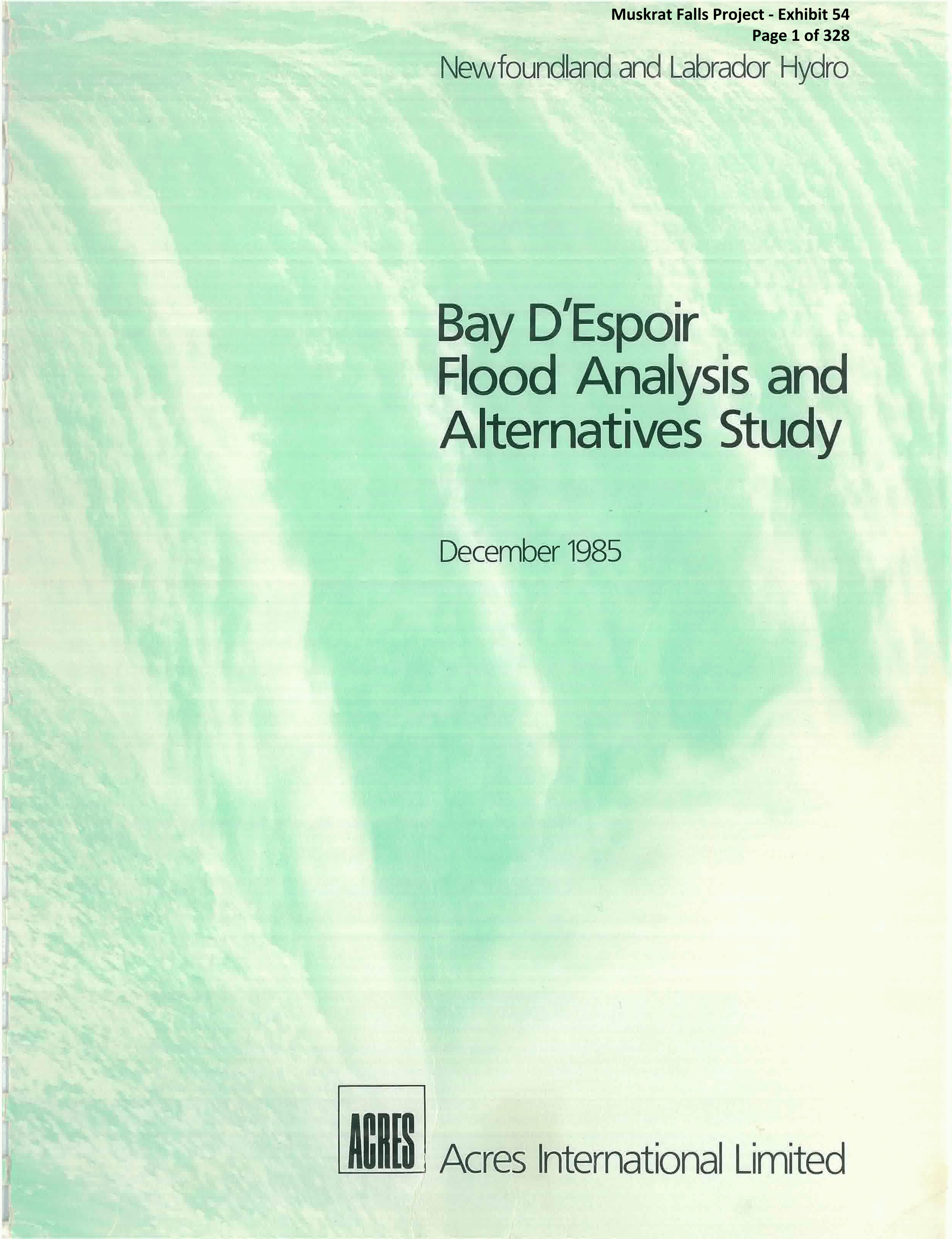

Newfoundland and Labrador Hydro

Bay D'Espoir Flood Analysis and Alternatives Study

December 1985

ACRES Acres International Limited

ACRES

December 20, 1985
P7497.00

Newfoundland and Labrador Hydro
P.O. Box 9100
Philip Place
St. John's, Newfoundland
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<u>Attention:</u> Mr. L.G. Sturge
Manager of Engineering

Gentlemen:

<u>Bay d'Espoir - Flood Analysis and Alternatives Study - Final Report</u>

We are pleased to submit the final report on the Bay d'Espoir Flood Analysis and Alternatives Study.

The study confirms that the present flood handling capabilities of the Burnt, Upper Salmon and Long Pond reservoirs are inadequate to handle the probable maximum flood.

Alternatives for improving the flood handling capabilities of these reservoirs were examined, and recommendations are included in this regard.

The freeboard requirements of the Burnt, Upper Salmon and Long Pond reservoirs under probable maximum flood level conditions were also examined and found to be sufficient except at Burnt Canal which will require remedial measures.

We wish to acknowledge the cooperation and assistance provided by Hydro during this interesting assignment.

Yours very truly,

A.L. McKechnie
Project Manager

ALM:jap

encl.

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DECEMBER 1985

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FINAL REPORT
BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY

TABLE OF CONTENTS

PLATES

APPENDICES

BAY D'ESPOIR FREEBOARD STUDY IN PMF CONDITIONS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY OF ABBREVIATIONS

AES	Atmospheric Environment Service
ARSP	Acres reservoir simulation program
DOT	Department of Transport
FRC	Flood Rule Curve - water level below which reservoir must be held. Spillway gates are opened as required through the year in order to maintain this water level. During the winter, the FRC level will vary depending on the amount of snow on the ground. All cases of late winter flood events presented in this report assume a maximum historic snowpack of 330 mm at the time of the flood event.
FSL	Full Supply Level - Reservoir water level at which reservoir is considered to hold 100% of its live storage capacity.
LSL	Low Supply Level - Reservoir water level below which it is undesirable or impossible to draw down the reservoir (dead storage level).
MFL	Maximum Flood Level - Reservoir water level above which flood damage is incurred.
NLH	Newfoundland and Labrador Hydro
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation

SUMMARY

EXECUTIVE SUMMARY

The purpose of the Bay d'Espoir Flood Handling and Analysis Study was to review the flood handling capabilities of the reservoirs in the Bay d'Espoir system, and to prepare layouts and order-of-magnitude cost estimates for various alternatives in the Salmon basin. In addition, a separate limited freeboard study was carried out to verify the adequacy of the available freeboard under probable maximum flood conditions.

Tables S.1 and S.2 summarize the results of the two studies.

Table S.1
Summary of Results of
Flood Handling Analysis
and Alternatives Study

Basin	Required Spillway Increase or Late Winter Drawdown Level for existing conditions	Most Promising Alternative	Action Recommended
Long Pond	72%	Modification of Centre Gate of Existing Spillway	Feasibility Level Study
Upper Salmon	29%	North Salmon Spillway Extension or New West Salmon Spillway	Comparison Study
Meelpaeg	264.96 m	Low Saddle Dyke	Cost/Benefit Analysis
Granite	None	________	None
Burnt Pond	47%	Not determined	Further Study Required
Victoria	322.5 m	Low saddle dyke	Cost/Benefit Analysis

Table S.2

Summary of Results
of Freeboard Study Under PMF Conditions

Basin	Structure	Assumed MFL	Required Freeboard Increase	Action Recommended
Long Pond	Salmon Dam	182.73	None	None
	South Cut off Dams	182.73	None	None
	North West Cut off Dam	182.73	None	None
	Power Canal Embankment	182.73	None	None
Burnt Pond	Burnt Dam	315.47	None	None
	Burnt Canal Dyke U/S of bridge	315.47	0.9 m	1) check freeboard under normal operating conditions 2) raise crest
	Burnt Canal Dyke d/s of bridge	varies	cannot be determined	Hydraulic analysis to determine water levels during PMF conditions
Victoria	Victoria Dam	327.36 (proposed)	None	None
	Victoria Dykes near control structure	"	0.2 m	Set MFL lower or add riprap

A. Flood Handling Analysis

The design event used in the flood handling analysis was the probable maximum precipitation (PMP) arriving in late winter on the estimated maximum historic snowpack. This criterion was established by considering the size of the structures and the consequences of failure. PMP's were developed for spring and fall events as well, but because of the large contribution of the snowmelt (the snowmelt water equivalent amounts to almost half the rainfall) the winter event is most critical for design. The PMP was centred over each basin separately to determine the worst case for that basin.

The inflows resulting from the PMP and the snowmelt were determined by the unit hydrograph method. These Probable Maximum Flood (PMF) inflows were then routed through the reservoirs, channels and spillways of the Bay d'Espoir system using a computer reservoir balancing model.

The model permitted the determination of additional spillway capacity in cases where the allowable Maximum Flood Level (MFL) was exceeded. Alternatively, the extent of drawdown prior to flood occurrence required to maintain the reservoir below the MFL was calculated.

The definition of acceptable limits of allowable water levels is an important design parameter, because the higher these limits, the less additional flood handling capacity is required. For this study, the MFL was taken to be the lowest elevation of the top of the core of any earth structure around a reservoir. The only exceptions are at Meelpaeg and Victoria, where the MFL was initially set at the elevation of the original ground at low areas. A second case was examined for each assuming the low areas were dyked.

The reservoirs in the Bay d'Espoir System fall into 2 broad categories in terms of their flood handling capabilities. One category handles floods primarily by spilling, the other by storage. Long Pond, Upper Salmon, Granite and Burnt Pond are in the first category, and Victoria and Meelpaeg in the second. The results of this study showed that all the reservoirs which handle floods by spilling require additional capacity, with the exception of Granite, i.e. Long Pond, Upper Salmon, and Burnt Pond. The long overflow sections on the Granite Lake dykes provide sufficient spillway capacity, and no extension is required. The required spillway capacity increases at the other locations are approximately as follows

Long Pond	72%
Upper Salmon	29%
Burnt Pond	47%

The two reservoirs which handle floods by storage, Meelpaeg and Victoria, require no new structures. They can be kept low enough to ensure that the PMF can be stored. However, the levels to which the reservoirs must be held before the PMF occurs are very low, and the corresponding drawdown may have serious operational and economic consequences. To permit a higher flood rule curve (FRC) level, a second case was therefore examined for each of these two reservoirs, assuming that the low area was dyked. The results were as follows.

	MFL (Maximum allowable flood level) (m)	FRC (Late winter required drawdown level) (m)	FSL (Full Supply level) (m)	FSL minus 2/3 snow-pack (draw down level expected from historic practice) (m)	Req'd additional draw-down below 2/3 snow-pack
Victoria					
1) no dyke	325.8	322.5	324.92	323.4 m	0.9 m
2) with dyke	327.4	324.4*	324.92		
Meelpaeg					
1) no dyke	267.1	264.96	266.55	265.45	0.5 m
2) with dyke	268.4	266.33			

*Assumes control gates open and some spill down the Victoria River (limited to 227 m^3/s).

The table above shows that without the low saddle dykes, drawdown below that expected from historic practice is required. Some operational constraints would also be expected throughout the rest of the year without the saddle dykes. It is noted that an economic analysis is required to compare the benefits of higher levels with the costs of construction of the dykes.

B. Salmon Basin Alternatives

In the second part of the study, layouts and cost estimates were prepared for a number of alternatives in the Salmon Basin to alleviate flooding during a PMF event.

1. Long Pond

The alternatives considered at Long Pond and their approximate costs are as follows.

	Alternative	Approximate Cost ($M)
1.	Centre gate modification: Lowering of the centre section of the existing spillway to provide additional discharge.	5.8
2.	Dam raising: Raising the dams and dykes (and other structures as required) to provide additional storage capacity.*	7.5 (excluding concrete structures)
3.	Bypass Spillway: Constructing a bypass channel and spillway at the existing Salmon Dam spillway.	12.1
4.	Witch Hazel Hill: Constructing an ungated overflow spillway and discharge channel in the Witch Hazel area (about 5 km north of Salmon Dam).	32.1

The possibility of providing storage capability at Round Pond was examined, but it is costly, and additional storage is limited.

*This option was studied separately. See Reference 7 of main study report.

A comparison between the two most promising alternatives shows the centergate modification to be 1.7 million dollars (30%) less costly.

In addition, the cost of raising the concrete structures in the Long Pond Basin is considerable and is not included in the cost estimate of the dam raising alternative. Also, the construction works required to raise the intakes of the Bay d'Espoir power plant may interfere with plant operation. The benefit of flood forecasting to reduce the extent of remedial measures will be less for the dam raising alternative as prespilling will be limited due to high setting of the existing gates. Therefore, although the cente gate modification will require the installation of a unique type of gate, this alternative is clearly most advantageous.

It is noted that the final design and costs for the alternative chosen at Long Pond must be determined in conjunction with the Upper Salmon alternative, because the rate of spilling at Upper Salmon will affect the total inflows into Long Pond.

Upper Salmon

A number of alternatives at Upper Salmon were identified. These are

1. Extend existing North Salmon spillway.
2. Construct a new spillway at West Salmon dam.
3. Provide storage at Island Pond.
4. Increase capacity of diversion channels between Great Burnt.
5. Raise West Salmon dam, dykes, and intake.

Alternatives 1 and 2 were judged to be the most promising. With a West Salmon spillway, more water could be stored in Great Burnt, where dam cores are higher. In consequence, a spillway at West Salmon could be smaller, and discharges to Long Pond would be reduced. Even if the cost of a spillway at West Salmon is more costly than a North Salmon extension, the combined cost of Upper Salmon and Long Pond remedial projects could be lower because of this reduced discharge.

On the other hand, the extension of the North Salmon Spillway is technically simple to design and construct and does not require much field investigation. Also, the original Salmon River streambed, downstream from the existing spillway is the natural discharge channel for large flows. The economic and technical advantages and disadvantages of both alternatives cannot be determined without further study, including the determination of separate inflow hydrographs, for the Cold Spring and Great Burnt basins. To obtain a representative estimate of the cost for a remedial measure in the Upper Salmon Basin, a layout and cost estimate of the North Salmon spillway extension only was prepared. The estimated cost is about 6.9 million dollars.

The remaining three alternatives would all be expected to be considerably more costly.

C. Freeboard Study

The raising of maximum allowable flood levels to the minimum top of core elevation, adopted in this study, was not previously considered and constitutes a change from the original design of the Bay d'Espoir reservoir system (except for Upper Salmon). Consequently, the effects of the encroachment on available freeboard were checked separately for structures at Long Pond, Burnt Pond and Victoria reservoirs. Granite was not checked because it does not rise to the top of the core and at Meelpaeg, the maximum allowable flood level is established by other structural considerations.

The design criterion for testing available freeboard is that no waves should overtop the structure at a design windspeed of just under 40 km/h from the critical direction, corresponding to typical conditions which could be expected to occur together with maximum flood levels during a PMF event. In addition, the number of waves overtopping the top of the dams during the maximum historic wind from the critical direction was calculated, to determine vulnerability under higher wind conditions. The results of this study are as follows.

1) All Long Pond structures have adequate freeboard under the PMF conditions assumed. A short section of the Power Canal Embankment is the most vulnerable structure because it has no downstream slope protection, but considering the infrequency of the PMF event, no remedial work is necessary.

2) Burnt Canal Dyke has a serious lack of freeboard upstream of the bridge, and possibly downstream as well, where ponding allows fetch lengths of over 1/2 km to develop. The length requiring attention is of the order of 120 m.

3) Victoria Dykes near the control structure have inadequate freeboard when reservoir levels are at the top of the core, because the dykes have no riprap on the crest. However, Victoria can be operated at levels which will ensure that this maximum flood level is never reached.

