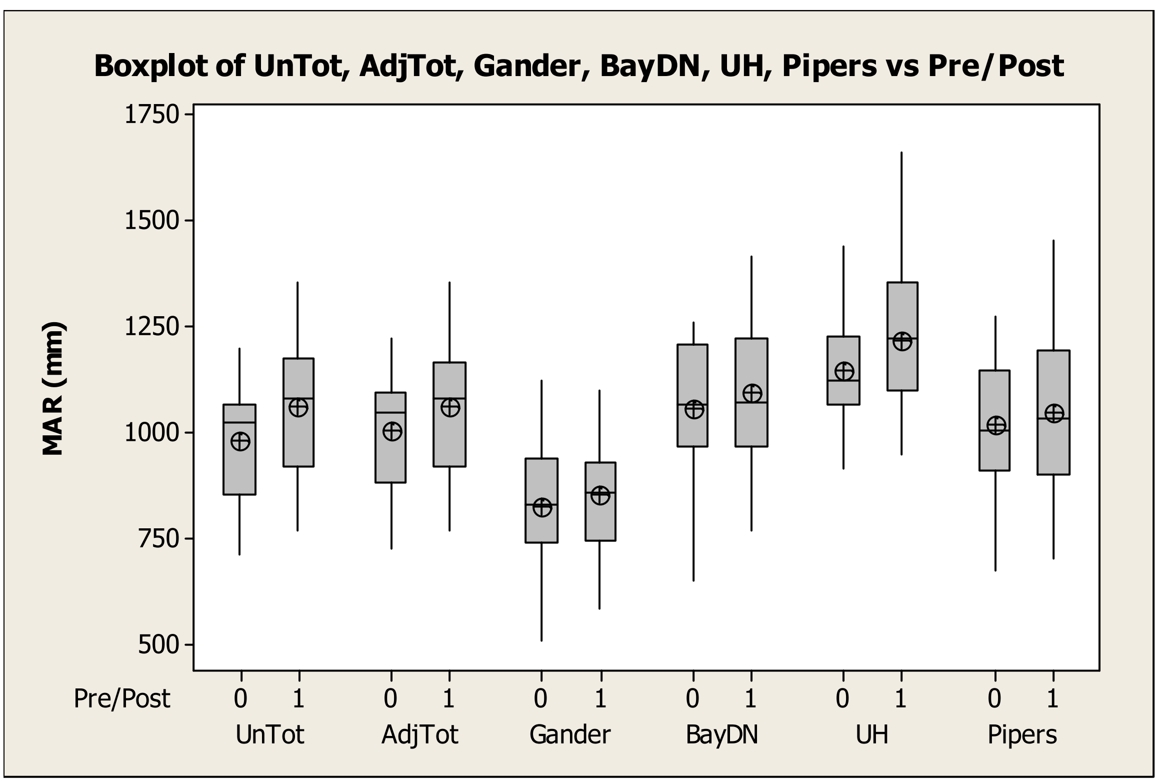


Table I1: Summary of Trend Analysis - Bay d'Espoir Total System and Nearby Rivers

			Mann-Kendall using resampling				Linear Regression				
Name of Series	**Years**	**n**	**S**	**Z**	**p-value1**	**Sen's β**	**Reg b_1**	**R^2**	**p-value2**	**Category**	**Remarks**
MAR (mm)											
Upper Humber River	1953-2002	50	89	0.752	0.452	1.031	1.125	1.1	0.474	3	Weak upward trend
Gander River	1950-2002	53	102	0.753	0.452	1.018	1.157	1.7	0.351	3	Weak upward trend
Bay du Nord River	1952-2003	51	-55	-0.423	0.672	-0.357	0.072	0.0	0.966	3	Practically horizontal
Pipers Hole River	1953-2002	50	80	0.664	0.507	0.967	1.360	1.3	0.430	3	Weak upward trend
Total System (Adjusted)	1950-2002	***53***	***160***	***1.227***	***0.220***	***1.726***	***1.881***	***3***	***0.189***	***3***	***Weak upward trend***
Total System Unadjusted)	1950-2002	53	217	1.65	0.099	2.426	2.384	5.4	0.095	4	Mild upward trend

All data sets are normally distributed with p-values > 0.1 using the Anderson-Darling test.

Categories: 1=SI (p1<0.05), 2=MI (0.05 <p1<0.10), 3 = Weak or No trend, 4 = MD (0.05 <p1<0.1), 5 = SD (p1< 0.05)

Tablel2: Summary of Runs Analysis: Total System and Nearby Rivers

			Runs above and below the median					Length of runs				
Name of Series	**Years**	**n**	**RAB**	**E(RAB)**	**LRABM**	**p-value 1**	**p-value 2**	**NRUD**	**E(NR)**	**LRUD**	**p-value 3**	**p-value 4**
MAR (mm)												
Upper Humber River	1953-2002	50	26	26.00	7	0.500	0.500	29	33.00	3	0.086	0.914
Gander River	1950-2002	53	23	27.26	6	0.116	0.884	30	35.00	4	0.049	0.951
Bay du Nord River	1952-2002	51	24	26.49	6	0.240	0.760	33	33.67	3	0.411	0.589
Pipers Hole River	1953-2002	50	19	26.00	6	0.023	0.977	26	33.00	5	0.008	0.992
Total System (Adjusted)	***1950-2002***	***53***	***25***	***27.49***	***8***	***0.245***	0.755	***33***	***35.00***	***3***	***0.254***	0.746
Total System (Unadjusted)	1950-2002	53	25	24.49	8	0.245	0.755	33	35.00	4	0.254	0.746

All data sets are normally distributed with p-values > 0.1 using the Anderson-Darling test.

RAB = Number of runs about the median, E(RAB) = Expected number of runs, LRABM = Longest run about the median, p-value 1 = p-value for clustering

p-value 2 = p-value for mixtures, NRUD = Number of runs up and down, E(NR) = Expected number of runs, LRUD = Longest run up or down

p-value 3 = p-value for trends, p-value 4 = p-value for oscillation. Red = statistically significant at the 5% level

Table I3: Step Trend Tests (2-sample t-test, 2-tailed): Total System comparison with Rivers Nearby

River	Pre-Project	Post-Project	n_1, n_2	p-value	Remarks
Upper Humber River	1953-1970	1971-2002	18,32	0.102	Post- is higher but n.s.
Gander River	1950-1970	1971-2002	21,32	0.495	Post- is higher but n.s.
Bay du Nord River	1952-1970	1971-2002	19,32	0.441	Post- is higher but n.s.
Pipers Hole River	1953-1970	1971-2002	18,32	0.585	Post is higher but n.s.
Total System (Adjusted)	***1950-1970***	1971-2002	***21,32***	***0.212***	***Post- is higher but n.s.***
Total System (Unadjusted)	1950-1970	1971-2002	21,32	0.064	Difference significant at 10%

All assumptions of the t-test are met. Before and After data are both approximately normally distributed.

Table I4: Homogeneity of Variance Tests (Levene's 2-tailed test): Total System comparison with Rivers Nearby

River	Pre-Project	Post-Project	n_1, n_2	p-value	Remarks
Upper Humber River	1953-1970	1971-2002	18,32	0.197	Post- is higher but n.s.
Gander River	1950-1970	1971-2002	21,32	0.469	Pre- is higher but n.s.
Bay du Nord River	1952-1970	1971-2002	19,32	0.482	About equal
Pipers Hole River	1953-1070	1971-2002	18,32	0.499	Post- is higher but n.s.
Total System (Adjusted)	***1950-1970***	1971-2002	***21,32***	***0.691***	***About equal***
Total System (Unadjusted)	1950-1970	1971-2002	21,32	0.707	About equal

Pre/Post period = Period before and after plants came into operation

Red = significant at 5% level

SGE Acres

St. John's • Clarenville
Corner Brook • Sydney • Halifax
Moncton • Saint John • Fredericton

May 19, 2005
16208D1

Newfoundland and Labrador Hydro
Hydro Place, 500 Columbus Drive
St. John's, NL A1B 4K7

Attention: Mr. D. Harris, P.Eng.

Dear Sir:

Newfoundland and Labrador Hydro
SYSSIM Model Review

In 2003, SGE Acres Limited (SGE Acres) recommended that Newfoundland and Labrador Hydro (NLH) implement a computer simulation methodology for determining the average hydroelectric capability for its facilities. This recommendation was stated in the 2003 report titled "Island Hydrology Review" conducted by SGE Acres in response to order P.U. 7 (2002-2003) by the Board of Commissioners of Public Utilities. NLH assessed the capabilities of its three main water management tools (SYSSIM, ARSP, and Vista) in 2004 to address SGE Acres recommendation. NLH concluded that Vista was not suitable to the task due to its optimization routines for hydroelectric production and that ARSP is not suitable due to its inability to directly model load limitations. NLH concluded that SYSSIM offered the greatest potential for application to developing the average hydroelectric capability for NLH's facilities.

In December 2004, NLH engaged SGE Acres to review its SYSSIM model, make changes to model input, and confirm the suitability of SYSSIM to the recommended application. In addition, should the model be confirmed to be suitable, SGE Acres was requested to provide the preferred methodology when developing the estimates.