   If Victoria is allowed to rise to the top of the core, water will overtop the gates at the Victoria River Spillway if they are not open, and will also flow down to Burnt Pond through a low saddle area. Although overflow for short periods could likely be tolerated, nevertheless it is recommended that gates be operated so that overtopping does not occur, or that flashboards be added. The low saddle area would have to be dyked if the MFL is set at the top of the core.

4) A check of the stability of the concrete structures at Victoria, Burnt Pond, and Long Pond showed that acceptable factors of safety exist for the various loading conditions. However, Burnt Canal bridge deck is vulnerable under ice loading at MFL.

It is noted that the available freeboards are considered to be adequate only under PMF conditions. The high reservoir levels cannot be considered for normal operation.

CONCLUSIONS

CONCLUSIONS

Based on probable maximum flood (PMF) calculations, reservoir routing studies, and freeboard checks under PMF conditions, the conclusions of the study are as follows.

1. Long Pond

Additional flood handling capability is required. The most promising option is lowering the centre gate section of the existing 3-gate spillway at the Salmon Dam to increase discharge from about 1520 m^3/s to 2500 m^3/s at maximum flood level (MFL). Final sizing depends on the option selected at Upper Salmon, the benefits of operation at higher reservoir levels and the effect of flood forecasting. The next best option is raising dam and dyke cores and crests by about 1.3 m, and modifying concrete structures as necessary. It is estimated that this option is less suitable from an economic and technical viewpoint.

Freeboard at MFL was found to be adequate at all Long Pond earth structures under PMF conditions.

2. Upper Salmon

Present flood handling capacity at Upper Salmon is inadequate. The two most promising alternatives are a one-gate extension to the existing spillway at North Salmon dam, or a new spillway at West Salmon. A detailed study of the two options, and of the effect of each on required capacity at Long Pond, is required before the best solution can be chosen.

3. Meelpaeg

No additional flood handling capacity is required at Meelpaeg, if the reservoir is drawn down to 264.95 m, about 1.6 m below full supply level. This level is lower than the two-thirds snowpack drawdown presently considered standard practice, and will have operational and economic consequences. A low saddle dyke near Ebbegunbaeg would allow water levels to be kept very close to full supply level, even in the late winter period. Although the late winter storm only was evaluated in this study, lower drawdown than normal would probably be required throughout the year.

4. Granite Lake

Granite Lake has sufficient spillway capacity to handle the PMF.

5. Burnt Pond

Several important findings resulted from the analysis of Burnt Pond.

a) Burnt Pond requires additional flood handling capacity. Either additional spillway or storage capacity could be provided. The option of additional storage capability, instead of additional spillway capacity, should reduce annual spill at Burnt, resulting in an annual energy benefit. It is understood that evaluation of alternatives will be addressed in a separate study by Newfoundland and Labrador Hydro.

b) Burnt Sidehill Canal Dyke upstream of the bridge does not have adequate freeboard when the reservoir is at the top of the core of Burnt Dam. This portion of the dyke is approximately 120 m long. It is possible that inadequate freeboard exists even at normal full supply level.

c) No conclusion can be drawn about the adequacy of the freeboard at Burnt Sidehill Canal Dyke downstream from the bridge because expected water levels are unknown. A hydraulic analysis of the canal during PMF conditions is necessary to establish water levels before the amount of freeboard available can be assessed.

6. Victoria

No new flood handling capacity is required at Victoria if the reservoir is drawn down to 322.5 m (2.4 m below full supply level) prior to the late winter design event. Victoria control gates and spillway gates (to a maximum of 227 m^3/s) are assumed to be available. This level is about a metre lower than two-thirds snowpack drawdown, and holding Victoria at this level may have operational and economic consequences.

Victoria can be kept much higher if the maximum flood level is 327.36 m (the elevation of the top of the core of Victoria Dam). Two remedial measures are required.

a) A low dyke long must be constructed to seal a low area (elevation 325.8 m) to the east of Victoria control structure;

b) Riprap must be added to the crests of the Victoria dykes near the control structure, to prevent damage due to wave overtopping. This riprap is only required for an MFL above about 327.1 m.

Overtopping of the gates at Victoria River spillway will also occur if they are left closed. Although overtopping for short periods could likely be tolerated, nevertheless it is recommended that gates be operated so that overtopping does not occur, or that flashboards be added.

With these remedial measures in place, Victoria Reservoir can be allowed to rise to a maximum of 324.4 m prior to the late winter design event; this is about a half a metre below FSL.

RECOMMENDATIONS

RECOMMENDATIONS

The recommendations arising from the study are listed below.

1. Long Pond

a) The design of the centre gate option should be carried to feasibility level. Final sizing will depend on the option selected for Upper Salmon, the benefits from operating Long Pond at higher levels and the effect of flood forecasting.

The feasibility study should include the determination of gate type and arrangement, the selection of optimum crest elevations (taking into account the effects of flood forecasting and reservoir operation), an engineering and construction schedule, and a capital cost estimate.

b) To permit a direct comparison between the centre gate modification and the raising-of-dams options, the raising-of-dams option should be brought to the same study level as the other alternatives. This requires a technical and cost review of the present report on the dam-raising and the preparation of a cost estimate for additional work, in particular raising of the concrete structures.

2. Upper Salmon

A feasibility study should be undertaken to determine the most suitable means of increasing flood handling capacity during PMF conditions. This study should include

a) Preparation of a layout and capital cost estimate for the West Salmon dam option. This requires a detailed study of the interaction between Cold Spring Pond and Great Burnt Lake, including the development of separate inflow hydrographs.

b) Determination of the PMF flow discharging from the most promising options at Upper Salmon and its effect on the size and cost of the alternative at Long Pond. The choice of the most economical option for the 2 basins as a whole can then be made.

Although an Island Pond storage scheme by itself is uneconomical and ineffective for flood handling alone, NLH may wish to study this scheme to the same level as other alternatives in order to assess benefits for a possible future power project.

3. Meelpaeg

a) A cost/benefit analysis should be undertaken to determine whether the economic and operational benefits through the year justify the capital cost of a low saddle dyke.

4. Burnt Pond

a) A detailed study of the options available for providing additional flood handling capacity at Burnt Pond should be undertaken. The two major options are to provide additional storage, or to provide additional discharge capacity. Preliminary surveys of suitable sites, especially for possible storage dam locations, could be done this winter (1985/86).

b) A freeboard analysis of Burnt Canal Dyke upstream of the bridge at full supply level should be undertaken immediately. Soundings should be made as soon as possible of the northeastern end of Burnt Pond; this could be carried out when a safe ice cover has developed on the lake.

c) A hydraulic study should be undertaken to establish water levels in Burnt Canal during PMF conditions. No assessment of freeboard downstream of the bridge can be made until these levels are available.

5. Victoria

a) The costs and benefits of the necessary remedial measures to allow higher MFL's in PMF conditions should be assessed. The benefits are economic and operational through the year; the costs are the capital cost of a small low saddle dyke, and riprap on the crest of the Victoria dykes near the control structure if an MFL above 327.1 m is envisioned.

6. General

a) Gate hoist capacities under the MFL's finally selected should be checked.

b) A brief study should be undertaken to assess the costs and benefits of flood forecasting.

1 - INTRODUCTION

1.1 - Purpose

This report describes the work undertaken and the results obtained in the Bay d'Espoir Flood Analysis and Alternatives Study. The study required the determination of the extreme flood hydrology for the Bay d'Espoir basin, the analysis of the response of the reservoir system to extreme flood events, and the examination of remedial measures to alleviate unacceptable flooding conditions in the Salmon basin.

The purpose of the present study was

1) to review the spillway capacities and the flood handling capability of the reservoirs in the Bay d'Espoir System under extreme flood conditions
2) to examine flood handling alternatives in the Salmon Basin.

1.2 - Background

A severe flood event in January 1983 led to concern about the flood handling capability of the structures and reservoirs in the Bay d'Espoir system. Newfoundland and Labrador Hydro (NLH) commissioned ACRES to undertake flood studies for the Bay d'Espoir system. Early results showed that the probable maximum precipitation (PMP) event estimated for the original design had been exceeded in the storm of January 1983, and estimation of the PMP by statistical analysis also suggested that a much higher value should be used.

NLH then commissioned ACRES to undertake a PMP study in consultation with the Atmospheric Environment Service (AES) of Environment Canada. The final PMP report of November 1984[1] was accepted by NLH after a thorough review, and the present spillway capacity/flood handling study and examination of alternatives in the Salmon basin uses the PMP estimates from that study.

1.3 - Approach

The approach taken is outlined below and described fully in the report.

a) Establish design criteria.
b) Develop unit hydrographs for all subbasins. Use these to derive inflow hydrographs for the design event.
c) Route the inflows through the system. If routed maximum water levels exceed the maximum allowable levels, calculate required spillway capacity increase to keep levels within the allowable limits. If floods are handled primarily by storage, as at Meelpaeg and Victoria reservoirs, solve for an acceptable starting level rather than a spillway capacity.
d) For the Salmon basin, examine the most promising structural flood handling alternatives, and develop layouts and cost estimates for them.

Any change in operating levels in the reservoirs of the Bay d'Espoir system may have economic effects. The terms of reference for this study do not include any examination of these effects.

It is noted that the hydrology and reservoir routing runs were carried out by both Acres personnel and NLH staff. Although some of this work was undertaken in NLH's offices, Acres has generally reviewed the results presented here.

2 - FLOOD DESIGN CRITERIA

Two types of flood design criteria were established. One was the selection of a design flood event, and the other was the selection of the maximum flood levels to be allowed in the reservoirs.

2.1 - Design Flood Event

The design flood event recommended by ACRES and accepted by NLH is the probable maximum flood (PMF). This recommendation is based on the guidelines of the US Army Corps of Engineers, considering size of structures and overall hazard potential, and is consistent with the recommendations of the International Congress on Large Dams (ICOLD). A summary of the design flood criteria for each major structure is presented in Table 2.1, (a) to (c). The Corps guidelines are summarized in Table 2.2.

2.2 - Probable Maximum Flood (PMF)

A probable maximum flood (PMF) is a deterministic estimate of a very large flood, based on the physics of the climatic and hydrologic factors which combine to make a large flood event. A PMF is of a magnitude less than a physically conceivable upper limit, but the probability of exceedance is so small as to be of no realistic concern.

The PMF is generally taken to be the flood resulting from the PMP. The rainfall during the PMP is transformed into runoff, using unit hydrographs for example, and the resulting flows are the inflows during the PMF. In addition to rainfall, various antecedent and coincident conditions must be considered. Some judgement must be exercised in the selection of values for each of these to ensure that the overall event is highly improbable, and yet not unreasonably so.

The results of the 1984 PMP study are given in Table 2.3. The coincident conditions making up the total flood event are summarized in Table 2.4. This table shows that of the various physical factors, only a few are maximized; others are the largest of record, but not the maximum physically possible.

TABLE 2.1A

DAM CLASSIFICATION

Sub-basin	Major Structure*	Total Storage to Crest (Mm^3)	Maximum Height (m)	Category
Long Pond	Northwest Dam	>3000	41	Large
	Power Canal		21	
	Salmon Dam		40	
Upper Salmon	N. Salmon Dam	>750	20	Large
	W. Salmon Dam		23	
Meelpaeg	Pudops Dam	>3000	21	Large
	Ebbegunbaeg C.S.	2100	9	
Granite	Granite Dam	280	30	Large
Burnt	Burnt Dam and Sidehill Canal	200	20	Large
Victoria	Victoria Dam	>3100	63	Large

*Although other structures may be important, such as the south dams at Long Pond, the power canal at Upper Salmon, and the smaller dams around Granite Lake, they are not included here because they do not govern the choice of design event.

TABLE 2.1B

HAZARD POTENTIAL

Subbasin	Major Structure	Loss of Life	Economic Loss	Category
Long Pond	Northwest Dam	High	High	High
	Power Canal	High	High	
	Salmon Dam	Low-Sig.	High	
Upper Salmon	N. Salmon W. Salmon	High	High	High
Meelpaeg	Pudops Dam	Sig.	High	High
	Ebbegunbaeg C.S.	High	High	
Granite	Granite Dam	Sig.	High	Sig. to High
Burnt	Burnt Dam and Sidehill Canal	Sig.	High	Sig. to High
Victoria	Victoria Dam	High	High	High

TABLE 2.1C

SUMMARY OF FLOOD DESIGN CRITERIA

Subbasin	Dam Classification	Overall Hazard Potential	Resulting Criterion
Long Pond	Large	High	PMF
Upper Salmon	Large	High	PMF
Meelpaeg	Large	High	PMF
Granite	Large	Sig. to High	PMF
Burnt	Large	Sig. to High	PMF
Victoria	Large	High	PMF

TABLE 2.2

GUIDELINES FOR DESIGN FLOOD CRITERIA FOR DAMS*

A - Dam Size Classification

Category	Storage (Mm^3)	Height m
Small	0.06 to 1.2	below 12
Intermediate	1.2 to 62	12 to 30
Large	over 62	over 30

B - Hazard Potential Classification

Category	Loss of Life	Economic Loss
Low	none expected	minimal
Significant	few	appreciable
High	more than a few	excessive

C - Recommended Spillway Design Return Frequencies

	Dam Size		
Hazard Potential	Small	Intermediate	Large
Low	100 years	100 years to 1:10000 yrs	1:10000 yrs to PMF
Significant	100 years to 1:10000 yrs	1:10000 yr to PMF	PMF
High	1:10000 yrs to 1.0 PMF	PMF	PMF

*In accordance with guidelines established by the US Army Corps of Engineers.

TABLE 2.3

RESULTS OF 1984 PMP STUDY

MODIFIED SEASONALLY OR WIND ADJUSTED PMP FOR 1000-KM^2 AREA

	Duration Hours (PMP in mm)					
Season	24	36	48	60	72	84
Winter						
- January	405	440	470	490	510	525
- March	405	440	470	490	510	525
Spring	320	355	375	400	415	425
Fall	405	440	470	490	510	525

TABLE 2.4

COINCIDENT CONDITIONS CONSTITUTING PMP/PMF

1.	Storm Track	northeastern seaboard route
2.	Season	most critical (winter)
3.	Time in season	end of March (maximum snowpack)
4.	Precipitable Water	maximum of record from upper air data
5.	Water Supply Rate	1 in 50 year upper atmosphere wind speed
6.	Storm Efficiency	implicit in maximized large storm of record
7.	Storm Movement Rate	implicit in maximized large storm of record
8.	Orographic Effects	implicit in maximized large storm of record
9.	Depth-Area-Duration	derived from isohyetal maps and mass curves of precipitation for largest storms of record
10.	Snowpack	fully developed, late winter, maximum historic snowpack of record (330 mm water equivalent, about 2.5 m snow)
11.	Temperature Sequence	maximum recorded 15-day sequence of March temperatures
12.	Temperature Distribution	15-day sequence arranged to have the snowpack fully primed at the beginning of the PMP, with maximum temperatures occurring during PMP to maximize snowmelt
13.	Duration of PMP	duration producing the greatest excess volume with the current flood handling rules (84-hours)

Most of the conditions listed in Table 2.4 are discussed in detail in the Probable Maximum Precipitation report.(1)

The design event used is the PMF, as described above. For the original Bay d'Espoir design studies, a different design event was selected, i.e. the PMP plus a second large storm several days after the PMP. This criterion was not used in the present study because the imposition of a second large storm immediately after the PMF brings the magnitude of the total event beyond the PMF design flood criterion. The PMP plus a second storm therefore was not considered as a reasonable design event.

With reference to the original Bay d'Espoir design criterion, it is noted, however, that in the case of Meelpaeg, ordinary storms following the PMF could be handled using Ebbegunbaeg gates. At Victoria, both the control gates and the Victoria River spillway gates would be available to handle secondary storms.

2.3 - Reservoir Constraints

In the reservoirs of the Bay d'Espoir system, floods are handled by storage as well as by spilling. The starting level and maximum flood level determine the amount of storage available for flood handling, and results are sensitive to the levels chosen.

Starting levels:

For this study, the starting level used was a typical late winter level, at reservoirs which handle floods primarily by spilling. These reservoirs are Long Pond, Upper Salmon, Granite Lake, and Burnt Pond. At Meelpaeg and Victoria, which handle floods by storage, the starting levels had to be determined by calculation.

There are economic tradeoffs to be considered in the choice of starting levels. Starting levels are the levels at which reservoirs must be held in anticipation of floods. Higher levels may be more desirable for operation or energy production. On the other hand, capital costs will be incurred if additional flood handling facilities (spillways or dykes) must be built to maintain higher levels.

An examination of the tradeoffs between the costs of new flood handling facilities and various starting levels through the year was not within the terms of reference for this study, but should be undertaken before any final designs are carried out.

Maximum flood levels:

The maximum allowable flood level (MFL) was taken as the lowest elevation of the top of the core of the earth structures in each reservoir, except at Meelpaeg and Victoria. The maximum flood levels are applicable at all times of the year.

At Meelpaeg, a low area near Ebbegunbaeg sets the maximum allowable flood level. If this area is sealed, the allowable MFL is 268.4 m, as in the original design. It is noted that other considerations prevent the MFL from being set at the top of the core. At Victoria, a low area near the control structure sets the MFL at 325.8 m. If this area is dyked, the MFL could be set at the top of core elevation of 327.36 m.

Maximum flood levels at the top of the core are considerably higher than those used in the original design of the project. In consequence, a freeboard study was carried out to determine whether available freeboard during PMF conditions is adequate, when reservoirs are at top of core elevations. Only Long Pond, Burnt Pond and Victoria structures were checked in the freeboard study. Granite Lake and Meelpaeg do not rise to the top of the core, and at Upper Salmon, the MFL has not changed since the original design.

The freeboard study, appended to this report, showed that freeboard is adequate for all earth structures at Long Pond, and for Victoria and Burnt Dams. Burnt Sidehill Canal dyke upstream of the bridge requires remedial work. Freeboard on the dyke downstream of the bridge cannot be checked until water levels in the canal under PMF conditions are established by hydraulic analysis.

Victoria Control Dykes require additional riprap if Victoria Lake is taken to the elevation of the top of the core of Victoria Dam, elevation 327.36. An alternative to placing riprap is to set the MFL slightly lower, at about 327.1m, to ensure adequate freeboard.

In the freeboard study the factors of safety for all concrete structures at Long Pond, Burnt Pond and Victoria, were also checked and found to be acceptable under PMF conditions. It is noted that Burnt Bridge is vulnerable to ice damage at the proposed MFL of 315.47 m.

It is assumed that the increases in MFL would not endanger the stability of any of the earth structures in the system. For Long Pond the increase over the previous MFL is only about 1 m, and ordinarily such a relatively small increase would have a negligible effect on dam stability.

The stability of earth structures under increased MFL's should be checked with the dam design consultant, since such an analysis was not included in the Terms of Reference for the present study.

A detailed discussion of MFL's for each reservoir is presented in Section 4, along with a table of reservoir parameters.

3 - DETERMINATION OF PMF INFLOWS

The PMP rainfall over each basin was transformed into flood inflows using unit hydrographs, as summarized below. A complete description of the derivation of the unit hydrographs is given in Appendix A.

3.1 - Derivation of Unit Hydrographs

A unit hydrograph is defined as the hydrograph of flow which would result from a unit of rainfall falling uniformly over a basin for a specific length of time. The unit hydrographs derived for this study were 25-mm, 6-h unit hydrographs.

The unit hydrographs for each subbasin were determined using the hydrograph package HEC-1 developed by the US Army Corps of Engineers, Hydraulic Engineering Centers.[2] The optimized unit hydrographs and loss rate parameters were determined by matching recorded and computed (simulated) hydrograph values for the January 1978 and January 1983 storms in the basin. Each storm included snowmelt as well as heavy rain.

The two main inputs to the model are the observed rainfall over the subbasin and the observed inflow hydrographs to the subbasin reservoir. Daily data were available to calculate the inflow hydrographs and twice daily data were available for rainfall. The time step required for the routing model to ensure that peak flood flows are not masked is 6 hours. Consequently, the daily data were reviewed and plotted so that the best estimate could be made of the 6-h values.

Snowmelt was included by using a snowmelt coefficient calibrated against measured snowmelt during the two storms. An average value of 11 mm/C degree day produced good agreement for both storms. This coefficient is only appropriate for snowmelt during heavy rainfall since it implies heat input to the snowpack from the rain itself. The observed temperature sequence for each individual storm was plotted, the snowmelt per 6-h period was calculated, and the resulting water equivalent values of melt were applied to the model as additional precipitation.

For all basins, it was necessary to calculate the inflows during historic storms by additional backrouting of recorded outflows, except for Victoria, where the inflows could be taken directly from the hydraulic data sheets supplied by NLH. The subbasins and the routing procedures used are described in Appendix A.

3.2 - Probable Maximum Flood Event Inflow Hydrographs

3.2.1 - Approach

Using the PMP values and unit hydrographs as described, a series of PMF event inflow hydrographs were computed for each of the seven subbasins. Separate inflow hydrographs to each subbasin were required for each different storm center. The development of subbasin inflow hydrographs is described in more detail in Section 3.2.2.

The winter PMF event (March) with full snow accumulation was used for design purposes. PMF events for other times of the year were less critical, even considering that higher reservoir levels normally occur in other seasons.

At Long Pond, the required spillway capacity increase was calculated for the late winter storm. The water level just prior to the storm was taken to be a typical late winter level. Maximum allowable spring and fall levels can be calculated assuming that this additional spillway capacity is in place. These spring, fall and late winter maximum allowable starting levels are three defining points on the annual flood rule curve (FRC).

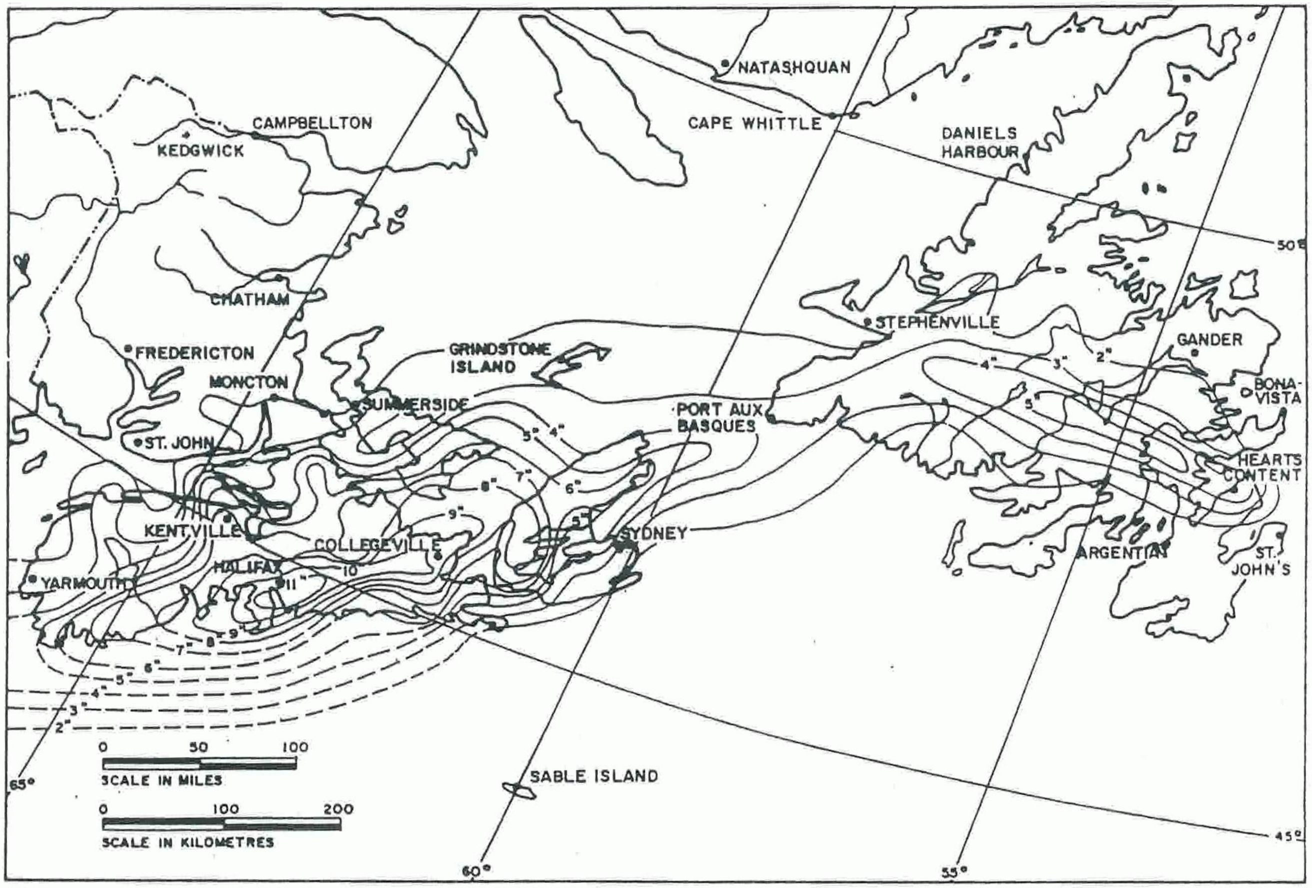
Note that the fall PMF inflow hydrographs were based on a preliminary PMP estimate of 575 mm, rather than the final estimate of 525 mm. Any results presented for the fall are thus conservative. The final PMF inflow hydrographs for a PMP of 525 mm should be regenerated using the same procedure when final design parameters throughout the system have been selected. FRC's in the spring and fall for Victoria and Meelpaeg could be similarly calculated.

3.2.2 - Subbasin Inflow Hydrographs

The design criteria specified that the storm be centred over the basin in question. For example, to obtain the required spillway capacity increase at Burnt Pond, the storm was centred over the Burnt Pond subbasin. Inflows to all the basins were calculated for this storm centre reduced appropriately. With the storm centred over Burnt Pond, for example, the total precipitation (including snowmelt) was 750 mm over Burnt, but only about 550 mm over Long Pond during the same event. The same procedure was used for all storm centres.

Details of the procedure used are as follows.

(a) Using the PMP isohyets and the depth/area curves for each event, determine the reduced PMP for each subbasin outside the storm center. The isohyets and depth/area curves are reproduced in Figures 3.1 to 3.4. For the fall event, the isohyetal map from the August 1971 storm was used, while for the winter and spring event, the January 1983 map was used.



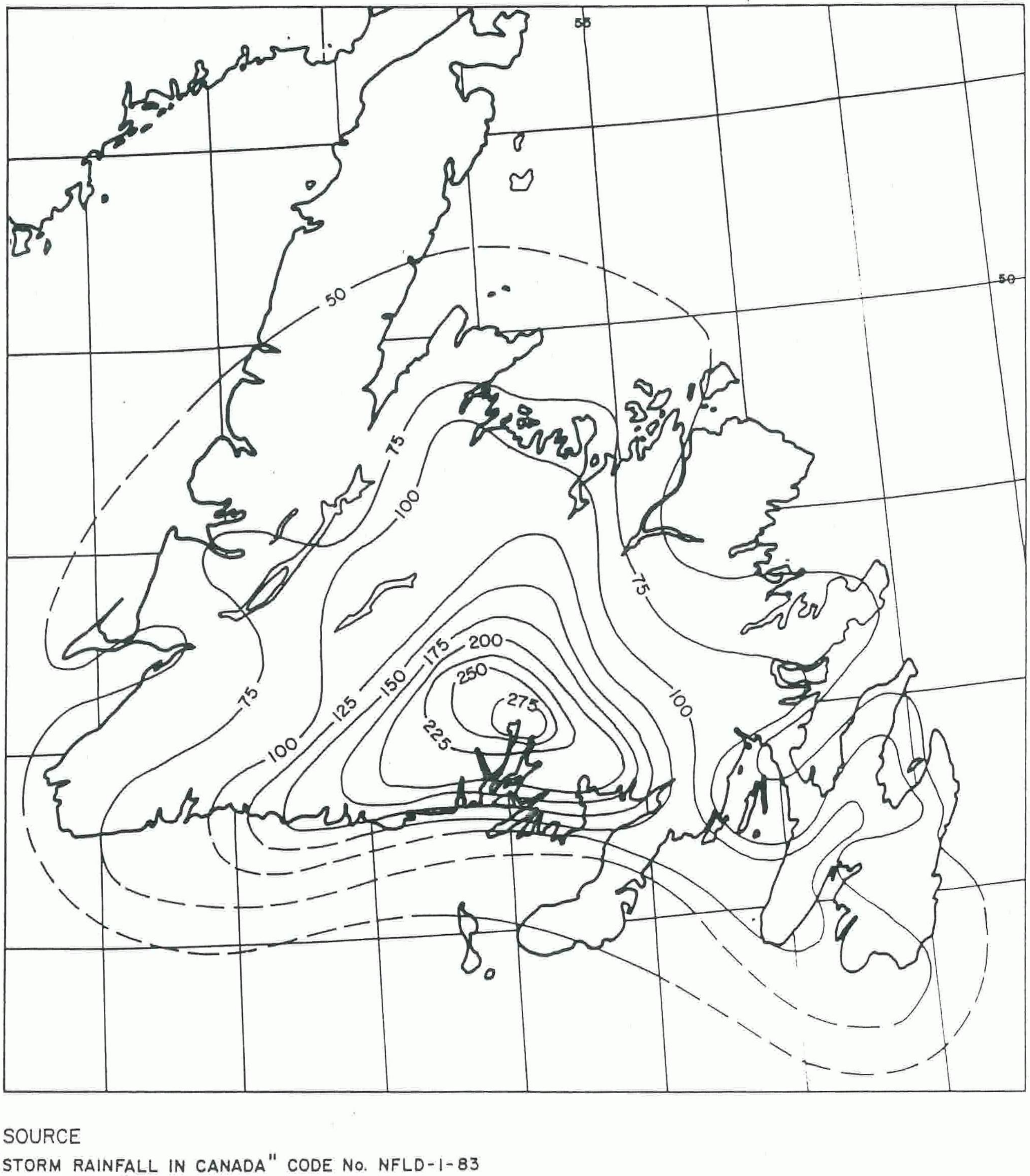
SOURCE

" STORM RAINFALL IN CANADA" CODE No. NS-8-71

FIG. 3.1

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY
ISOHYETAL MAP- AUG 1971

ACRES



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ISOHYETS AT 25 mm INTERVAL

FIG.3.2

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY
ISOHYETAL MAP - JANUARY 1983