This report documents the analysis and results undertaken for this study.

1 Review and Update Existing SYSSIM Model

SYSSIM was developed by Acres International for the purposes of reflecting hydroelectric uncertainly on generation expansion planning. Accordingly, the tool inherently reflects the impacts of thermal generation and load limitations on hydroelectric production, a key consideration for the Island Interconnected System. SYSSIM relies upon ARSP for the purpose of simulating hydroelectric energy production. NLH's current SYSSIM model, which was set up in 1999, includes an Infeed to the Island from Labrador, and the Granite Canal and Island Pond Hydroelectric generating stations. Its original purpose was to determine the impact of energy from the proposed stations on thermal production and supplying future demands on the Island. Since this study is focused on NLH's existing system configuration, changes were required to remove the Infeed load and proposed generating stations from the model. It should be noted that the purpose was to update the model configuration and not the model inputs. It is expected that since the model was previously developed more than five years ago, there would be required updates to physical input data, such as station characteristics and operating policies.

Further changes were required to allow comparison with historic data. The generation from the Granite Canal and Exploits River Hydro Partnership generating stations has only recently become available to the system, so the data record for these stations is too short to use for comparison. The SYSSIM model therefore had to be first set up to exclude these stations to conduct a comparison with historic data. Once the historic comparison was complete, these stations were reinserted. As a result, two separate model setups were required for this study, as follows.

- Historic data comparison model setup (excludes Granite Canal and Exploits River Hydro Partnership generating stations).
- Existing system model setup (includes Granite Canal and Exploits River Hydro Partnership generating stations).

The two models were set up separately, system operation simulated, and results tabulated. The comparison of model results with historic data and spreadsheet results is further discussed in the following section.

2 Comparison

Two sets of comparison were made, one with historic data and the other with results from NLH's spreadsheet, as discussed further in the following subsections.

2.1 Historic Comparison

The methodology for conducting the historic comparison is provided below.

- Modify and develop load for three year test period.
- Simulate for a three year period that overlaps with a period for which historic data are available.
- Adjust SYSSIM model results to take into account differences in energy conversion factors and ending storage differences.
- Compare historic data and SYSSIM results.

The historic data comparison model setup was set up to represent the existing system, not including Granite Canal and Exploits River Hydro Partnership generating stations. The purpose of this comparison was to determine whether the SYSSIM computer model could replicate historic data, thus providing confidence that the model was adequately set up and an effective tool that could be used to estimate average annual hydroelectric energy production.

Annual historic hydroelectric and thermal energy production ending June 2001, June 2002, and June 2003 were provided by NLH. Hydroelectric and thermal energy production was reviewed, and the gross generation (i.e., including NLH's station service loads) was used in SYSSIM to represent the annual demand for those years. System operation was simulated for the three years and the annual results, along with the historic annual data, are provided in Table 1.

As can be seen from Table 1, SYSSIM underestimates hydroelectric energy generation when compared with the historic data; it consequently overproduces thermal energy generation to meet the prescribed demand for each year. It should be noted that the model is currently set up to directly model Bay d'Espoir, Hinds Lake, Upper Salmon, and Cat Arm generating stations, while the other stations are not directly modeled and the energy values noted for SYSSIM are average values for each year.

Reviewing the total generation for each of the stations modeled directly in SYSSIM indicates that SYSSIM is under producing hydroelectric energy generation by 4.5 percent. The station with the highest discrepancy is Hinds Lake Generating Station at 9.7 percent. However, before it was concluded that there is a difference, it was important to first review the energy remaining in storage.

Adjusting the energies to balance out the energy remaining in storage shows that the SYSSIM simulation has 30.0 GWh less energy remaining in storage compared with the historic results, as shown in Table 2. Subtracting this from the total simulated hydroelectric energy generation in Table 1 produces a total simulated hydroelectric energy generation of 12,624.3 GWh compared to the historic total of 13,256.3 GWh, or a difference of approximately 4.8 percent. This shows that there is not much difference with respect to water remaining in storage. Since the current model setup is more than five years old and some of the data in the model on unit characteristics date back to at least 10 years, the most likely source of the differences are the energy conversion factors derived from the station characteristics. Up-to-date energy conversion factors for each of the stations for each year were provided by NLH and compared to those reported by SYSSIM. Table 2 presents these energy conversion factors and the SYSSIM results adjusted by the difference of these factors.

As can be seen in Table 2, the energy conversion factors provided by NLH are higher than those currently reported in SYSSIM, so simulated hydroelectric production would be expected to be lower than the historic. The energies calculated in SYSSIM were adjusted using the ratio of energy conversion factors, reducing the discrepancy from 4.5 percent to 2.4 percent. This illustrates that updating unit characteristics in the SYSSIM model would be expected to produce simulation results that are within 2.4 percent of those recorded.

Although the above calculations show that the SYSSIM model can predict total hydroelectric generation for three years within approximately three percent of historic data, there still remains a relatively high difference for Hinds Lake Generating Station, even with the adjustments. This difference may be attributable to the assumption made for this study for Hinds Lake tailwater levels. Since the purpose of this study is to test SYSSIM's applicability for matching historic data and estimating average annual hydroelectric energy production, not all details were added to the model. For this study it was assumed that Hinds Lake would have an average, constant, tailwater level. However, it is known that this is not the case. Hinds Lake tailwater level is a function of flow and also a function of the downstream reservoir levels on Grand Lake. A better representation of the tailwater levels should be considered in updating the model.

Simulation results within approximately three percent of historic show that SYSSIM can be an effective tool for estimating long-term energy production. Since it was decided that the comparison was a success, it was decided to proceed with the second phase of the study, which was to compare the SYSSIM model results with NLH's spreadsheet results.

2.2 Spreadsheet Comparison

Since it was shown that the SYSSIM model could simulate hydroelectric generation similar to that recorded, it was decided to compare results from the model with the results from NLH's spreadsheet analysis. The methodology for conducting the spreadsheet comparison was as follows.

- Add Granite Canal and Exploits River Hydro Partnership generating stations to model.
- Modify and develop load for test period.
- Simulate for 10-year period.
- Adjust SYSSIM model results to take into account differences in energy conversion factors.
- Account for difference in spill.
- Compare spreadsheet and SYSSIM results.

The NLH spreadsheet has been developed over a number of years to determine the average annual hydroelectric energy production from all hydroelectric stations. To compare the SYSSIM results with the spreadsheet, the SYSSIM model was updated to include the Granite Canal and Exploits River Hydro Partnership generating stations. As with some other stations, noted above, the generation from the Exploits River Hydro Partnership Generating Station is not modeled directly and the energy reported from SYSSIM is just the average annual energy estimate. However, Granite Canal has been added to the model in detail and is simulated directly.

For the purposes of the spreadsheet comparison, system operation was simulated to start in 2003 for a demand similar to that year. To ensure that results would not be affected by water remaining in storage, the model was run over 10 years for 54 different hydrological sequences and the same demand. The sequences selected represents the period for which hydroelectric records are available for all NLH hydroelectric facilities. For this study existing hydrological records provided by NLH were used; changes recommended to the hydrological record in 2004 were not incorporated for this study. The results of the analysis are presented in Table 3.

As can be seen in Table 3 for the hydro generation summary table, SYSSIM results under estimate hydro generation by 2.6 percent when compared with NLH's spreadsheet results. The percent difference for each of the stations is close, at approximately two to three percent. Granite Canal Generating Station hydroelectric energy generation has been omitted from the comparison due to insufficient operating experience and data; however, it would be expected that when more data are available, the SYSSIM results would match historic and updated spreadsheet results to the same tolerance similar to that presented in this study for the other generating stations.

To further assess the differences in generation, similar to the process above for the historic data comparison, the SYSSIM results were adjusted to take into consideration the difference in energy conversion factor and spill. Modifying the SYSSIM results, however, is no indication that the spreadsheet results are necessarily more accurate; the purpose was to illustrate that when two sets of data are compared and adjustments are made for known data such as energy conversion factors and spill, the differences can be explained. This same exercise could have been done by adjusting the spreadsheet results, but since the historic comparison was completed by adjusting the SYSSIM results, the same was done for this comparison. In fact, when the model is updated to include current energy conversion factors and operations, it would be expected to give better estimates than the spreadsheet, especially for spill.

The first adjustment made was with respect to energy conversion factor. The actual energy conversion factors are slightly different from those presented in Table 2, since these factors represent the long term average, while those presented previously were for a three year period. As can be seen from Table 3, adjusting the SYSSIM energies by energy conversion factor decreases the overall difference from 2.6 percent to 0.5 percent. Adjusting SYSSIM energies to account for the difference in spill further decreases the overall difference, albeit slightly, from 0.5 percent to 0.2 percent. Once all the adjustments are made, the difference in energy for each of the stations is less than one percent.

2.3 Sensitivities

To develop appropriate guidelines for the methodology to be followed when applying SYSSIM to the determination of average annual hydroelectric capability, the sensitivity of the model to three key parameters was tested, as follows.

- Adjustment to starting levels.
- Number of simulation years.
- Years for overdrafting.

As expected, the SYSSIM results showed relatively higher hydroelectric generation in the first couple of years compared to the other years in the 10-year simulation, due to the assumed starting levels. A re-simulation was conducted to smooth the energies for the first two years making sure that the starting levels matched the ending levels.