AGRES

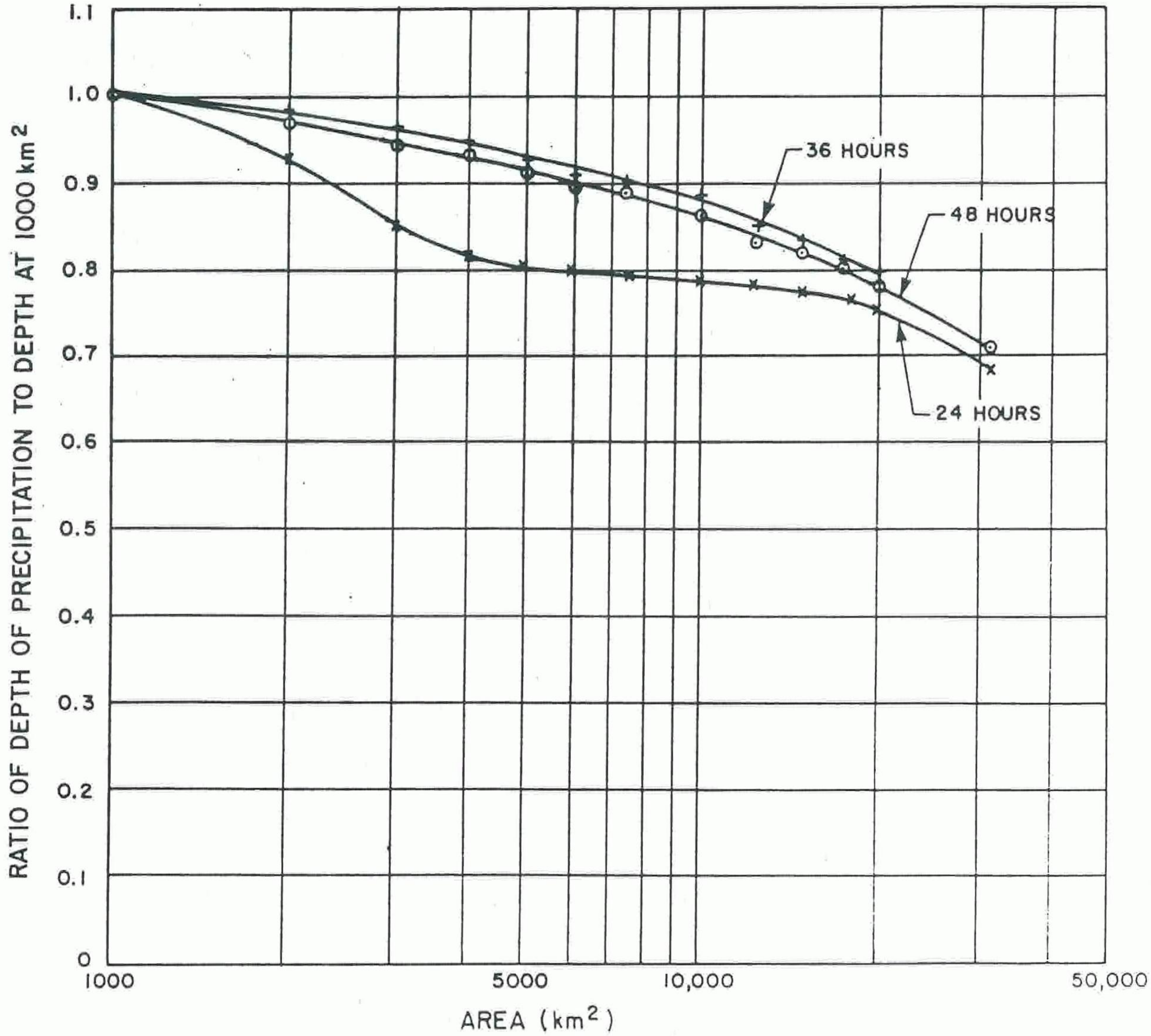

FIG.3.3

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY
NONDIMENSIONAL DEPTH/AREA DURATION CURVES AUGUST 1971

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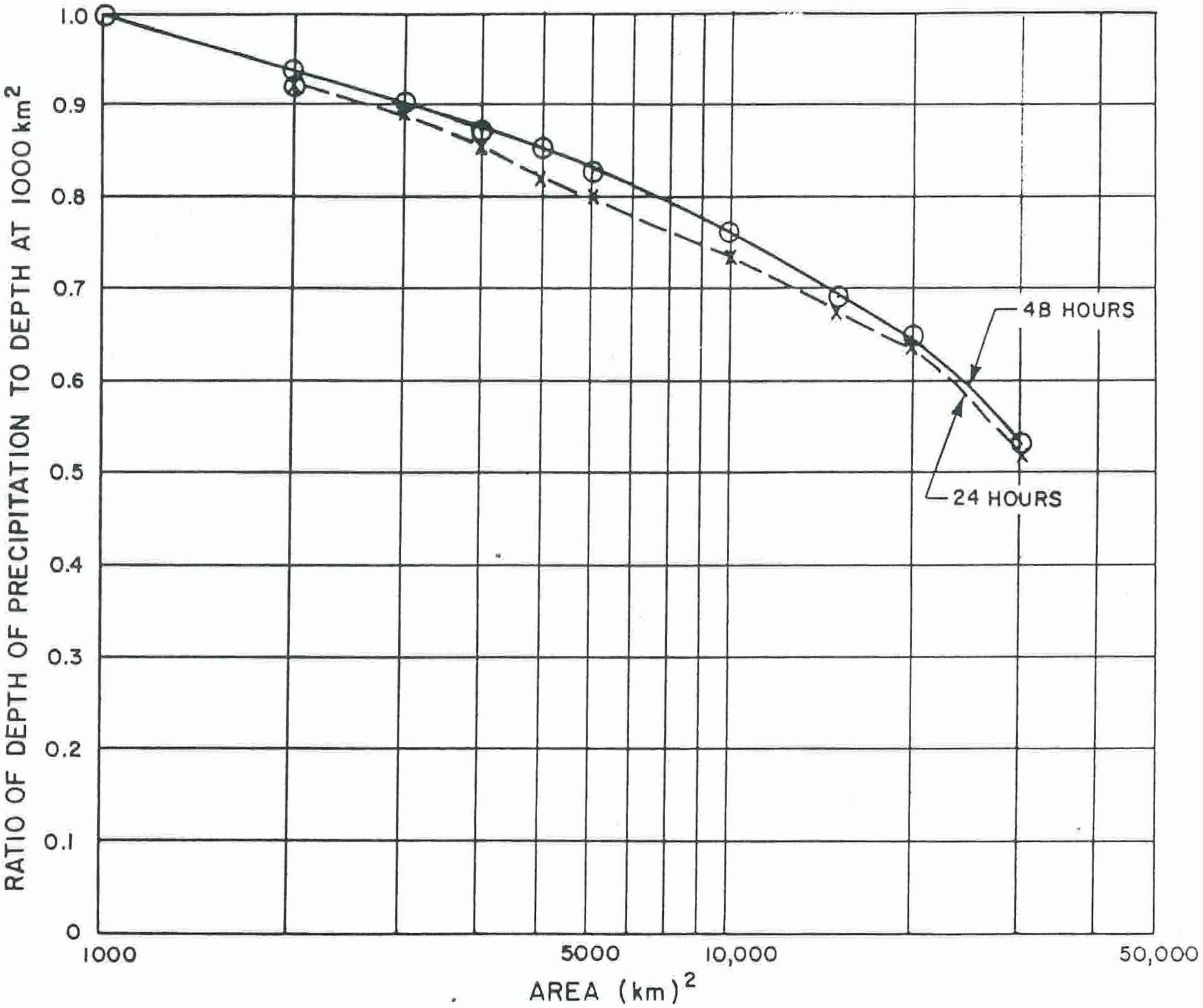

FIG.3.4

NEWFOUNDLAND AND LABRADOR HYDRO

BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY

NONDIMENSIONAL DEPTH/AREA DURATION CURVES-JAN 1983 STORM

ACRES

Note that the shape of the isohyetal plot can be different for different events. The fall storm for example covers a larger area so the reduction in precipitation away from the storm center is less.

(b) Using the appropriate mass curve for the event, distribute the total PMP over the 84-h duration of the storm in 6-h increments. Figures 3.5 and 3.6 show the mass curves used.

(c) Add the snowmelt contribution.

(d) Input the total precipitation to the HEC-1 model for each subbasin, with the unit hydrograph parameters for that subbasin. Run the model to generate the local subbasin flood inflows for that event.

The precipitation and resulting inflow hydrographs for each event for each subbasin are given in Appendix C.

3.2.3 - Snow Available During the Late Winter Event

The late winter (March) event is the most critical because a fully developed snowpack could occur at that time as well as a major rainstorm. The estimated maximum historic snowpack is 330 mm (13 in.) water equivalent, or about 2.5 m of snow on the ground as estimated in the 1965 PMP report.[3] An examination of snowcourse data since 1965 indicates that no greater amount has occurred. As in the 1965 study, the snow was assumed to begin melting 10 days before the storm.

3.2.4 - Snowmelt Coefficients

A melt coefficient of 1.84 mm/C degree day was used during the initial rainfree period. This corresponds to 0.04 in./F degree

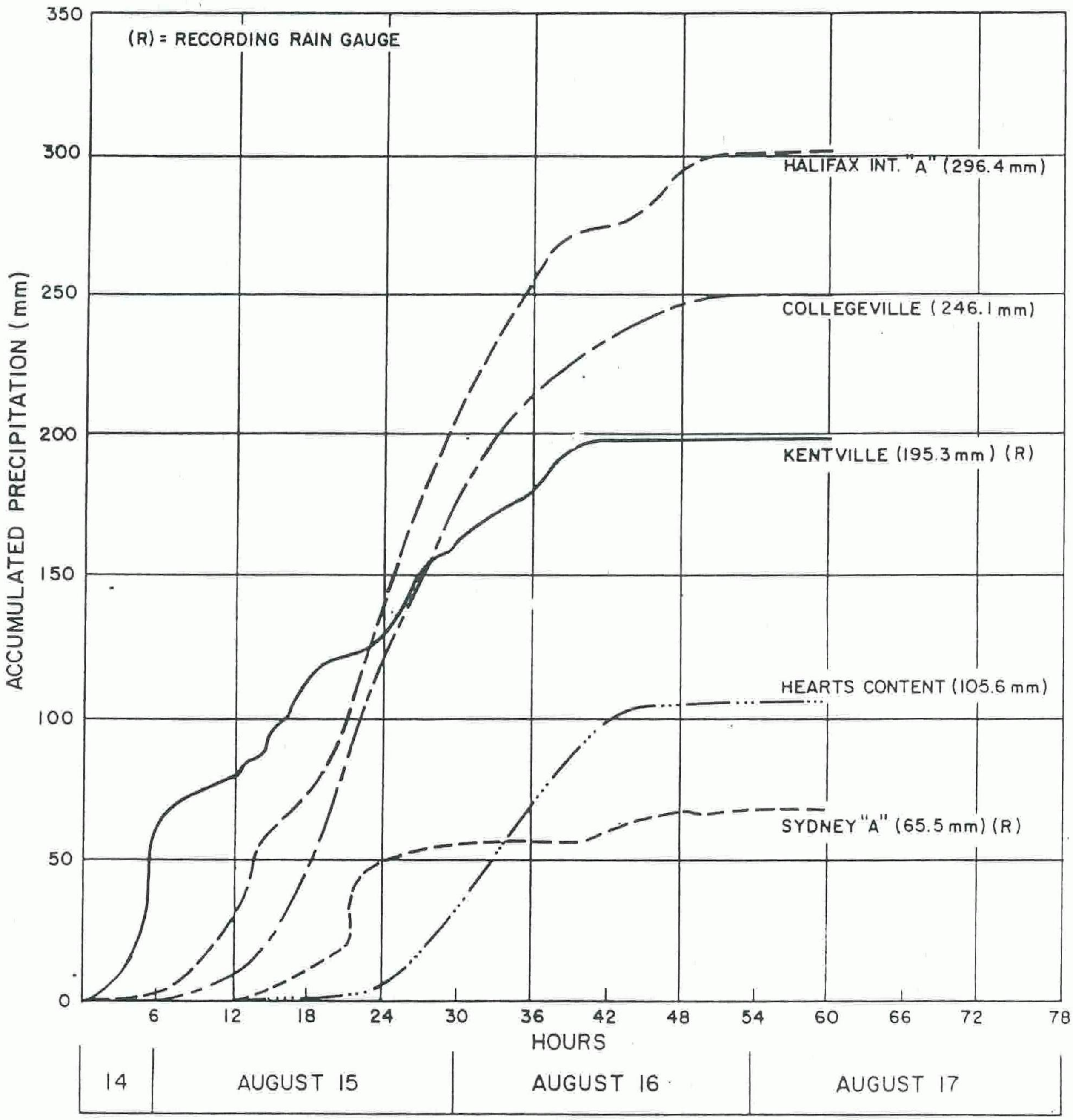

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FIG. 3.5

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY
MASS CURVES OF RAINFALL- AUGUST 1971

ACRES

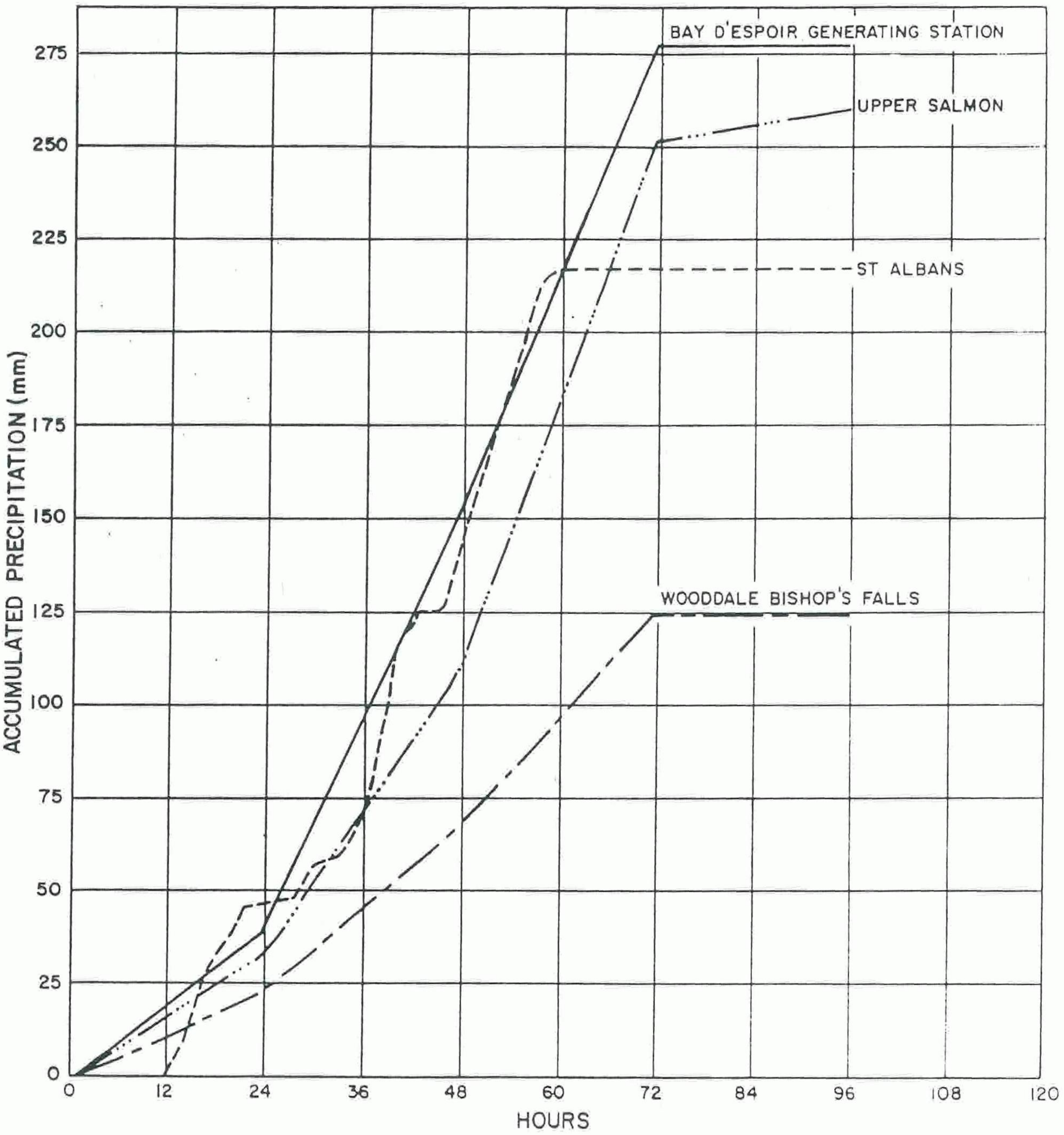

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FIG. 3.6

NEWFOUNDLAND AND LABRADOR HYDRO

BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY

MASS CURVES OF RAINFALL - JANUARY 1983

ACRES

day, the value reported in the original Stage I and Stage II design and a typical rate which is given in the literature[4] for the time of year and the assumed temperatures. During the storm, the snowmelt coefficient of 11 mm/C degree day obtained from the 1978 and 1983 records was used as discussed in Appendix A. The snowmelt resulting from the critical temperature sequence during a PMP event is given in Table 3.1.

TABLE 3.1

SNOWMELT DURING MARCH CRITICAL TEMPERATURE SEQUENCE

Day (°C)	Temp (mm water equivalent)	Snowmelt
1	1.1	2.0
2	1.1	2.0
3	1.1	2.0
4	1.1	2.0
5	1.1	2.0
6	1.1	2.0
7	0.4	0.7
8	0.4	0.7
9	5.5	10.1
10	5.5	60.5
11	8.4	92.4
12	5.5	59.4
13	0.4	2.6
14	1.1	2.0
15	1.1	2.0
16	1.1	2.0
17	1.1	2.0
18	1.1	2.0
TOTAL		248.4

Note: Storm starts Day 10.

Note that it is only the snowmelt on the days of heavy rain (212 mm on Days 10 to 12) which makes a substantial contribution to the results. The small amount of snowmelt (about 25 mm) in the rainfree period before the rain can easily be handled by the present structures. The small flows at the tail end of the storm result in reservoir levels dropping more slowly after the peak.

3.3 - Comparison with Previous Probable Maximum Event Inflows

The results of this study (Section 4) indicate that the flood handling capability required in the Bay d'Espoir system is much greater than had originally been estimated in the Stage I and Stage II designs. There are essentially two main reasons for the increase,

- an increase in the estimate of the PMP event
- the change in unit hydrographs, indicating a much flashier runoff response.

Because these results have such far-reaching implications in terms of additional flood handling measures, they have been compared and corroborated with the results from previous studies wherever possible.

3.3.1 - Increase in Probable Maximum Precipitation

The total precipitation during the critical PMP event includes both rainfall and snowmelt. The increase in the total runoff intensity relates to both these components, and is due to

- an increase in the estimate of the rainfall during the PMP event

- a decrease in the temperatures of the critical sequence and adjustment of its timing relative to the rainfall event.

(a) Rainfall Estimate

The Stage I and Stage II designs were based on a PMP estimated in 1965 by the Department of Transport (DOT), in its report "Historical Rainstorm Analysis and Estimation of Maximum Storm Rainfall in Southern Newfoundland."[5] At that time, very little storm information was available on the island and it was necessary to transpose storm experience from Nova Scotia. Table 3.2 compares the 1965 estimates of PMP for various seasons for a 72-h storm for a drainage area of approximately 1000 km^2 with the ACRES 1984 estimate. The actual 72-h rainfall experienced in the January 1983 event at the Bay d'Espoir generating station is also listed.

From this, it is clear that the January 1983 storm actually exceeded the previous estimated PMP for a winter event. The revised estimate (ACRES 1984 - 510 mm) is about double the previous estimate of 253 mm.

(b) Critical Temperature Sequence

The critical temperature sequence derived in the 1984 PMP study is substantially lower than that used for the original 1965 design as shown in Table 3.3.

TABLE 3.2

COMPARISON OF PMP EVENTS
(mm)

	Duration 72 Hours* Area 1000 km^2			
	Spring	Summer	Fall	Winter
DOT** 1965 PMP	353	281	391	253
ACRES 1984 PMP	415	-	510	510
January 1983 actual	-	-	-	260***

---

* The 72-h duration was selected for illustration because it was the duration used in the original 1965 design. ACRES 1984 PMP study showed the 84-h duration to be only slightly more critical. The January 1983 storm duration was also approximately 72 hours.

** DOT values have been converted from inches to millimetres, for a drainage area of 1000 km^2. DOT results were presented in inches for drainage areas ranging from 300 to 2000 mi^2.

*** The point rainfall recorded at Bay d'Espoir was 276 mm. This is reduced to 260 mm to account for a larger (1000-km^2) drainage area.

TABLE 3.3

COMPARISON OF CRITICAL TEMPERATURE SEQUENCES AND RESULTING SNOWMELT

Day	Temp 1965 (°C)	Snow-melt (mm)	Temp 1984 (°C)	Snow-melt (mm)
1	12.2	22.4	1.1	2.0
2	15.0	27.6	1.1	2.0
3	6.7	12.3	1.1	2.0
4	12.8	23.6	1.1	2.0
5	11.1	20.4	1.1	2.0
6	10.6	19.5	1.1	2.0
7	10.6	19.5	0.4	0.7
8	11.1	20.4	0.4	0.7
9	12.2	22.4	5.5	10.1
Subtotal Prerain		188.1*		23.5
10**	12.8	50	5.5	60.5
11	9.4	30	8.4	92.4
12	13.9	60	5.5	59.4
Subtotal during rain		140.0***		212.3
TOTAL TO END OF RAIN		328.1		235.8

---

* Assumes snowmelt coefficient of 1.84 mm/C degree day (0.04 in./F degree day).

** Rain starts on Day 10.

*** Read from 1965 plot reproduced in Figure 2.7. 1984 snowmelt uses coefficient from calibration of 11 mm/C degree day.

The 1965 temperatures were derived by considering 2-, 4-, 8-, and 16-d sequences of maximum station temperatures from November 23 to April 30. The highest values of the sums were used to develop the sequence. ACRES used a similar technique for 1-, 4-, 7-, 15- and 30-d sequences, for maximum mean daily temperatures for March only. (Maximum mean daily temperatures rather than maximum instantaneous were used because mean daily values provide a better interpretation of daily snowmelt.)

Despite the lower average temperature sequence determined in the 1984 study, it produces a greater runoff intensity for two reasons.

- With the long period of warm temperatures used in the 1965 study[3], much of the snow (188 mm) had melted and run off prior to the commencement of the rain. The amount of snow available during the rain to contribute to peak runoff was significantly less in the 1965 study. The lower temperatures of the 1984 study leave substantially more snow on the ground at the start of the rain.

- The 1965 study assumes that temperatures drop significantly as the rain begins. As shown in Figures 3.7 and 3.8, the temperatures during the 1978 and 1983 storms actually rose as the rain began. For the current study, the maximum temperatures have therefore been assumed to coincide with rainfall thereby intensifying the runoff.

The combined effect of the increased amount of snow available and the higher PMP estimate is an increase in the total precipitation available in the 3 days of a 72-h PMP on a 1000-km^2 drainage area from 420 mm (spring 353 mm + 67 mm snow) to 722 mm (late winter

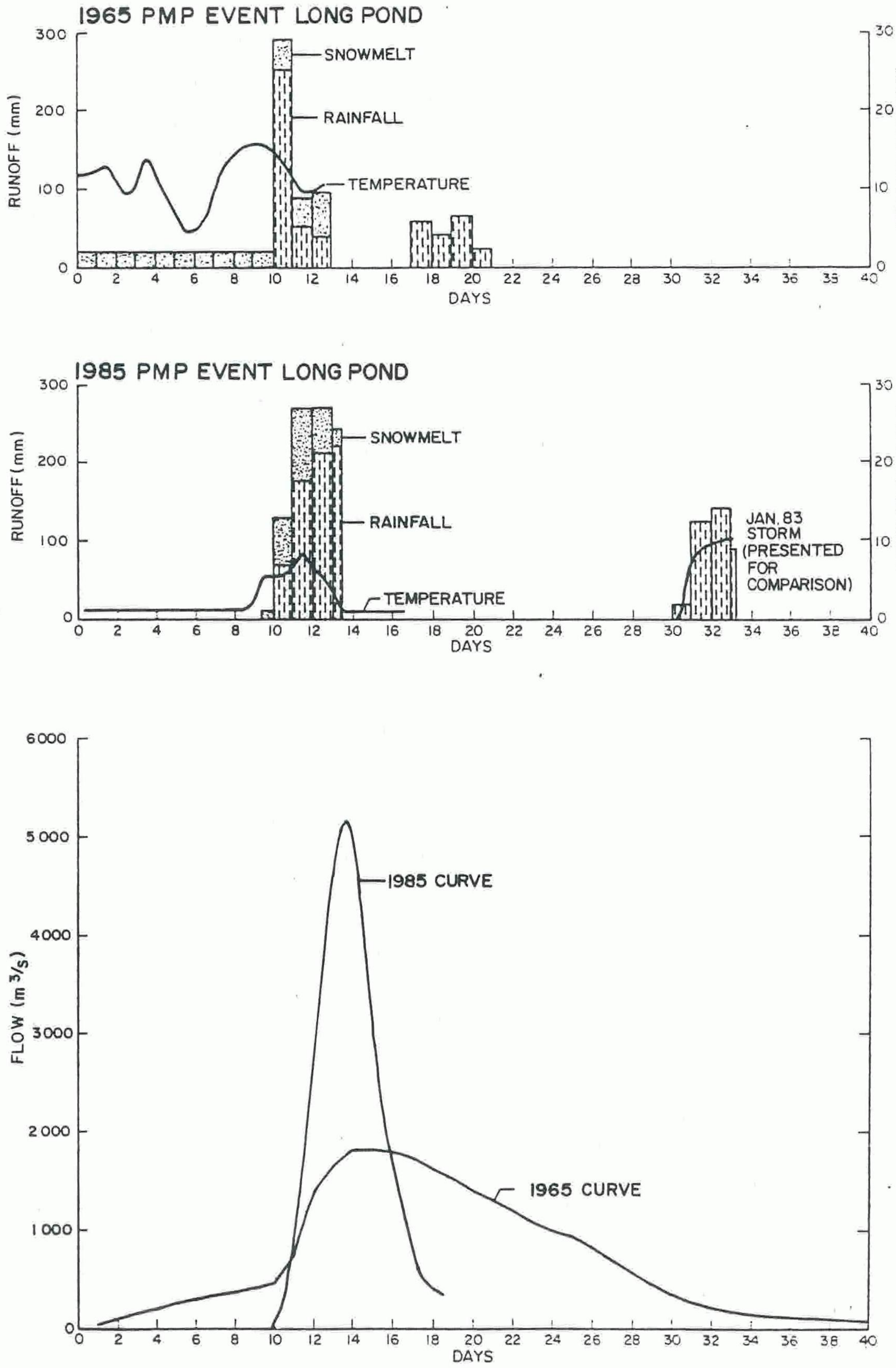
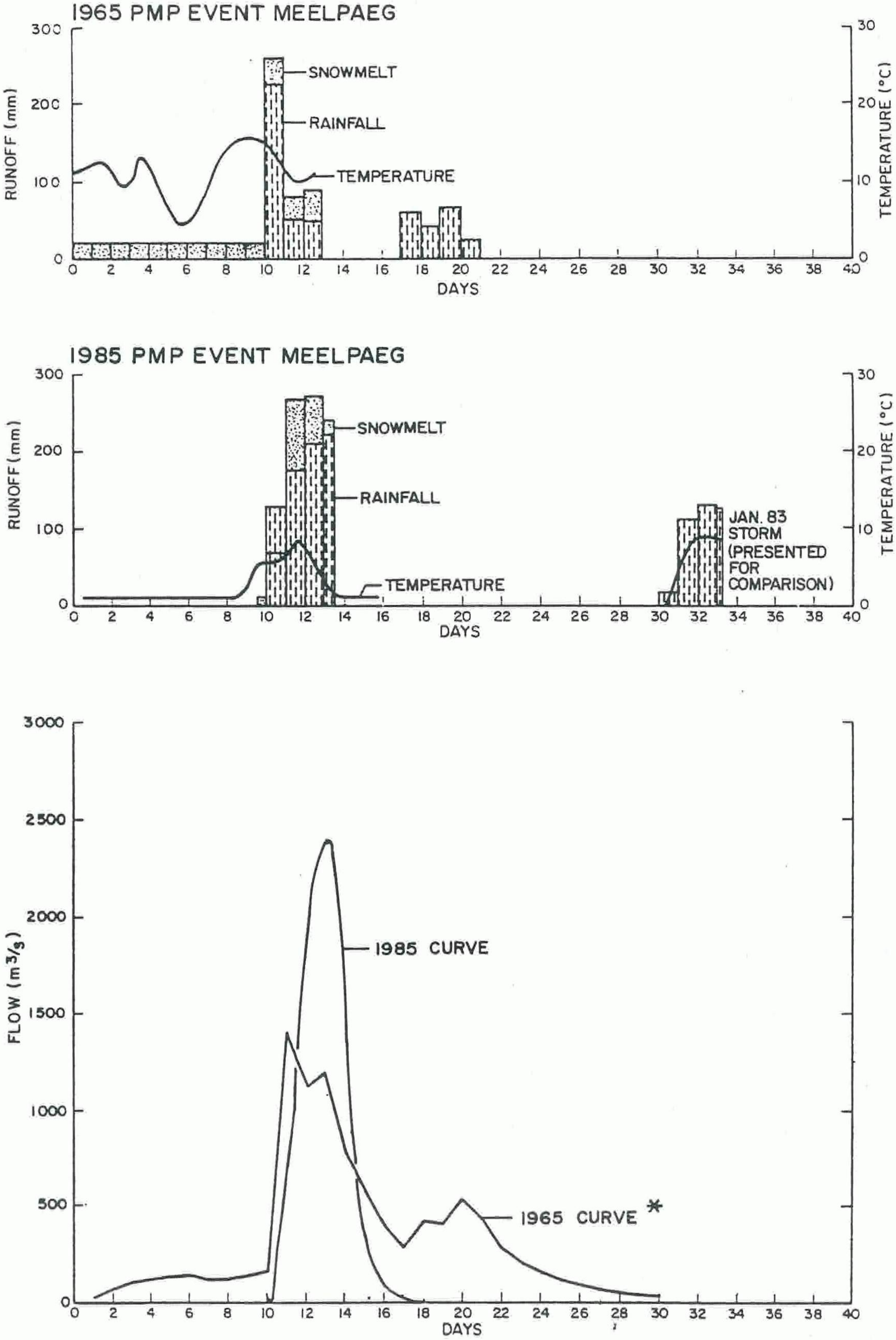


FIG. 3.7

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY

PRECIPITATION
AND PMF INFLOW HYDROGRAPHS 1965 AND 1985 LONG POND (WINTER)

ACRES



* Excluding Granite Cannel

FIG.3.8

NEWFOUNDLAND AND LABRADOR HYDRO

BAY D ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY

PRECIPITATION
AND PMF INFLOW HYDROGRAPHS 1965 AND 1985 MEELPAEG (WINTER)

ACRES

510 mm rain + 212 mm snow); a total increase of over 70% from the 1965 design event to the 1984 event.

This dramatic difference is modified by 2 factors.

1) The 1965 study assumed that all the rainfall and almost all of the snowmelt appeared as runoff. The HEC-1 model used in the 1985 study calculates loss rates from recorded data on the hydraulic data sheets for the basins. The equations account for a certain amount of loss due to land surface interception, depression storage, and infiltration. (Interception and depression storage are intended to represent the surface storage of water by vegetation, local depressions, cracks and crevices, or other areas where water is not free to move as overland flow. Infiltration represents movement of water to areas beneath the surface.) An examination of the hydraulic data sheets during and following 2 major storms (January 1978 and January 1983) indicated that the water lost did not reappear, at least for the several weeks following the storm, so the use of the calibrated loss rate equations in the model is appropriate.

2) The 1965 event included a second storm after the PMP, with a precipitation of over half of the 1965 estimated PMP. The total event lasted a month or more. The 1985 design event is a single storm PMF, as described in Section 2.