Since changing the starting level to match ending level removes the concern of slightly higher generation at the beginning of the simulation, a longer period of simulation may not be required. To test this, a 5-year simulation period was chosen and it was shown that there was negligible difference in average hydroelectric energy for this simulation when compared with the 10-year simulation average. Although this result suggests a shorter simulation period can be used, a 10-year simulation is still recommended since difference in simulation time is not significant and there would be more results to average for the 10-year simulation.

The results presented in Table 3 assume no overdrafting (i.e., overdrafting set to 0 years). Overdrafting is the concept of having a draft rate for one year imposed on the hydroelectric system that is higher than the sustainable yield by relying on other sources of energy within the system available to satisfy demand (i.e., thermal resources). Overdrafting is a riskier strategy than demanding a sustainable draft rate from the hydroelectric system because if generating at the higher rate means that the hydroelectric system is unable to generate the sustainable yield in the following year, the difference must be made up with thermal generation.

To test the sensitivity overdrafting may have on the average annual hydroelectric energy production, overdrafting was set to 1 year, 2 years, and 5 years. It was shown that the results are the same for each simulation with overdrafting and the difference between this value was negligible when compared to the result with no overdrafting. Since overdrafting did not affect the results, any future analysis should be conducted using no overdrafting. It should be noted; however, that overdrafting was tested for a constant load, and that a varying or increasing load was not tested. Overdrafting would be a much larger concern if SYSSIM is being used for long term generation expansion planning. In the present application, the results would not be expected to be sensitive to overdrafting, and the overdrafting period should be set to zero (i.e., eliminated).

3 Implementation

As shown in the previous section, once appropriate adjustments were made to account for the differences in energy conversion factor, water remaining in storage, and spill, the energies produced by SYSSIM matched those historically recorded for a short term period and also long term average generation from the NLH spreadsheet. This shows that both approaches are reasonable for estimating average annual hydroelectric energy production. However, due to SYSSIM's sophisticated capabilities and better assessment of spill in the system, it is recommended as an appropriate model for NLH to use to estimate average annual hydroelectric energy production.

To implement the use of SYSSIM for this purpose, the SYSSIM code requires updating to newer operating platforms. The model input data should also be updated to reflect current power plant characteristics and operational procedures, as follows.

- Review and update all power plant characteristics (including tailwater levels, especially at Hinds Lake).
- Review and update all fishery releases, as required.
- Review and update all structure curves, reservoir rule curves, and priorities, as required.
- Add generation systems to the model, as required to better match historic generation, that are not currently being simulated directly.

Once SYSSIM has been updated to represent the existing NLH configuration, the model should be used to simulate a number of years for which historic data are available and a comparison conducted, similar to the one conducted for this study. This comparison should also be done monthly for at least one year to ensure that the model is reflecting NLH's actual operating decisions. Any differences should be examined and the model data should be revised accordingly. At that point, the model will be ready for implementation and the following methodology should be employed to estimate average annual hydroelectric energy production.

- Estimate demand for forecast year.
- Assume no overdrafting.
- Simulate model for 10 years with forecast year demand in all years, and using all hydrological sequences (1950 and onward).
- Enter starting levels to match ending levels.
- Simulate.
- Calculate average annual hydroelectric energy production for each station over 10 years.

4 Conclusions and Recommendations

To conclude, the SYSSIM model has been shown to reasonably replicate historic energy production and predicted long term average annual hydroelectric energy production. Therefore, we recommend that NLH use SYSSIM to estimate average annual hydroelectric energy production. Prior to implementing SYSSIM for this purpose, the model should be updated to reflect current power plant characteristics and operational strategies, and the software should be upgraded to current operating platforms. The updated model should be compared with historic data prior to implementation. Once implemented, the model should be reviewed every five years, or if major changes are made to the system, to ensure the model continues to reflect NLH's configuration and operating polices.

Yours very truly,

S. H. Richter, P.Eng.
Senior Hydrotechnical Engineer

RDW:sjc

Attachments

Table 1

Historic Data Comparison Results - Unadjusted SYSSIM Output

STATIONS	1999/2000		2000/2001		2001/2002		Total		
	Actual	SYSSIM	Actual	SYSSIM	Actual	SYSSIM	Actual	SYSSIM	Difference
HYDRO GENERATION									
Bay D'Espoir	3,049.8	2,936.1	2,924.8	2,763.8	2,220.7	2,177.6	8,195.3	7,877.5	-3.9%
Hinds Lake	373.1	331.6	365.0	327.5	323.8	300.3	1,061.9	959.4	-9.7%
Upper Salmon	652.6	652.2	605.1	575.2	465.9	460.1	1,723.6	1,687.5	-2.1%
Cat Arm	816.2	786.8	786.1	736.5	673.2	606.6	2,275.5	2,129.9	-6.4%
SUB TOTAL SIMULATED HYDRO GENERATION	**4,891.7**	**4,706.7**	**4,681.0**	**4,403.0**	**3,683.6**	**3,544.6**	**13,256.3**	**12,654.3**	**-4.5%**
Paradise River	35.6	-	32.5	-	31.8	-	-	-	-
Mini Hydro Sites	5.5	-	4.3	-	5.8	-	-	-	-
Star Lake	139.6	-	141.1	-	139.8	-	-	-	-
Rattle Brook	17.6	-	14.4	-	13.4	-	-	-	-
Other	-	193.9	-	193.9	-	193.9	581.4	581.7	0.0%
TOTAL HYDRO GENERATION	**5,090.0**	**4,900.6**	**4,873.3**	**4,596.9**	**3,874.4**	**3,738.5**	**13,837.7**	**13,236.0**	**-4.3%**
THERMAL GENERATION									
Holyrood Thermal	1,059.7	1,140.3	1,531.5	1,652.8	2,580.6	2,480.1	5,171.8	5,273.2	
GNP Diesel	0.4	0.0	0.2	0.0	0.4	11.0	1.0	11.0	
Hardwoods GT	0.8	15.8	0.2	37.0	0.2	65.5	1.2	118.3	
Holyrood GT	0.2	0.0	0.1	0.0	0.1	6.0	0.4	6.0	
Stephenville GT	0.2	83.7	0.0	115.7	0.0	155.3	0.2	354.7	
TOTAL THERMAL GENERATION	**1,061.3**	**1,239.8**	**1,532.0**	**1,805.5**	**2,581.3**	**2,717.9**	**5,174.6**	**5,763.2**	
SYSTEM GROSS GENERATION	**6,151.3**	**6,140.4**	**6,405.3**	**6,402.4**	**6,455.7**	**6,456.4**	**19,012.3**	**18,999.2**	

***Notes:** Simulations start June 1 of the first year and end May 31 of the second year.*

Other SYSSIM Hydro Generation is subtotal of Paradise River, Mini Hydro Sites, Star Lake, and Rattle Brook. Generation from these facilities were forced to match actual to facilitate comparison of major reservoir simulations to actual operations.

Table 2

Historic Data Comparison Results - Adjusted SYSSIM Output

STATIONS	1999/2000		2000/2001		2001/2002		Total		
	Actual	SYSSIM	Actual	SYSSIM	Actual	SYSSIM	Actual	SYSSIM	Difference
HYDRO GENERATION									
Bay D'Espoir	3,049.8	2,981.9	2,924.8	2,806.9	2,220.7	2,211.5	8,195.3	8,000.3	-2.4%
Hinds Lake	373.1	343.2	365.0	338.9	323.8	310.8	1,061.9	992.9	-6.5%
Upper Salmon	652.6	656.1	605.1	578.6	465.9	462.8	1,723.6	1,697.5	-1.5%
Cat Arm	816.2	828.6	786.1	775.7	673.2	638.9	2,275.5	2,243.2	-1.4%
SUB TOTAL SIMULATED HYDRO GENERATION	4,891.7	4,809.8	4,681.0	4,500.1	3,683.6	3,624.0	13,256.3	12,933.9	-2.4%
Paradise River	35.6	-	32.5	-	31.8	-	-	-	-
Mini Hydro Sites	5.5	-	4.3	-	5.8	-	-	-	-
Star Lake	139.6	-	141.1	-	139.8	-	-	-	-
Rattle Brook	17.6	-	14.4	-	13.4	-	-	-	-
Other	-	193.9	-	193.9	-	193.9	581.4	581.7	0.0%
TOTAL HYDRO GENERATION	5,090.0	5,003.6	4,873.3	4,694.0	3,874.4	3,817.9	13,837.7	13,515.6	-2.3%

Note: Results are a product of adjustments to raw data in Table 1 based on difference in energy conversion factors.