For reservoirs like Meelpaeg and Victoria, which handle floods primarily by storage, the total flood volume is more important than the intensity. Considering the differences in losses and snowmelt, and the addition of a second storm, the total precipitation and resulting inflows in the 1965 event are greater than in 1985, as the table below for Meelpaeg shows.

The contribution from Granite Lake is excluded.

Precipitation (mm)

	1985	1965	
PMP rainfall excess (after losses)	368	315	(12.4")
Snowmelt	241	330	(13")
Second storm rainfall	0	186	(7.31")
	610 mm	831 mm	(32.7")
		(848)[1]	(33.4")
Inflow volume[2]	589 Mm^3	826 Mm^3	

Notes:

(1) The actual table of total precipitation used as the design inflow in 1965 adds up to 848 mm; no breakdown other than the one above is available.

(2) Volume under curve, Figure 3.8.

3.3.2 - Unit Hydrographs

The second major difference between the 1965 and 1985 results arises because the 1984 unit hydrographs show a much flashier response. The data from the 1978 and 1983 events, which were studied in detail, show that the basins respond to rainfall more quickly than had previously been assumed. This difference is shown in the PMF inflow hydrographs for Long Pond in Figure 3.7. Table 3.4 compares peaks and volumes for the 1965 and 1985 events.

TABLE 3.4

PMF PEAKS AND VOLUMES, 1965 AND 1985

Reservoir	Peak (m^3/s)		Volume (Mm^3)	
	1965	1985	1965	1985
Meelpaeg (local only)	1400	2340	826	590
Long Pond (local plus Round Pond)	1820	4930	2440	1590

Notes

1985 event duration - 210 hr.
1965 event durations: Salmon basin - 42 days
Meelpaeg - 31 days

Meelpaeg 1965 results are taken from Ref. 4, Table 6, p. 14, Case DDT (ii). Results given in the Stage II Report, Section 3.4(7), are for DOT case (i), i.e. the critical conditions for a flood on the Salmon River. Inflows from the White Bear diversion, including Granite Canal, were not considered.

Long Pond

The 1985 unit hydrographs were calculated by examining two recent severe storms, whereas the 1965 report used much longer runoff events for calibration. The difference in the historical data used in each case is shown in Figure 3.9, with the January 1983 inflow hydrograph to Long Pond superimposed on the winter storms available for calibration in 1965. With such different types of storms used to derive the unit hydrographs, it is not surprising that the results are markedly different, as shown in Figure 3.10. The peak flow into Long Pond in the 1985 event is about 170% higher than indicated in 1965. Because the 1965 storm is much longer, and includes a second large rainstorm 7 days after the PMP event, the total volume in the 1985 event is less.

Meelpaeg

The unit hydrograph derived in 1965 is closer to that used in 1985, because it was based on Indian River data, which showed the same flashy response evident in 1985. The increase in the peak inflow is about 75%. As with Long Pond, the total volume is less, by about the same proportion. The addition of the second rainstorm, and the longer duration of the event, cause this reduction.

Other Subbasins

Comparisons in the other subbasins are not particularly useful, because the peak flows and volumes used in the 1965 design were estimates based on Long Pond. As expected, peaks are relatively overestimated and volumes are relatively underestimated, compared with Long Pond.

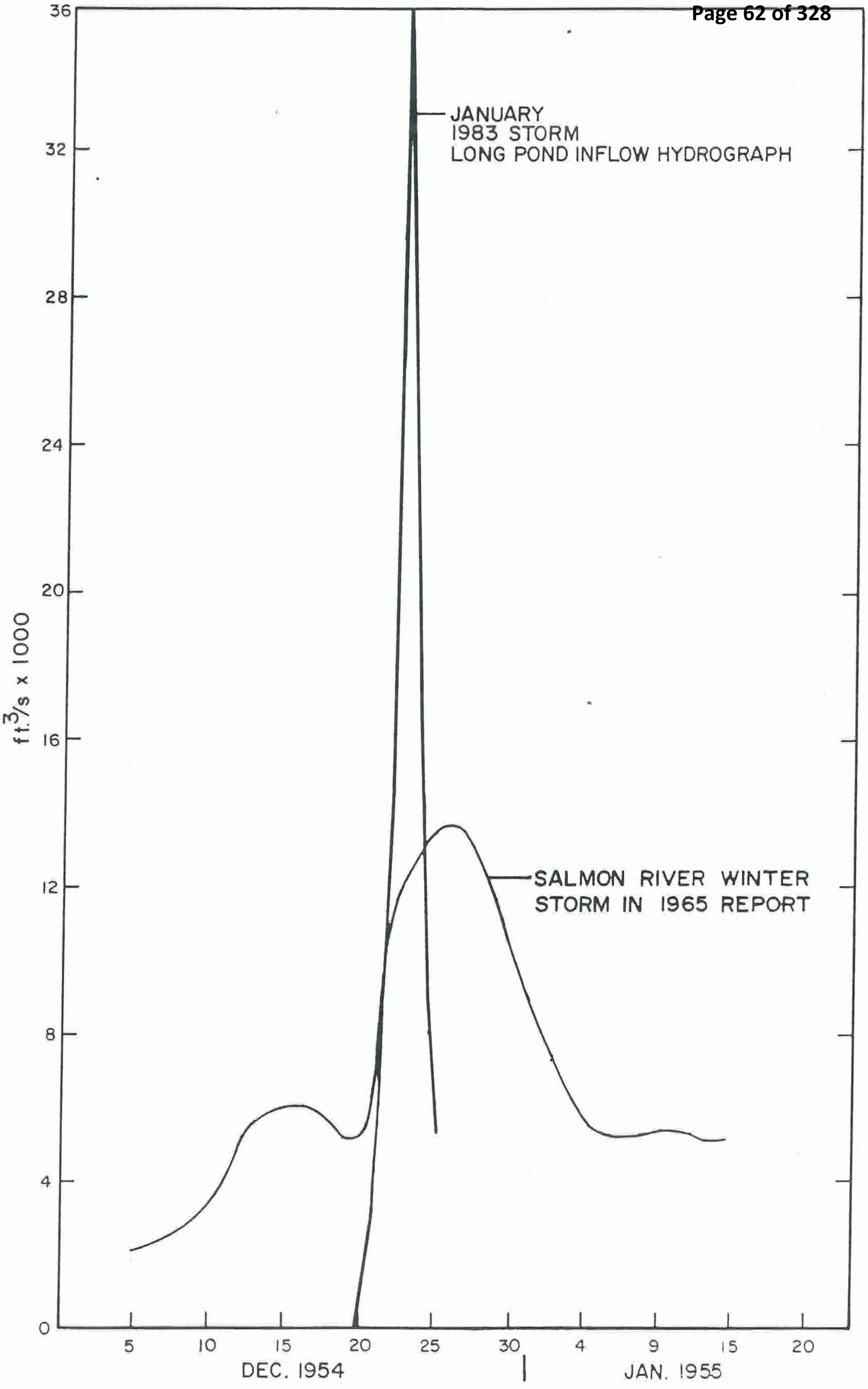


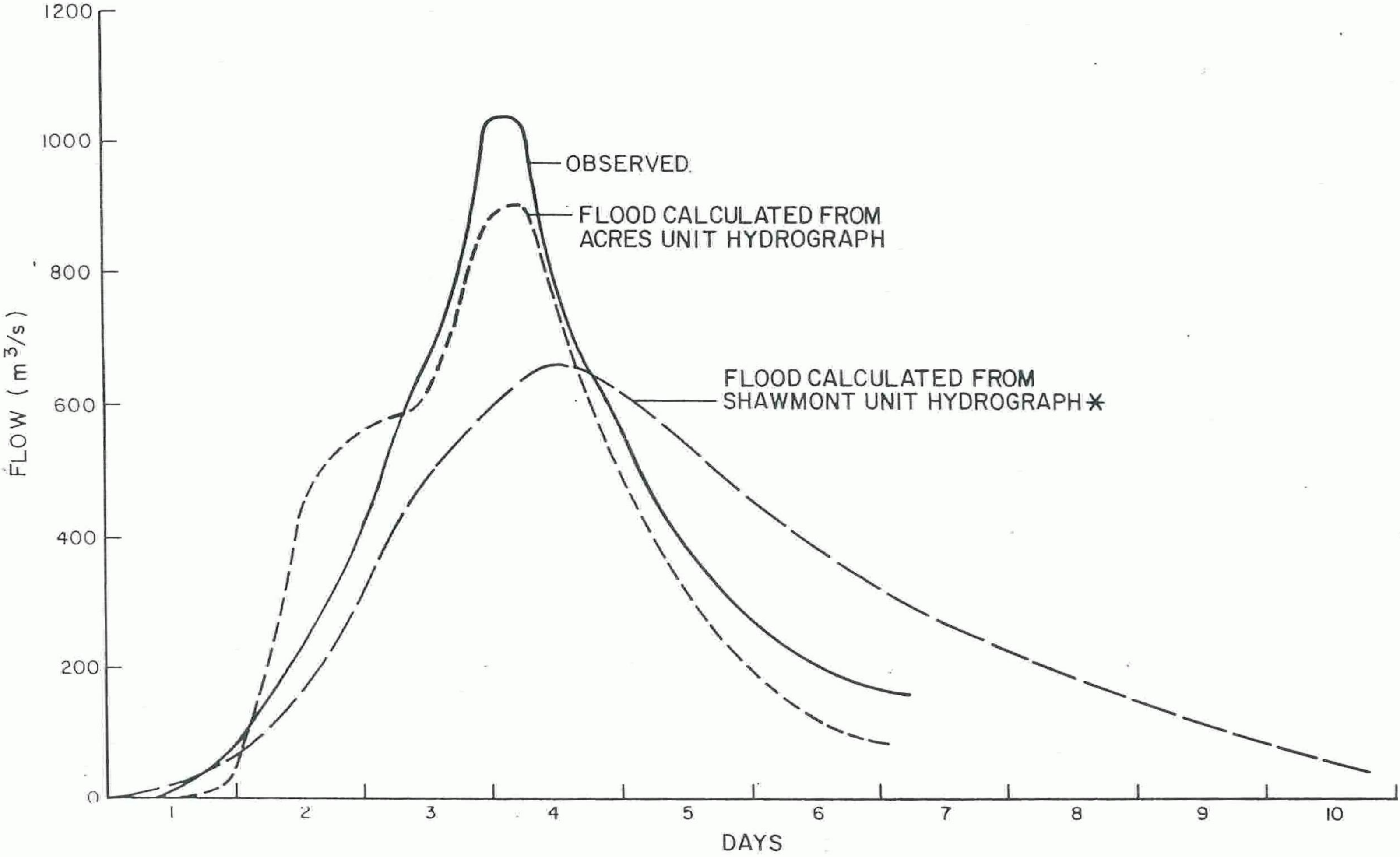
FIG.3.9

NEWFOUNDLAND AND LABRADOR HYDRO

BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY

HISTORICAL FLOOD HYDROGRAPHS

ACRES



* Derived from Tables of Routed Flows for Long Pond Basin

FIG.3.10

NEWFOUNDLAND AND LABRADOR HYDRO

BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY

LONG POND HYDROGRAPH - JANUARY 1983 STORM

ACRES

4 - DETERMINATION OF FLOOD HANDLING CAPABILITY

Having established the PMF inflow hydrographs for all subbasins, the next step in the analysis was to route the floods through the seven subbasins, for each storm centre, to determine their flood handling requirements.

ACRES reservoir simulation program (ARSP) was used for the flood routing. Section 4.1 describes the routing model. Section 4.2 then discusses the constraints and the results for each reservoir in turn. A separate User's Manual has also been prepared.

4.1 - Description of ARSP Flood Routing Model

The purpose of the ACRES Reservoir Simulation Program (ARSP) is to model a river/reservoir system. The program represents both the physical reservoir system and the decision making required to operate it.

ARSP is a general water system model capable of modelling systems with various requirements. The version used in this study was specifically set up for flood routing in the Bay d'Espoir reservoir system.

The ARSP model has several advantages over ordinary simulation models.

1) In each period, the model considers the entire system before deciding on the best operating decision.

2) The data describing the physical network of reservoirs and channels is contained in data files, not in the program itself. Thus, changing the discharge characteristics of a structure, replacing a structure or changing a rule curve is easily done.

3) Operating policies, required for decision-making, are also described in data files, not in the program itself. Generally, once the model is set up satisfactorily, these will not be changed. In the initial stages, however, or in the case of a change in operating philosophy, the policies can be readily altered.

4.1.1 - General Operating Strategy

The strategy of the model is to consider, for each time period, the inflows into the system and the demands on the system. It then decides how best to route the water. Costs or penalties are assigned to the various options, i.e. storage, spillage, or channel flow, according to the policy of the user. The best route is the one with minimum total penalty.

The cost assigned to each option reflects the operator's knowledge of the system. During a flood, for example, the operator would do everything possible to avoid going above the maximum flood level, even if it meant spilling. (In a non-flood case, the operator would of course avoid spilling.) To imitate this action, the program user puts a relatively low cost on spillage and a relatively high cost on storage above the maximum flood level.

The data files describe the physical capacities of the reservoirs, channels and spillways. The model then represents the action of the chief operator during a flood. It uses the same information, i.e. present reservoir levels and expected inflows in the next 6 hours. The model then decides which gates should be opened or closed in order to keep water at the desired levels. It proceeds in 6 hour time steps, making the least cost decision in each period.

The model has the capability of simulating several different definitions of reservoir operation policy to evaluate desired storage deviations from the rule curve, namely

- equal balancing of reservoirs by elevation
- equal percentage balancing of reservoirs
- assigned priorities

For example, if the inflows at Victoria are too large to keep Victoria at its rule curve, the model will route water downstream into Meelpaeg reservoir (if physically possible). It always tries to keep the reservoirs balanced, according to the chosen policy.

An important feature of the model is the numerical integration of spillway and control gate discharge rating curves within each 6-hr time period. The mean discharge through the structure can thus be accurately evaluated. The integration accounts for the change in potential head on the structure during the 6-h time period due to reservoir storage and the change in discharge through the structure due to the change in potential head.

Change in volume in reservoirs is continually recalculated by integrating the elevation-area curves.

4.1.2 - Bay d'Espoir System Configuration

The Bay d'Espoir system consists of a series of reservoirs with interconnecting channels as schematically represented in Figure 4.1. Discharges within the system are controlled by the Victoria control gate, Ebbegunbaeg control gate and the Upper Salmon spillway. Uncontrolled discharges within the system occur at Burnt Pond, Granite and Round Pond. The controllable spillage out of the system occurs at Salmon spillway on Long Pond, Burnt spillway on Burnt Pond and Victoria spillway on the Victoria

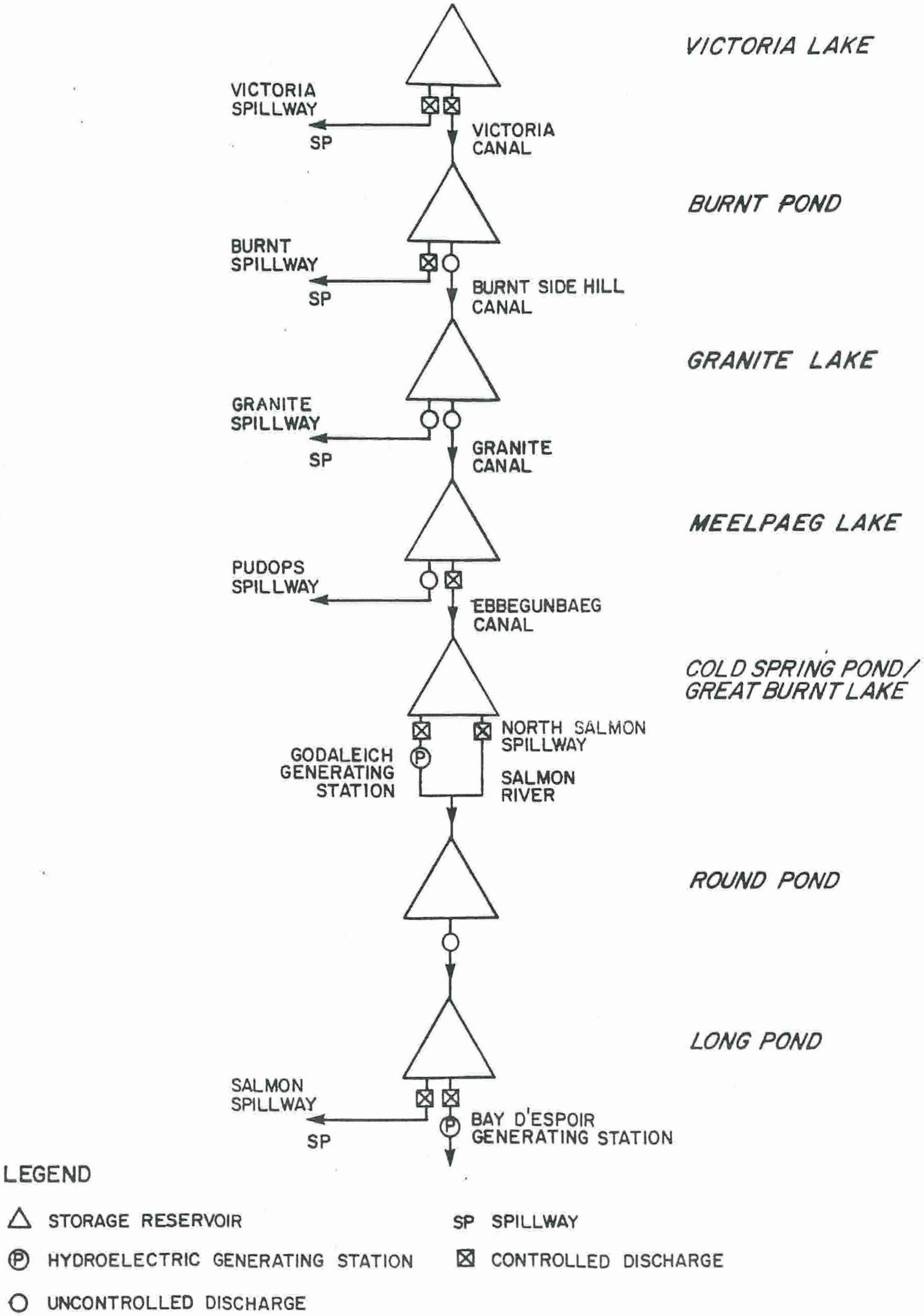


FIG.4.1

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY
BAY D'ESPOIR DEVELOPMENT - SCHEMATIC

ACRES

reservoir. The Granite spillways are uncontrolled. Power flow in the system occurs at Upper Salmon and Bay d'Espoir generating stations.

Some particular features of the Bay d'Espoir system which have been incorporated into the model include

- a 6 hour time lag between North Salmon spillway releases and the flows reaching Round Pond (using a time delay routing equation)

- the backwater effects from Granite on the discharge capability of the Burnt Sidehill canal

- reservoir operations policy of equal percentage balancing of reservoirs while the water levels remain below the FSL and a priority operations policy above FSL

- zero power flows in the Godaleich power plant during the flooding events and a reduced power flow of 173.9 m^3/s at the Bay d'Espoir generating station.

Documentation of the model, with sample input and output, is presented in the ARSP User's Manual accompanying this report.

4.2 - Physical Description of System

The model requires a physical description of the system, including reservoir area-elevation curves, maximum and minimum levels, starting elevations, and stage-discharge curves for all structures and channels.

Important reservoir levels are presented in Table 4.1, provided by NLH. Area-elevation curves and stage-discharge curves are given in Appendix B. These were obtained from previous design

TABLE 4.1

Reservoir Parameters

Structure	Crest Elev.	Top of Core Elev.	Maximum Flood Level (MFL)	Full Supply Level (FSL)	Low Supply Level (LSL)	Freeboard (Crest-MFL)	Desired Starting Elev.* (FRC)	Solve For: **	Comments
1. Long Pond Reservoir									
a) Northwest Cut-off LD-2	184.4	183.95	182.73	180.75	178.31		180.29 (591.5')	Spillway	Include Excess Vol.
b) Power Canal Embankment LD-1	183.2	182.73	182.73	180.75	178.31		180.29	"	"
c) Southeast Cut-off J-3A, LD-3B & LD-3C	184.4	183.79	182.73	180.75	178.31		180.29	"	"
d) Southwest Cut-off LD-4	184.4	183.95	182.73	180.75	178.31		180.29	"	"
e) Salmon River Dam LD-5	183.8	183.20	182.73	180.75	178.31		180.29	"	"
2. Upper Salmon Reservoir									
a) West Salmon Dam SD-1	243.5	242.5	242.0	242.0	241.0		241.95	Spillway	Include Excess Vol.
b) North Salmon Dam SD-2	244.5	243.0	242.0	242.0	241.0		241.95	"	"
c) Intake Dyke	243.5	242.5	242.0	242.0	241.0		241.95	"	"
d) Upper Salmon Power Canal	243.5	242.5	242.0	242.0	241.0		241.95	"	"
3. Meelpaeq Reservoir									
a) Ebbegunbaeg Cut-off Dam									
MD-1A (1)	270.82	270.21	268.4	266.55	261.67		Nil	FRC	
MD-1B (2)	269.92	269.30	268.4	266.55	261.67		Nil	"	
MD-1C (3A)	270.92	270.21	268.4	266.55	261.67		Nil	"	
MD-1D (3)	269.92	269.30	268.4	266.55	261.67		Nil	"	
b) Pudops Dam MD-2	270.82	270.36	268.4	266.55	261.67		Nil	"	

*or lowest allowable level, for each reservoir.
**indicate whether spillway size or FRC is required for each reservoir
***may change depending on FRC

Reservoir Parameters

Structure	Crest Elev.	Top of Core Elev.	Maximum Flood Level (MFL)	Full Supply Level (FSL)	Low Supply Level (LSL)	Freeboard (Crest - MFL)	Desired Starting Elev.* (FRC)	Solve For: **	Comments
4. Granite Reservoir									
a) Granite Dykes & Overflow Spillways									
MD-3									
MD-4									
MD-5									
MSD-6 Dyke Spillway	313.83	313.37	313.37	311.2	307.85		311.2	Spillway	Include Excess Volume
MSD-7 Dyke Spillway									
MSD-8 Dyke Spillway									
b) Granite Dyke MD-9	313.94	313.49	313.37	311.2	307.85		311.2	"	"
c) Granite Dam MD-10	314.86	313.94	313.37	311.2	307.85		311.2	"	"
5. Burnt Reservoir									
a) Burnt Dam MD-11	316.40	315.47	315.47	313.94	313.0		313.94	Spillway	"
b) Burnt Sidehill Canal	315.5 to 314.9	315.5 to 314.9	-	-	-	-	-	-	-
c) Fusible Plug	313.34	313.34	-	-	-	-	-	-	Assume fusible plug improved
6. Victoria Reservoir									
a) Victoria Canal Dyke No. 1	328.0	327.51	327.36	324.92	319.0		323.40	Spillway	Include Excess Volume
b) Victoria Dyke VD-2	328.0	327.51	327.36	324.92	319.0		323.40	Spillway	"
c) Victoria Dam VD-3	328.0	327.36	327.36	324.92	319.0		323.40	"	"
d) Victoria Dykes									
VD-4A	328.0	327.36	327.36	324.92	319.0		323.40	"	"
VD-4B	328.0	327.51	327.36	324.92	319.0		323.40	"	"

*or lowest allowable level, for each reservoir.

**indicate whether spillway size or FRC is required for each reservoir reports and data provided by NLH. Extrapolations to the increased reservoir levels and additional area calculations based on 1:50000 scale mapping were confirmed by NLH. An exception was Round Pond; detailed mapping was commissioned for this study to permit the preparation of a new area/elevation curve for the reservoir, and of a stage-discharge curve for the outlet to Long Pond. Water Survey of Canada profiles and discharge measurements at the outlet were used in combination with the mapping to develop the rating curve.

4.3 - Flood Routing Analysis

The following section gives details on the cases considered for each reservoir, e.g. starting levels, maximum allowable levels, and special considerations and cases considered for each. In all cases, the design storm was the late winter PMF, centred over the basin in question.

4.3.1 - Long Pond

Starting level - 180.29 m
Maximum allowable level - 182.73 m (top of core, power canal embankment)

Bay d'Espoir plant is assumed to operate at about half its flow capacity (173.9 m^3/s).

Required: Spillway discharge capacity increase to maintain these levels
Result: 72% increase required.

Comments:

The specified increase of 72% assumes an additional spillway section at the same sill elevation and with the same discharge characteristics as the existing spillway. Alternative layouts are discussed in Section 5.

The results are quite sensitive to starting levels and maximum flood levels. The spillway capacity increase is 72% only if the reservoir is at elevation 180.29 m just prior to the PMF, and if the maximum flood level is 182.73 m. This MFL level is the elevation of the top of the core of the power canal embankment. Flood forecasting can have an important effect on starting levels, as prespilling can be undertaken. The extent of these benefits requires further study.

At Long Pond in particular, the levels are also important because they determine the head available for power generation. An increase in spillway capacity beyond the 72% specified in the present study would allow the reservoir to be maintained at higher elevations. An examination of available water and possible power and energy benefits is required to assess the economic trade-off between capital costs and energy benefits.

Note that when the reservoir is at MFL, the spillway gates are all fully open. If the gates were closed, they would be overtopped.

Throughout this analysis, the model closes the Ebbegunbaeg canal gates as Long Pond levels rise. This is an appropriate flood handling procedure as it restricts the contribution to Long Pond from Meelpaeg reservoir. Under this operating practice, the total contribution from Meelpaeg is only 31 Mm^3 during the critical March PMP event centred over Long Pond.

Spring and Fall FRC's:

Two additional cases for different times of the year were considered for Long Pond, as follows.

Required: Find the reservoir levels (FRC's) just before the spring and fall storms which will ensure that water levels will not rise MFL (top of core). Assume that the 72% increase in existing spillway capacity required for the late winter design storm is in place.

		Sample FRC	
Results:	Case 1 (spring)	182.67 m	
	Case 2 (fall)	181.75 m	(unadjusted for 11% reduction in fall PMP).

Note: These FRC's are acceptable for flood handling, but may not be allowable for other reasons, such as freeboard or operating considerations.

Spring and fall FRC's are sensitive to both spillway capacity and MFL, and the results quoted above are specific to the case examined. They are examples only, not allowable operating levels.

Test with Storm Centre at Round Pond:

Since outflows from Round Pond are a large component of total Long Pond inflow, a test case was run with the storm centred over the Round Pond subbasin. Results showed that this situation does not produce more critical conditions for Long Pond than centering the storm over Long Pond itself.

4.3.2 - Upper Salmon

Starting level, Great Burnt - 241.95 m
Maximum reservoir level, Great Burnt - 242.00 m (maximum allowable GB level to protect West Salmon core)

Required: Spillway increase to maintain in these levels
Result: 29% increase required.

Comments: The Upper Salmon basin contains 2 reservoirs, Great Burnt (GB) upstream and Cold Spring Pond (CS) downstream, joined by a diversion channel. Normally, the flows in the diversion channel are from GB to CS, to maintain the power flow at Godaleich plant. During the PMF (and in lesser floods as well), the inflows into CS are so large that even if Godaleich were operating the flow in the diversion channel would reverse, from CS to GB. The levels would then be higher in CS than in GB. Consequently, in order to protect the West Salmon Dam at CS, the maximum level in Great Burnt must not exceed 242.0 m. (Top of core level in North Salmon Dam at GB is 243.0 and does not govern; this was established by freeboard requirements during high winds under normal operating conditions.)

The operating procedure used in the flood routing model during floods is based on procedures specified in ACRES Upper Salmon operating manual. It assumes that at the onset of a flood, the gates are opened to draw the level of GB down to 241.6 m before the peak inflows arrive.

Godaleich power plant is assumed to be out during the PMF event, because it consists of only one unit remotely located. An outage during the PMP could occur for various reasons, such as penstock or transmission line failures or flooding of the powerhouse. Repairs could take several days because of difficult access.

4.3.3 - Meelpaeg

Starting level	- to be determined.
Maximum allowable level Case 1	- 268.4 m (original design MFL; proposed low saddle dyke to conform)

Case 2 - 267.1 m (assumed elev. of top of existing low saddle area)

Case 1 assumes that a low saddle dyke has been built to allow a maximum flood level of 268.4 m (original design MFL). Case 2 assumes no low saddle dyke; the MFL of 267.1 m is established by the elevation of the low saddle itself.

	Maximum allowable flood level (m)	Late winter required drawdown level (m)	Full Supply level (m)	FSL minus 2/3 snowpack (drawdown level expected from historic practice) (m)
Case 1: With dyke	268.4	266.33		
Case 2: No Dyke	267.1	264.96	266.55	265.45

Without a low saddle dyke, a drawdown of about half a metre below the level expected from historic practice for snowpack drawdown is required. The snowpack drawdown itself is 1.1 m below FSL.

Approximate estimates of required preflood levels before the spring and fall events show that they are also both below FSL, i.e. Meelpaeg could never be operated at its FSL. The spring level is about 266.1 m and the fall level about 265.5 m. Construction of the proposed low saddle dyke should allow operation at or close to FSL throughout the year, except for some snowpack drawdown in late winter. An economic analysis is required to assess the costs and benefits of the construction of the dyke.

Comments on Ebbegunbaeg operation: The model assumes that Ebbegunbaeg gates are available to pass flow downstream to a maximum of 197 m^3/s. As described in Section 2, the model opens or closes gates as required, to keep the reservoirs balanced according to the prescribed operating policy. As the outflow tables in Appendix C show, the operation of the gates varies according to how quickly each of the major reservoirs is rising.

4.3.4 - Granite

Starting level - 311.2 m
Maximum allowable level - 313.37 m (top of core of small dykes)

Results: No spillway increase is required. The highest level reached is 312.44 m, 0.9 m below the top of core elevation of the small dykes, and 1.5 m below the top of the core of Granite Dam.

4.3.5 - Burnt Pond

Starting level - 313.94 m
Maximum allowable level: - 315.47 m (top of core, Burnt Dam. Assumes remedial measures in place at Burnt Dyke to prevent wave damage.)

Required: Spillway increase for 2 cases, as follows.

Case 1: Victoria control gates available.
Case 2: Victoria control gates closed.

Results:

	Percent spillway increase
Case 1 (available)	47%
Case 2 (closed)	45%

Comments: When Victoria control gates are available, the model operates them considering the overall balancing of the reservoirs in the system. Generally, they are open early in the flood, but as levels rise in downstream reservoirs, they close, then reopen later in the flood.

As in other cases, the required percent increase in spillway capacity assumes that the additional gates will be at the same elevation and will have the same discharge characteristics as the present structure. There are other flood handling alternatives layouts; these will be examined in a separate study.

4.3.6 - Victoria

The situation at Victoria is similar to that at Meelpaeg; a low saddle area to the east of Victoria control structure sets a maximum allowable flood level of 325.8 m. If this area is sealed with a low saddle dyke, the reservoir can be allowed to rise to an elevation of about 327.1 m. If, in addition, riprap is added to the crest of the Victoria dykes near the control structure to prevent damage from wave overtopping, the maximum flood level can be allowed to rise to the elevation of the top of the core at Victoria dam, 327.36 m.