Storage Adjustment

RESERVOIR	Ending Water Level		Storage (mcm)		Adjustment	
	Actual	SYSSIM	Actual	SYSSIM	cms	GWh
Victoria	323.9	322.9	827.1	668.0	(1.7)	(29.8)
Meelpaeg	265.9	265.5	1,260.0	1,145.1	(1.2)	(21.6)
Cold Spring	241.4	241.3	94.1	87.8	(0.1)	(1.2)
Long Pond	181.3	182.1	550.6	722.5	1.8	24.9
Cat Arm	389.5	388.8	254.0	220.6	(0.4)	(10.1)
Hinds Lake	308.8	309.7	145.6	189.1	0.5	7.8
					Difference	(30.0)

Energy Conversion Factors (GWh/cms)

STATIONS	Conversion Factor	
	Actual	SYSSIM
Bay D'Espoir	13.685	13.475
Hinds Lake	17.030	16.455
Upper Salmon	4.061	4.037
Cat Arm	28.497	27.058

Table 3

Spreadsheet Comparison Results

Hydro Generation Summary

STATIONS	2003 - 2012 (10 Year Period)		Percent Different (%)
	NLH	SYSSIM	
SIMULATED HYDRO GENERATION			
Bay D'Espoir	2,602.0	2,533.0	-2.7%
Hinds Lake	340.0	328.3	-3.4%
Upper Salmon	551.0	539.8	-2.0%
Cat Arm	707.0	691.1	-2.2%
TOTAL HYDRO GENERATION	**4,200.0**	**4,092.2**	**-2.6%**

Energy Conversion Adjustment

STATIONS	2003 - 2012 (10 Year Period)		Percent Different (%)
	NLH	SYSSIM	
SIMULATED HYDRO GENERATION			
Bay D'Espoir	2,602.0	2,569.8	-1.2%
Hinds Lake	340.0	338.6	-0.4%
Upper Salmon	551.0	546.9	-0.7%
Cat Arm	707.0	725.2	2.6%
TOTAL HYDRO GENERATION	**4,200.0**	**4,180.6**	**-0.5%**

Energy Conversion Factors (GWh/cms)

STATIONS	Conversion Factor		Percent Different (%)
	Actual	SYSSIM	
Bay D'Espoir	13.671	13.475	-1.4%
Hinds Lake	16.973	16.455	-3.1%
Upper Salmon	4.090	4.037	-1.3%
Cat Arm	28.395	27.058	-4.7%

Spill Adjustment

STATIONS	2003 - 2012 (10 Year Period)		Percent Different (%)
	NLH	SYSSIM	
SIMULATED HYDRO GENERATION			
Bay D'Espoir	2,602.0	2,590.8	-0.4%
Hinds Lake	340.0	337.8	-0.7%
Upper Salmon	551.0	552.2	0.2%
Cat Arm	707.0	709.3	0.3%
TOTAL HYDRO GENERATION	**4,200.0**	**4,190.1**	**-0.2%**

Spillway Summary

SPILLWAY	2003 - 2012 (10 Year Period)		Energy Adjustment (GWh/yr)
	NLH	SYSSIM	
AVERAGE SPILL (cms)			
Salmon River (Chn 3)	0.41	0.00	-5.6
Upper Salmon (Chn 7)	0.63	0.00	-2.6
Burnt Pond (Chn 22)	0.87	1.08	3.7
Victoria Lake (Chn 21)	0.05	0.00	-0.9
West Salmon (Chn 13)	1.95	1.95	0.0
Grey Reservoir/ Pudops (Chn 14)	0.41	1.42	17.9
White Bear River (Chn 15)	0.65	1.42	13.7
Cat Arm Spill (Chn 66)	0.60	0.04	-15.9
Hinds Lake Spill (Chn 74/ Chn 75)	0.46	0.41	-0.8
TOTAL SPILL	**6.03**	**6.32**	**9.5**

Average Energy Summary

NLH Total Generation	4,200.0	GWh/yr
SYSSIM Total Generation	4,092.2	GWh/yr
SYSSIM Energy Conversion Adjustment	4,180.6	GWh/yr
SYSSIM Spill Adjustment	4,190.1	GWh/yr

Final Percent Difference ---------------------------> -0.2%

SGE Acres

Office Memorandum

To Susan Richter

Date July 11, 2006

File No. H-322028

From Amy Pryse-Phillips

cc

Subject **NL Hydro ARSP Model Update - Estimating Spill**

NL Hydro is in the process of updating the ARSP models of its various hydro systems; the current analysis deals with the representation of spill in these models. Load-related spill should be captured by SYSSIM and hence is not a concern, but spill that occurs due to flashy reservoirs must be estimated and then included as a demand channel in ARSP so that generation is not overestimated. Burnt, Paradise, and Granite reservoirs are prone to intra-month spill, and the objective of this study is to develop a methodology for estimating the spill that occurred prior to the period of record for each spillway. All analysis was done on monthly inflow and spill data.

Spill has been recorded for each spillway for varying periods. The overlapping period of measured inflow and spill was analysed to determine if a suitable relationship could be developed between the two. It should be noted that the spill record was adjusted by NL Hydro to remove any spill caused by load limitations. A preliminary analysis considered relationships between spill and current month inflow, previous month inflow, and annual inflow (and various combinations). Neither the previous month inflow nor the annual inflow showed any promise, and were dropped from the analysis.

The available overlapping inflow and spill records for the Burnt and Paradise Spillways are sufficiently long that the methods presented herein for the estimation of spill need not be re-developed annually, but perhaps every five years or so as more data become available. There are only three years of spill data for the Granite Bypass and Granite Overflow Spillways and hence spill estimation methods should be reassessed on an annual basis as more spill data are collected.

The following sections describe the analysis of the inflow/spill correlation for each spill channel (Burnt, Paradise, Granite Bypass, and Granite Overflow) and the method recommended for the estimation of historic spill.

1 Burnt Spillway

1.1 Inflow/Spill Correlation

Monthly spill data are available since 1975, providing over 30 years of overlapping spill and inflow data from which to analyse the relationship. Figure 1 presents this data; it is apparent that the correlation between spill and inflow is poor. A seasonal analysis was also performed to determine if the relationship was any better on a seasonal basis but it was not.

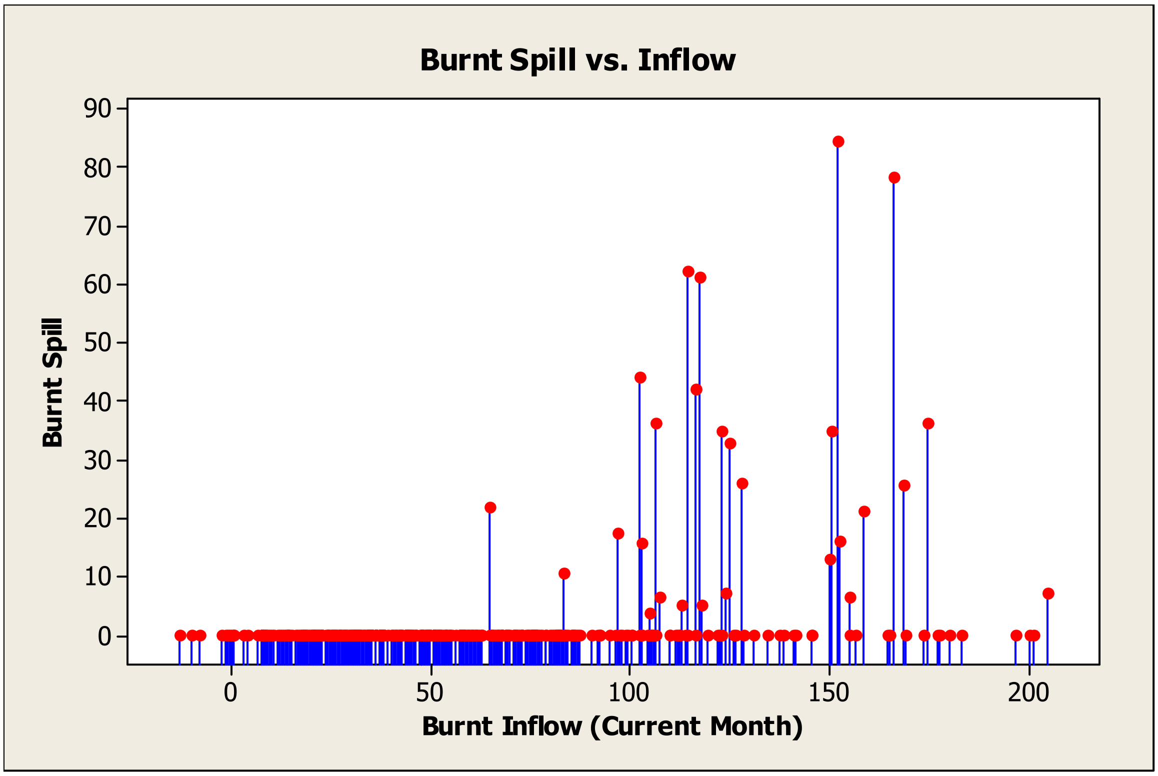


Figure 1 - Burnt Inflow/Spill Plot

As shown in Figure 1, spill generally occurs when the inflow is greater than 100 $m^3 \times 10^6$; however it does not necessarily occur when the flow is in this range. There was spill in one-third of all months with inflow greater than 100 $m^3 \times 10^6$.

1.2 Method of Spill Estimation

The occurrence of spill for inflows greater than 100 $m^3 \times 10^6$ appears random, as does the amount of spill that occurs. To generate spill values prior to the period of record, a systematic approach was adopted. The requirement is to determine if spill did occur, and if so, the amount of spill that occurred. The objective is to develop a representative sequence of spills, not to attempt to determine exactly how much would have occurred or exactly when. The occurrence of spill was randomly allocated such that there was a 33 percent probability of spill in any month with inflow greater than 100 $m^3 \times 10^6$ (this corresponds to the fraction of months in which spill occurred out of all months with inflow greater than 100 $m^3 \times 10^6$). The amount of spill was determined by randomly generating a value based on the assumed distribution of the measured spill data set. This has the advantage over simply taking an average spill value in that some natural variability is maintained. Several distributions were fit to the series of measured spill data and the Weibull distribution was found to provide the best fit, based on the Anderson Darling test statistic. Distribution parameters were estimated using the method of maximum likelihood.

The generated spill for the period of record (1975 to 2005) compares well with the measured spill for this period. Figure 2 illustrates this comparison (on a monthly and annual average basis) as well as the generated spill over the full period. A table of generated spill values from 1950 to 2005 is attached.

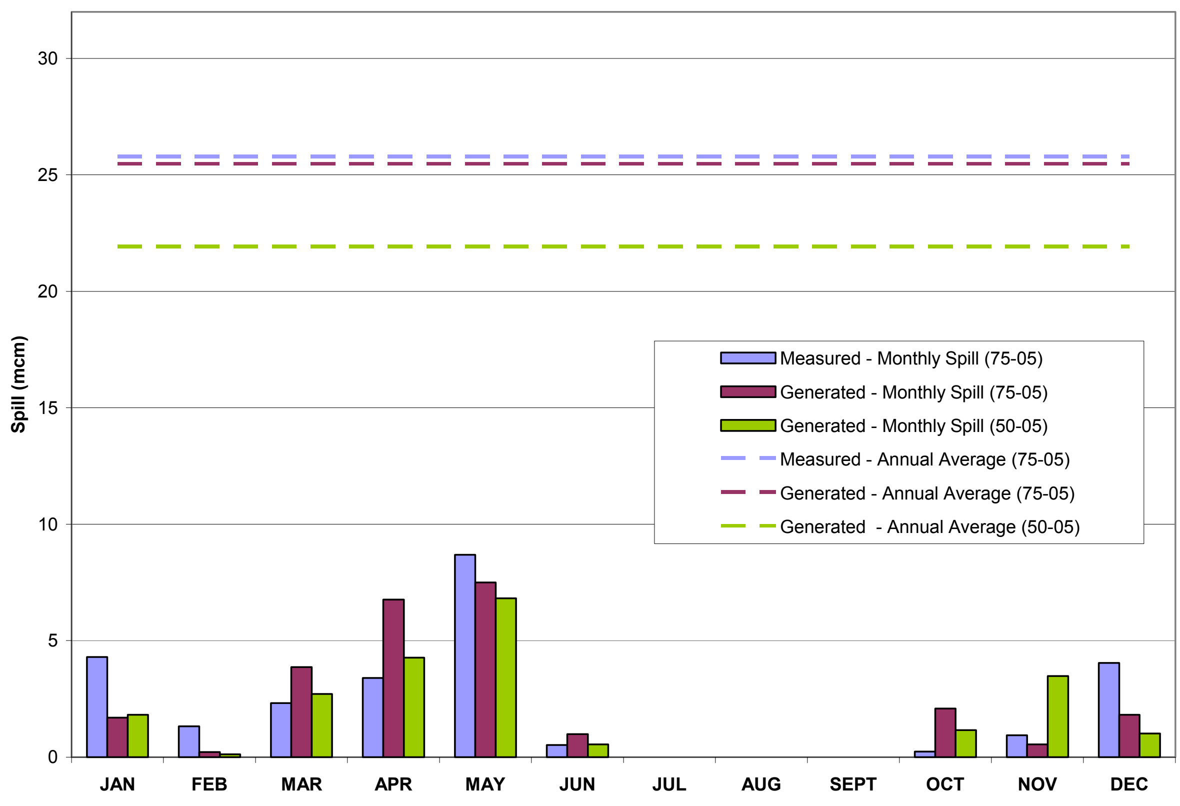


Figure 2 - Burnt Comparison of Measured and Generated Spill Series

2 Paradise Spillway

2.1 Inflow/Spill Correlation

Monthly spill data are available since 1990, providing 16 years of overlapping spill and inflow data from which to analyse the relationship. Figure 3 is a plot of inflow and spill; it suggests there may be a significant relationship between the two.

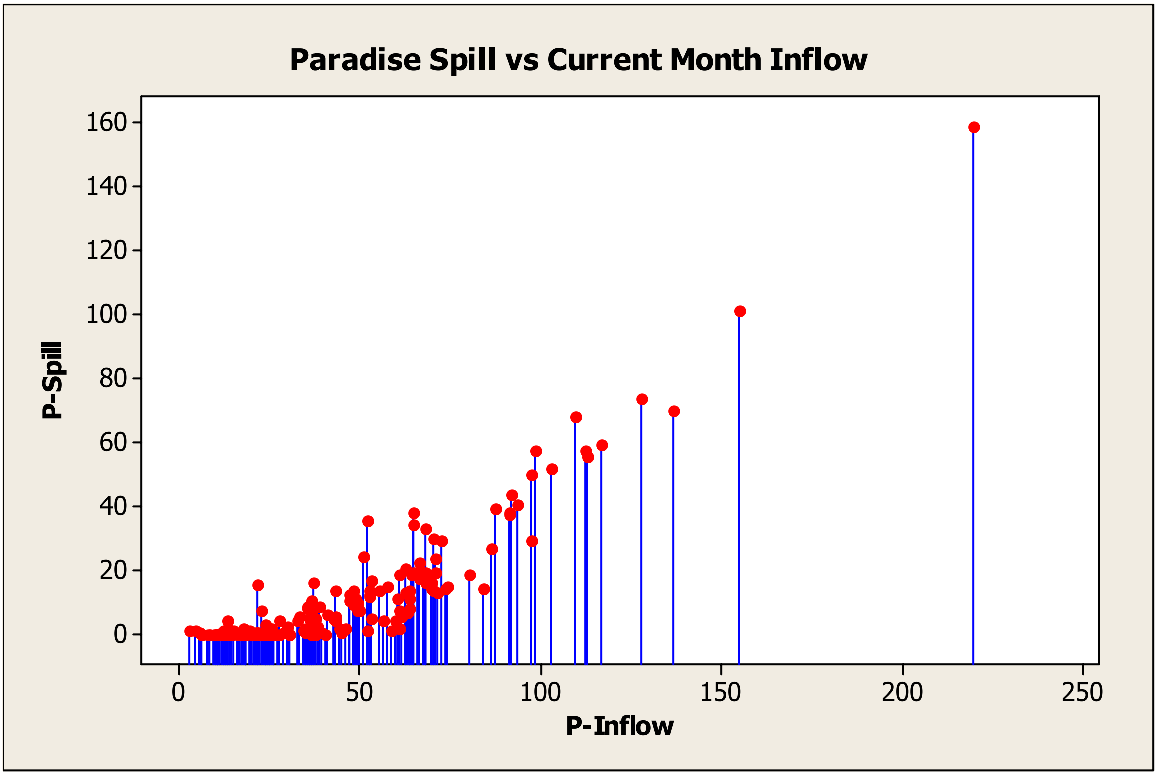


Figure 3 - Paradise Inflow/Spill Plot

Though the regression of the entire spill/inflow data set was significant, a higher significance level was achieved when a specific range of flows was considered. Figure 4 shows the same data as the above plot, separated into three flow ranges. As shown, the regression result for flows greater than 65 $m^3 \times 10^6$ is higher than the overall regression result (R-squared of 0.94 versus 0.81). The regression was not significant for the lower two flow ranges.

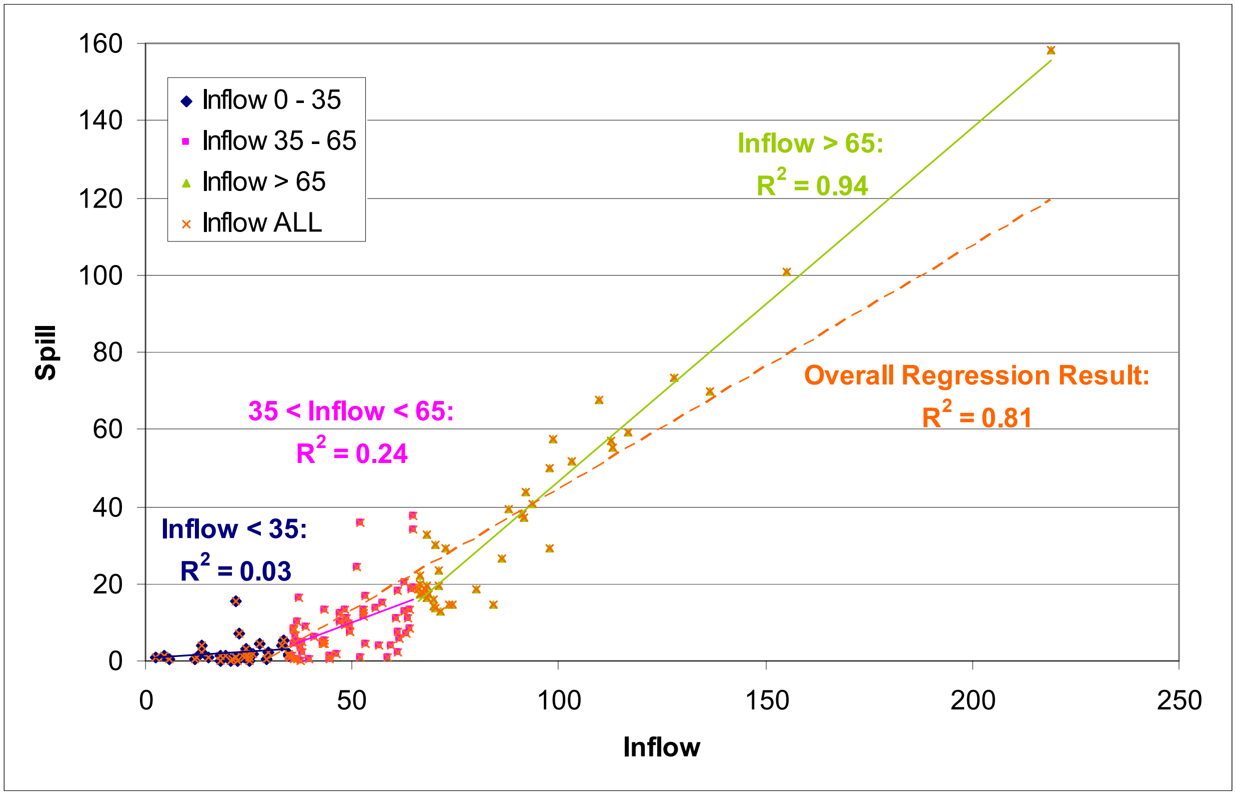


Figure 4 - Paradise Inflow/Spill Plot - by flow range

2.2 Method of Spill Estimation

Over the 16 years in which recorded spill data are available, spill occurred in 37 percent of the months when inflow was less than 35 $m^3 \times 10^6$, 97 percent of the months when inflow was between 35 and 65 $m^3 \times 10^6$, and 100 percent of the months when inflow was greater than 65 $m^3 \times 10^6$. Table 1 summarizes the method of estimating spill for each of the three flow ranges.

Table 1 - Paradise Spill Estimation

Flow Range ($m^3 \times 10^6$)	Percent of Months with Spill (Applied Randomly)	Spill Estimate ($m^3 \times 10^6$)
Inflow < 35	37	2.1
35 < Inflow < 65	100	9.4
Inflow > 65	100	0.92*Inflow – 45

A table of generated spill values from 1950 to 2005 is attached.

3 Granite Bypass Spillway

3.1 Inflow/Spill Correlation

Spill data are available only since 2003, providing only three years of overlapping inflow and spill data from which to form a relationship. Figure 5 is a plot of inflow and spill. Ignoring the two small spill occurrences for inflows close to 60 $m^3 \times 10^6$, spill generally (but not necessarily) occurs when the inflow is greater than about 110 $m^3 \times 10^6$.

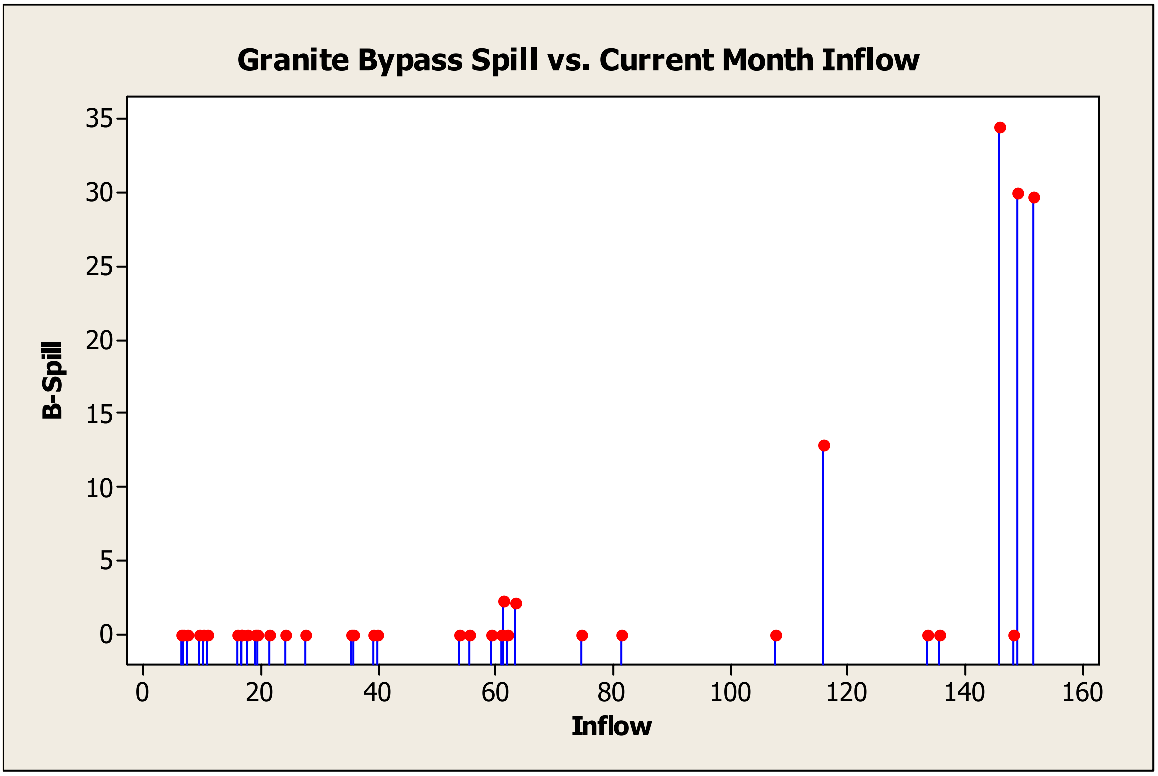


Figure 5 - Granite Inflow/Spill Plot

3.2 Method of Spill Estimation – Granite Bypass

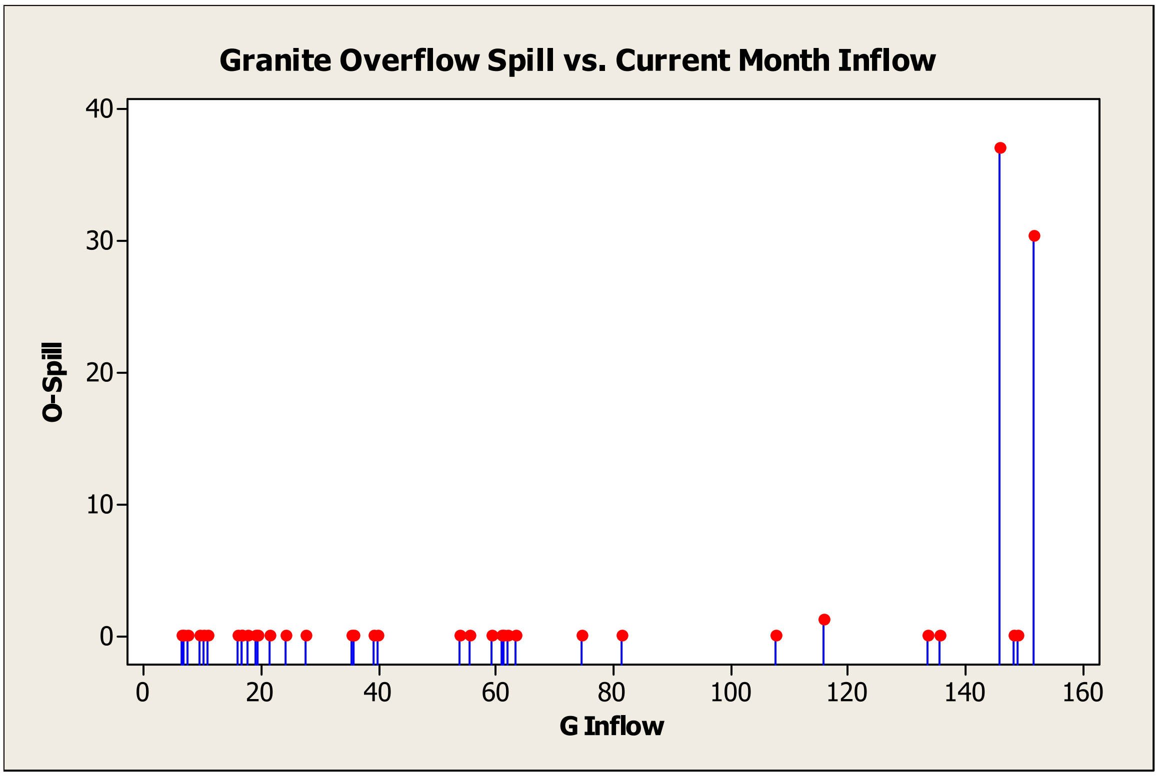
Though regression analysis shows some promise, there is very little data and hence a simple method of spill estimation was applied. An average flow value of 27 $m^3 \times 10^6$ was applied randomly to 57 percent of months with inflow greater than 110 $m^3 \times 10^6$ (this percentage corresponds to four historic spill occurrences out of seven months). This method of spill estimation should be reviewed on an annual basis.

A table of generated spill values from 1950 to 2005 is attached.

4 Granite Overflow Spillway

4.1 Inflow/Spill Correlation – Granite Overflow

As for Granite Bypass Spillway, spill data are available since 2003, providing only three years of overlapping inflow and spill data. Figure 6 is a plot of inflow and spill. Over the three years of recorded spill data, spill has generally occurred when the current month inflow was greater than 140 $m^3 \times 10^6$. Monthly inflow in this range has occurred four times, and spill occurred in two of these months.



4.2 Method of Spill Estimation

Again, a simple method of spill estimation was applied for Granite Overflow Spillway since there are only three years of data available at this time. An average flow value of 34 $m^3 \times 10^6$ was applied randomly to 50 percent of the months in which inflow was greater than 140 $m^3 \times 10^6$. A table of generated spill values from 1950 to 2005 is attached.

This method of spill estimation should also be reviewed on an annual basis.

5 Discussion

Burnt and Paradise Spillways have sufficiently long overlapping inflow and spill records such that the relationship between the two may be meaningfully analysed. These spill sequences and methodology provided in this memo need not be re-developed annually, but perhaps every five years or so, as more data are accumulated.

There are only three years of spill data for the Granite Bypass and Overflow Spillways and hence there is more uncertainty in these spill estimates. Simpler methods of estimating spill prior to the period of record were applied, and it is recommended that these methods be reassessed on an annual basis as more spill data are collected.

The methods used herein to estimate spill prior to the period of record for each spillway involve a random component and hence the estimated spill series will be different every time the method is applied even using the same data set.

BURNT SPILLWAY SPILLS

GENERATED SPILL

L:\H-322028 - NLH ARSP Calibration Review\Hydrotechnical\aprysephillips\Burnt\[Burnt - Estimated Spill.xls]generated spill

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	Total
	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	
1950	0.0	0.0	0.0	0.0	13.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5
1951	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.1	0.0	17.1
1952	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.9	0.0	11.9
1953	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1954	0.0	0.0	31.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.7
1955	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1956	49.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49.3
1957	0.0	0.0	0.0	0.0	15.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.1
1958	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1959	0.0	0.0	0.0	0.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4
1960	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1961	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1962	0.0	0.0	0.0	17.7	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.0
1963	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1964	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1965	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1966	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1967	0.0	0.0	0.0	0.0	64.1	0.0	0.0	0.0	0.0	0.0	103.7	0.0	167.7
1968	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1969	0.0	0.0	0.0	0.0	18.9	0.0	0.0	0.0	0.0	0.0	0.0	0.5	19.5
1970	0.0	0.0	0.0	0.0	11.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.8
1971	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.3	0.0	45.3
1972	0.0	0.0	0.0	0.0	0.0	0.0	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	0.0	0.0	0.0	0.0	0.0	0.0
1974	0.0	0.0	0.0	11.7	13.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.2
1975	0.0	0.0	0.0	0.0	0.0	0.0	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	0.0	0.0	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0	44.1	0.0	0.0	0.0	0.0	33.6	0.0	0.0	77.7
1978	52.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.4
1979	0.0	0.0	54.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.7
1980	0.0	0.0	0.0	61.1	55.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	116.6
1981	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	13.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.1
1983	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8
1985	0.0	0.0	0.0	0.0	0.0	30.6	0.0	0.0	0.0	0.0	0.0	0.0	30.6
1986	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1987	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0
1988	0.0	0.0	23.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.5
1989	0.0	0.0	0.0	0.0	13.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2
1990	0.0	0.0	0.0	83.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.2	125.6
1991	0.0	0.0	0.0	0.0	10.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4
1992	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7
1997	0.0	0.0	0.0	0.0	17.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.6
1998	0.0	0.0	41.8	38.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.3
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7
2001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2002	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2003	0.0	0.0	0.0	0.0	61.6	0.0	0.0	0.0	0.0	31.2	0.0	14.1	106.9
2004	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	5.8	16.3	0.0	0.0	0.0	0.0	0.0	16.9	0.0	39.0
Averages													
Generated 1975-2005	**1.7**	**0.2**	**3.9**	**6.8**	**7.5**	**1.0**	**0.0**	**0.0**	**0.0**	**2.1**	**0.5**	**1.8**	**25.5**
Measured 1975-2005	**4.3**	**1.3**	**2.3**	**3.4**	**8.7**	**0.5**	**0.0**	**0.0**	**0.0**	**0.2**	**0.9**	**4.0**	**25.8**
Generated 1950-2005	**1.8**	**0.1**	**2.7**	**4.3**	**6.8**	**0.5**	**0.0**	**0.0**	**0.0**	**1.2**	**3.5**	**1.0**	**21.9**

PARADISE SPILLWAY

GENERATED SPILL

Drainage Area 476.5 square kilometers

L:\H-322028 - NLH ARSP Calibration Review\Hydrotechnical\aprysephillips\Paradise\[Paradise Spill Analysis.xls]generated spill

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	Total
	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	
1953	9.4	9.4	9.4	49.9	2.1	0.0	0.0	0.0	0.0	9.4	9.4	21.2	120.2
1954	9.4	37.0	27.3	9.4	9.4	0.0	2.1	0.0	2.1	9.4	9.4	32.9	148.4
1955	33.3	9.4	9.4	9.4	9.4	9.4	2.1	0.0	0.0	20.2	37.0	9.4	149.0
1956	43.8	2.1	9.4	71.3	9.4	0.0	2.1	2.1	0.0	2.1	27.1	15.0	184.4
1957	9.4	2.1	9.4	9.4	9.4	2.1	0.0	0.0	21.0	9.4	9.4	31.7	113.3
1958	9.4	0.0	9.4	0.0	0.0	2.1	0.0	0.0	9.4	9.4	15.5	9.4	64.6
1959	2.1	0.0	0.0	40.1	9.4	0.0	0.0	0.0	2.1	0.0	35.3	9.4	98.4
1960	2.1	9.4	2.1	29.0	31.7	0.0	0.0	2.1	0.0	2.1	9.4	0.0	87.9
1961	0.0	0.0	9.4	32.8	38.9	0.0	2.1	0.0	2.1	0.0	0.0	0.0	85.3
1962	2.1	83.2	65.2	38.0	0.0	0.0	0.0	0.0	2.1	9.4	36.8	9.4	246.2
1963	81.2	0.0	0.0	55.1	20.0	9.4	0.0	2.1	9.4	0.0	9.4	9.4	196.0
1964	0.0	9.4	0.0	110.8	9.4	0.0	2.1	2.1	0.0	25.3	9.4	9.4	177.9
1965	9.4	0.0	25.8	37.8	9.4	0.0	2.1	0.0	0.0	0.0	17.7	0.0	102.2
1966	0.0	2.1	9.4	60.1	9.4	0.0	2.1	0.0	2.1	0.0	9.4	27.3	121.9
1967	9.4	9.4	9.4	9.4	100.5	2.1	2.1	2.1	2.1	0.0	9.4	9.4	165.3
1968	9.4	18.8	31.3	0.0	9.4	9.4	0.0	9.4	0.0	2.1	9.4	9.4	108.6
1969	0.0	60.8	16.7	15.9	9.4	2.1	0.0	0.0	9.4	9.4	23.1	57.3	204.1
1970	2.1	26.9	66.4	9.4	0.0	0.0	2.1	9.4	0.0	9.4	22.4	20.6	168.7
1971	0.0	44.3	9.4	82.8	0.0	0.0	0.0	0.0	0.0	0.0	27.3	9.4	173.2
1972	9.4	0.0	25.5	9.4	23.2	0.0	0.0	0.0	2.1	9.4	20.0	2.1	101.1
1973	0.0	22.8	2.1	18.3	32.7	9.4	9.4	9.4	2.1	9.4	26.2	9.4	151.2
1974	2.1	2.1	0.0	32.4	9.4	0.0	2.1	0.0	0.0	37.5	9.4	25.2	120.2
1975	0.0	2.1	0.0	66.4	17.0	2.1	0.0	2.1	2.1	9.4	15.5	20.8	137.5
1976	47.5	9.4	9.4	34.5	2.1	0.0	2.1	0.0	0.0	9.4	9.4	26.2	150.0
1977	16.4	0.0	9.4	22.3	9.4	2.1	0.0	0.0	0.0	9.4	2.1	31.7	102.8
1978	68.1	0.0	9.4	31.5	9.4	2.1	0.0	0.0	0.0	9.4	0.0	2.1	132.0
1979	27.3	9.4	28.5	0.0	0.0	2.1	2.1	2.1	0.0	9.4	9.4	9.4	99.7
1980	0.0	2.1	9.4	86.8	28.3	9.4	9.4	9.4	9.4	9.4	44.6	9.4	227.6
1981	19.8	9.4	9.4	9.4	9.4	0.0	9.4	0.0	9.4	63.6	16.4	9.4	165.6
1982	9.4	0.0	9.4	76.3	41.6	0.0	0.0	0.0	0.0	2.1	0.0	26.5	165.3
1983	55.3	0.0	78.4	9.4	2.1	0.0	2.1	0.0	9.4	0.0	9.4	9.4	175.5
1984	53.5	52.4	9.4	36.4	20.0	2.1	2.1	2.1	16.0	0.0	0.0	9.4	203.4
1985	0.0	0.0	0.0	9.4	50.9	2.1	9.4	2.1	0.0	0.0	0.0	0.0	73.9
1986	24.0	2.1	9.4	97.1	2.1	0.0	2.1	2.1	2.1	9.4	9.4	2.1	161.9
1987	0.0	2.1	15.5	80.5	9.4	0.0	2.1	0.0	2.1	2.1	21.1	9.4	144.3
1988	2.1	93.9	106.4	38.4	9.4	9.4	9.4	2.1	0.0	2.1	9.4	0.0	282.6
1989	9.4	0.0	0.0	48.1	9.4	0.0	2.1	0.0	2.1	9.4	9.4	0.0	89.9
1990	9.4	9.4	9.4	97.7	9.4	15.6	2.1	2.1	0.0	9.4	9.4	23.3	197.2
1991	0.0	9.4	19.3	9.4	2.1	0.0	0.0	0.0	2.1	17.0	9.4	0.0	68.7
1992	9.4	0.0	45.5	17.6	17.2	0.0	0.0	0.0	0.0	9.4	2.1	9.4	110.6
1993	0.0	19.6	9.4	28.8	9.4	0.0	9.4	2.1	2.1	34.5	17.7	9.4	142.4
1994	9.4	0.0	58.6	62.6	9.4	2.1	0.0	0.0	2.1	0.0	9.4	2.1	155.7
1995	17.6	2.1	39.3	49.9	2.1	2.1	0.0	0.0	9.4	9.4	17.9	9.4	159.2
1996	9.4	9.4	9.4	2.1	2.1	2.1	9.4	0.0	0.0	9.4	9.4	9.4	72.1
1997	9.4	0.0	0.0	44.9	32.3	0.0	0.0	0.0	9.4	9.4	9.4	9.4	124.2
1998	0.0	9.4	9.4	80.7	2.1	0.0	2.1	0.0	9.4	9.4	9.4	9.4	141.3
1999	20.2	16.2	19.7	16.2	2.1	0.0	0.0	0.0	0.0	20.1	9.4	2.1	106.0
2000	44.8	0.0	19.0	9.4	9.4	0.0	0.0	9.4	0.0	9.4	9.4	9.4	120.2
2001	2.1	0.0	9.4	55.9	9.4	0.0	0.0	2.1	9.4	0.0	9.4	9.4	107.1
2002	9.4	9.4	39.5	9.4	0.0	2.1	0.0	0.0	0.0	9.4	21.8	9.4	110.4
2003	0.0	9.4	2.1	38.8	9.4	2.1	2.1	0.0	2.1	59.1	9.4	20.8	155.3
2004	0.0	0.0	0.0	156.8	2.1	0.0	0.0	0.0	9.4	9.4	16.0	41.2	234.9
2005	9.4	9.4	0.0	72.7	0.0	0.0	0.0	2.1	9.4	9.4	22.5	35.7	170.6
Averages													
Generated 1990-2005	**9.4**	**6.5**	**18.1**	**47.1**	**7.4**	**1.6**	**1.6**	**1.1**	**4.1**	**14.0**	**12.0**	**13.1**	**136.0**
Measured 1990-2005	**9.6**	**12.1**	**17.6**	**45.2**	**5.9**	**1.5**	**1.0**	**1.8**	**7.6**	**10.8**	**9.8**	**11.3**	**134.2**
Generated 1953-2005	**13.7**	**12.0**	**17.8**	**40.2**	**13.0**	**2.0**	**2.0**	**1.5**	**3.5**	**10.3**	**13.8**	**13.3**	**142.9**

GRANITE BYPASS SPILLWAY

GENERATED SPILL

Drainage Area 503 square kilometers

L:\H-322028 - NLH ARSP Calibration Review\Hydrotechnical\aprysephillips\Granite\[Granite Bypass Spill Analysis.xls]TABLE FOR MEMO

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	Total
	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM
1950	0	0	0	0	27	0	0	0	0	0	0	0	27.0
1951	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1961	0	0	0	0	27	0	0	0	0	0	0	0	27.0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1963	0	0	0	0	27	0	0	0	0	0	0	0	27.0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1969	0	0	0	0	27	0	0	0	0	0	0	27	54.0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1971	0	0	0	27	0	0	0	0	0	0	0	0	27.0
1972	0	0	0	0	27	0	0	0	0	0	0	0	27.0
1973	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
1975	0	0	0	0	27	0	0	0	0	0	0	0	27.0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1981	0	0	0	0	27	0	0	0	0	0	0	0	27.0
1982	0	0	0	0	27	0	0	0	0	0	0	0	27.0
1983	27	0	0	0	0	0	0	0	0	0	0	0	27.0
1984	0	0	0	0	27	0	0	0	0	0	0	0	27.0
1985	0	0	0	0	0	27	0	0	0	0	0	0	27.0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1990	0	0	0	0	27	0	0	0	0	0	0	0	27.0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1994	0	0	0	0	27	0	0	0	0	0	0	0	27.0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1997	0	0	0	0	27	0	0	0	0	0	0	0	27.0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0.0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0.0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0.0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0.0
2003	0	0	0	27	0	0	0	0	0	27	0	0	54.0
2004	0	0	0	27	27	0	0	0	0	0	0	0	54.0
2005	0	0	0	0	0	0	0	0	0	0	27	0	27.0
Averages													
Generated 2003-2005	**0.0**	**0.0**	**0.0**	**18.0**	**9.0**	**0.0**	**0.0**	**0.0**	**0.0**	**9.0**	**9.0**	**0.0**	**45.0**
Measured 2003-2005	**0.0**	**0.0**	**0.0**	**0.0**	**14.3**	**0.0**	**0.0**	**0.0**	**0.0**	**12.2**	**9.9**	**0.7**	**37.1**
Generated 1950-2005	**0.5**	**0.0**	**0.0**	**1.4**	**6.3**	**0.5**	**0.0**	**0.0**	**0.0**	**0.5**	**0.5**	**0.5**	**10.1**

GRANITE OVERFLOW SPILLWAY

GENERATED SPILL

Drainage Area 503 square kilometers

L:\H-322028 - NLH ARSP Calibration Review\Hydrotechnical\aprysephillips\Granite\[Granite Bypass Spill Analysis.xls]TABLE FOR MEMO

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	Total
	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM	MCM
1950	0	0	0	0	34	0	0	0	0	0	0	0	34.0
1951	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1967	0	0	0	0	34	0	0	0	0	0	0	0	34.0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1972	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
1974	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
1976	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0.0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0.0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0.0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0.0
2003	0	0	0	0	34	0	0	0	0	0	0	0	34.0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0.0
2005	0	0	0	0	0	0	0	0	0	0	34	0	34.0
Averages													
Generated 2003-2005	**0.0**	**0.0**	**0.0**	**0.0**	**11.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**11.3**	**0.0**	**22.7**
Measured 2003-2005	**0.0**	**0.0**	**0.0**	**0.0**	**0.4**	**0.0**	**0.0**	**0.0**	**0.0**	**12.4**	**10.1**	**0.0**	**22.9**
Generated 1950-2005	**0.0**	**0.0**	**0.0**	**0.0**	**1.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.6**	**0.0**	**2.4**

SGE Acres

St. John's • Clarenville
Corner Brook • Sydney • Halifax
Moncton • Saint John • Fredericton

June 20, 2006
H-322028

Newfoundland and Labrador Hydro
Hydro Place, 500 Columbus Drive
St. John's, NL A1B 4K7

Attention: Mr. D. Harris, P.Eng.

Dear Sir: **NLH ARSP/SYSSIM Model Review**

As requested, we have reviewed Newfoundland and Labrador Hydro's (NLH) methodology and model used to simulate the annual average hydroelectric capability of the Island Interconnected System. This represents the third phase in selecting an appropriate computer model for simulating the annual average hydroelectric capability of the Island Interconnected System. The first phase, conducted in 2004 by NLH, was the review of NLH's suite of applications; it concluded that SYSSIM was the preferred tool for simulating the annual average hydroelectric capability. The second phase, conducted in 2005 by SGE Acres, was conducted to review NLH's conclusion, and to confirm the adequacy of the tool. SGE Acres concluded that SYSSIM was indeed a suitable tool for estimating the annual average hydroelectric capability of the Island Interconnected System.

SYSSIM uses ARSP to calculate the hydroelectric generating capacity of the system. NLH has recently updated and calibrated the ARSP portion of the SYSSIM model to 2004 historic data, and validated the model using 2005 historic data. We have reviewed both the ARSP model setup and the methodology. We did not, however, review the detailed changes to the input data conducted by NLH, since this information comes from NLH's databases. Subsequent to this review, we also reviewed the SYSSIM model input updated by NLH. It is our conclusion that the updates to the model conducted by NLH and methodology used are applicable to determining the annual average hydroelectric capability of the Island Interconnected System and that the results are reasonable.

Should you have any further questions, please do not hesitate to call.

Yours very truly,

S. H. Richter, P.Eng.
Senior Hydrotechnical Engineer

RDW:sjc

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