Two cases were therefore considered. The first assumed an MFL at the elevation of the low area; the second assumed remedial works to be in place, and an MFL at the top of the core (327.36).

Starting level - to be determined

Maximum allowable level

Case 1 - 327.36 m (top of core, Victoria Dam)

Case 2 - 325.8 m (elevation of low area)

Victoria River Spillway - available to a maximum of 227 m^3/s

Victoria control gates - available as required.

Results:

	Maximum allowable flood level (m)	Late winter required drawdown level (m)	Full Supply level (m)	FSL minus 2/3 snowpack (drawdown level expected from historic practice) (m)
Case 1: With dyke	327.36	324.4		
Case 2: No Dyke	325.8	322.5	324.92	323.4

With no dyke, the required additional drawdown below expected levels from historic practice for snowpack drawdown is 0.9 m. Maintaining this level could impose serious operational and energy constraints. Although no detailed analysis was undertaken to determine allowable reservoir levels through the year, it is expected that drawdown below normal levels could be required throughout the year.

If remedial measures are undertaken to allow the reservoir to rise to the top of the core, the pre-flood starting level can be as high as 324.4m, about a half metre below FSL, and above expected winter levels. If the dyke is built, but no riprap added to the crests of Victoria dykes, the estimated starting level is about 324.1 m. Assessing the capital costs and operational benefits of the remedial measures was outside the terms of reference for this study, but should be examined.

Several other scenarios were examined to assess the effect of the availability of the control gate. The spillway was assumed to be available to a maximum of 227 m^3/s and the MFL was taken at 327.36 m. The scenarios and results are as follows.

Scenario	Required
1. Victoria control gates closed.	Maximum routed water level
2. Victoria control gates open.	Maximum routed water level
3. Victoria control gates closed.	Winter starting level (FRC)
4. Victoria control gates open.	Winter starting level (FRC)

Results:

Scenario	Control Gate	Starting Level	Maximum Routed Level	Elevation Difference to Top of Core
1	closed	323.4 m	326.83 m	0.53 m
2	open	323.4 m	326.57 m	0.79 m
3	closed	324.1 m	327.36 m	-
4	open	324.4 m	327.35 m	-

Comments: Clearly a variety of starting levels are possible, depending on whether the spillway and control gates are available. The fourth scenario series of routing runs sets the upper limit of possible winter starting levels, and is identical to case 1 above. Other intermediate levels could be similarly obtained, for different conditions or at different times of year. Victoria River Spillway is used in all cases to a maximum of 227 m^3/s. If the starting level is 323.4, however, and the MFL is at the top of core, as in Case 1, the spillway is not required. In fact, the entire inflow flood volume of 636 Mm^3 can just be contained in storage between elevations 323.4 and 327.36, with both the spillway and the control gates closed.

The top of the Victoria River spillway gates is at about elevation 325.4. If they are left closed, they will be overtopped by about 0.4 m when the reservoir is at the elevation of the low area, and by nearly 2 m if the reservoir reaches the top of core elevation. Although overflow for short periods could likely be tolerated, nevertheless it is recommended that gates be operated so that overtopping does not occur, or that flash boards be added.

4.4 - Summary of Results of Flood Handling Analysis

4.4.1 - General

Results for all reservoirs are summarized in Table 4.2, and graphically in Figure 4.2.

The results show that increased spillway capacity is required at Long Pond (72%), Upper Salmon (29%) and Burnt Pond (47%). (The results assume that remedial measures to increase freeboard on Burnt Dyke are in place.) Meelpaeg can handle the PMF by storage if the reservoir level is at 264.96 m (1.59 m below full supply level) in the late winter before the flood. If a low saddle dyke is built to allow maximum flood levels to rise to elev 268.4 m, then a late winter operating level of 266.33 m (0.22 m below FSL) is acceptable.

Granite can handle the PMF with existing storage and/or spillway capacity, assuming late winter levels are as specified for this study. Victoria can handle the PMF if the reservoir is drawn down to 322.5 m (2.4 m below FSL). If remedial measures are in place, the reservoir can be held to a maximum elevation of 324.4 m, half a metre below FSL. The exact level depends on what

Table 4.2

SUMMARY OF RESULTS

Basin	Required Spillway Increase %	Spillway Capacity at MFL (m^3/s) Present	Spillway Capacity at MFL (m^3/s) Required	Late Winter Level (FRC) (m)	Present FSL (m)
Long Pond	72%	1520	2610	180.29	180.75
Upper Salmon	29%	1020	1320	241.95	242.0
Meelpaeg					
-with low saddle dyke	-	-	-	266.33(1)	266.55
-no low saddle dyke				264.96(1)	
Granite	0	3200	-	311.2	311.2
Burnt Pond				313.94	313.94
- Victoria gates avail.	47%	770	1130		
- Victoria gates closed	45%	770	1120		
Victoria					
- with measures	0	227	227	324.4(1)	324.92
- no remedial measures	0	227	227	322.5(1)	

Notes:

1. FRC determined in present study.

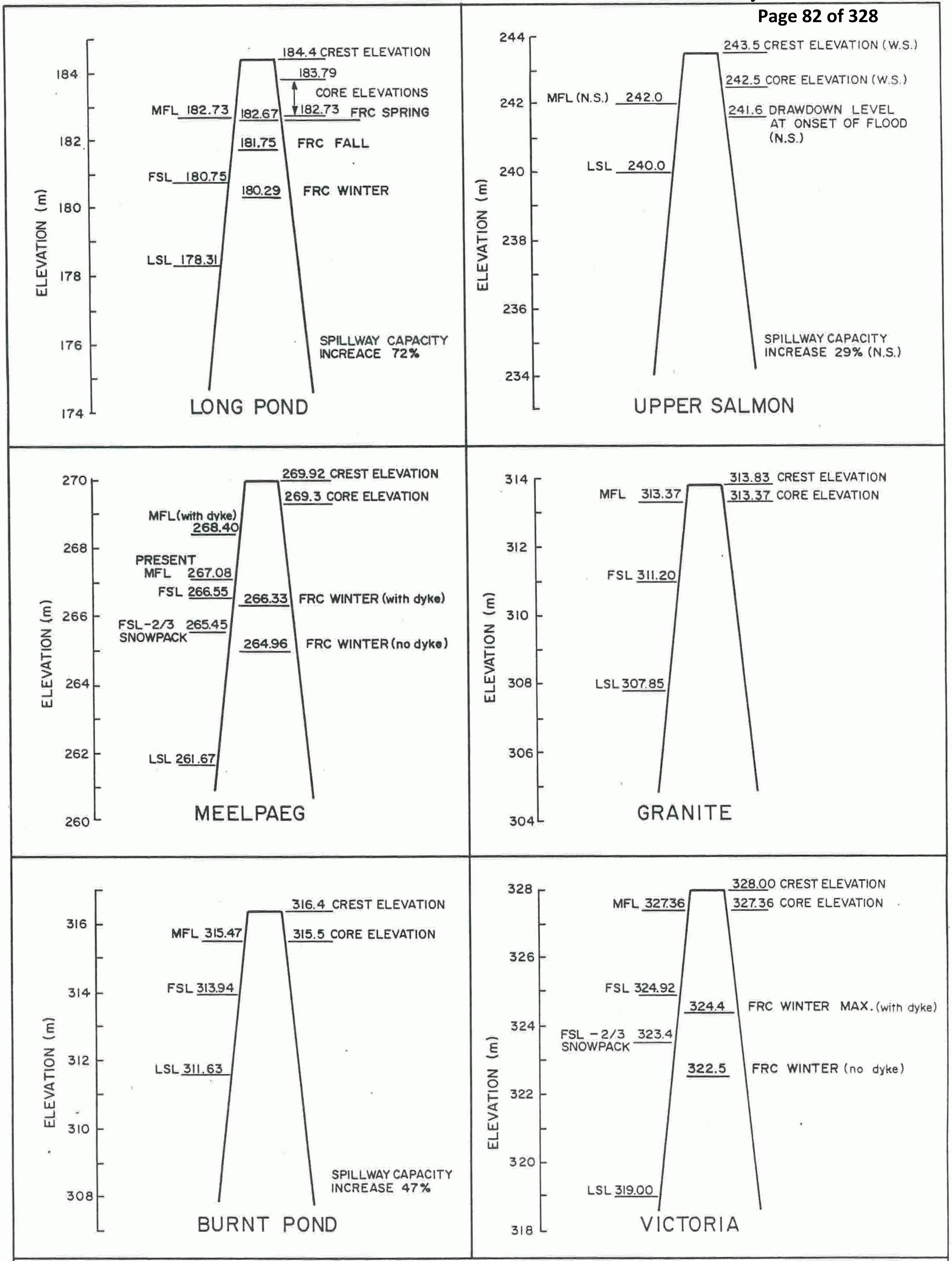


FIG. 4.2

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY
SUMMARY OF FLOOD HANDLING RESULTS

remedial measures are in place, and on the operation of the spillway and control gates.

Peak inflows and outflows, and total inflow, outflow, and flood storage volumes are presented in Tables 4.3 to 4.9 (e). Appendix C contains complete tables of precipitation, local inflows and routed outflows, and reservoir trajectories.

Determination of spring and fall FRC's should be done when spillway capacities have been finally selected.

Table 4.3
Summary of Peak Flows and Volumes
Storm: WINTER
Centre: LONG POND
Routing Duration: 7 days

Basin	Long Pond	Round Pond	Upper Salmon	Meel-paeg	Granite Lake	Burnt Pond	Victoria Lake
Drainage Area (km2)	830	944	902	971	502	678	1057
Precip (mm)	746.5	733.7	733.7	697.5	621.3	565.3	548.2
Res. elev (m)							
- Start	180.29	185.00	241.95	266.33	311.20	313.94	323.40
- Peak	182.72	189.40	241.96	268.26	312.30	314.28	325.52
Peaks :							
Inflow (m3/s)							
- Local	1849	2154	1682	2169	982	1099	1596
- Upstream	3223	1308	189	187	154	187	
Outflow (m3/s)							
- Canal/Struct.	174	3223		189	187	154	187
- Spillway	2610		1308		817	930	150
Volumes:							
Inflow (Mm3)							
- Local	496	560	499	546	247	297	442
- Upstream	1053	566	31	103	67	68	
Outflow (Mm3)							
- Canal/Struct.	105	1053		31	103	67	68
- Spillway	1121		571		185	293	63
Stor Change (Mm3)	324	73	-40	618	26	5	311
IN-OUT-STO	-1	0	-1	0	0	0	0

Note:
Peak inflows and outflows cannot simply be added because they may occur at different times.

Table 4.4
Summary of Peak Flows and Volumes
Storm: WINTER
Centre: ROUND POND
Routing Duration: 7 days

Basin	Long Pond	Round Pond	Upper Salmon	Meel-paeg	Granite Lake	Burnt Pond	Victoria Lake
Drainage Area (km2)	830	944	902	971	502	678	1057
Precip (mm)	697.5	746.5	746.5	697.5	649.1	632.4	577.3
Res. elev (m)							
- Start	180.29	185.00	241.95	266.33	311.20	313.94	323.40
- Peak	182.64	189.44	242.00	268.27	312.34	314.85	325.71
Peaks :							
Inflow (m3/s)							
- Local	1709	2196	1717	2169	1033	1252	1694
- Upstream	3267	1316	189	188	154	188	
Outflow (m3/s)							
- Canal/Struct.	174			189	188	154	188
- Spillway	2582	3267	1316		882	985	156
Volumes:							
Inflow (Mm3)							
- Local	460	570	508	546	260	336	469
Upstream	1071	575	30	104	72	59	
Outflow (Mm3)							
Canal/Struct.	105	1071		30	104	72	59
Spillway	1111		580		202	319	65
Stor Change (Mm3)	315	75	-40	619	27	4	345
IN-OUT-STO	0	-1	-2	1	-1	0	0

Note:
Peak inflows and outflows cannot simply be added because they may occur at different times.

Table 4.5
Summary of Peak Flows and Volumes
Storm: WINTER
Centre: UPPER SALMON
Routing Duration: 6 days

Basin	Long Pond	Round Pond	Upper Salmon	Meel-paeg	Granite Lake	Burnt Pond	Victoria Lake
Drainage Area (km2)	830	944	902	971	502	678	1057
Precip (mm)	731.7	744.5	744.5	706.3	695.5	666.3	619.3
Res. elev (m)							
- Start	180.29	185.00	241.95	266.33	311.20	313.94	323.40
- Peak	182.73	189.44	242.00	268.24	312.38	314.97	325.94
Peaks :							
Inflow (m3/s)							
- Local	1812	2196	1717	2208	1121	1334	1842
- Upstream	3267	1316	189	190	154	190	
Outflow (m3/s)							
- Canal/Struct.	174	3267			190	154	190
- Spillway	2614		1316	189	965	1046	167
Volumes:							
Inflow (Mm3)							
- Local	472	562	477	551	280	349	492
- Upstream	972	539	30	90	60	41	
Outflow (Mm3)							
- Canal/Struct.	90	972		30	90	60	41
- Spillway	908		549		217	327	53
Stor Change (Mm3)	447	129	-40	610	34	3	397
IN-OUT-STO	-1	0	-2	1	-1	0	1

Note:
Peak inflows and outflows cannot simply be added because they may occur at different times.

Table 4.6 (a)
Summary of Peak Flows and Volumes
Storm: WINTER
Centre: MEELPAEG (with low saddle dyke)
Routing Duration: 7 days

Basin	Long Pond	Round Pond	Upper Salmon	Meel-paeg	Granite Lake	Burnt Pond	Victoria Lake
Drainage Area (km2)	830	944	902	971	502	678	1057
Precip (mm)	649.1	621.3	649.1	746.5	746.5	708.3	708.3
es. elev (m)							
- Start	180.29	185.00	241.95	266.33	311.20	313.94	323.40
Peak	182.15	189.04	241.74	268.38	312.44	315.23	326.40
Peaks :							
Inflow (m3/s)							
Local	1570	2196	1453	2343	1211	1425	2145
- Upstream	2834	1268	190	192	154	193	
utflow (m3/s)							
Canal/Struct.	174	2834		190	192	154	193
- Spillway	2398		1268		1062	1088	186
olumes:							
Inflow (Mm3)							
- Local	424	464	435	588	305	383	591
Upstream	911	507	35	105	75	55	
Outflow (Mm3)							
Canal/Struct.	105	911		35	105	75	55
Spillway	1042		512		247	358	73
tor Change (Mm3)	189	61	-40	658	27	5	463
IN-OUT-STO	-1	-1	-2	0	1	0	0

ote:
Peak inflows and outflows cannot simply be added because they may occur at different times.

Table 4.6 (b)
Summary of Peak Flows and Volumes
Storm: WINTER
Centre: MEELPAEG (without low saddle dyke)
Routing Duration: 9 days

Basin	Long Pond	Round Pond	Upper Salmon	Meel-paeg	Granite Lake	Burnt Pond	Victoria Lake
Drainage Area (km2)	830	944	902	971	502	678	1057
Precip (mm)	653.1	625.3	653.1	750.5	750.5	712.3	712.3
es. elev (m)							
- Start	180.29	185.00	241.95	264.95	311.20	313.94	323.40
- Peak	182.15	189.04	241.74	267.10	312.44	315.23	326.40
eaks :							
Inflow (m3/s)							
Local	1570	2196	1453	2343	1211	1425	2145
Upstream	2830	1268	197	192	154	193	
utflow (m3/s)							
Canal/Struct.	174	2830		197	192	154	193
- Spillway	2396		1268		1062	1088	186
olumes:							
nflow (Mm3)							
- Local	430	466	458	589	305	388	603
Upstream	1008	579	85	133	99	88	
Outflow (Mm3)							
Canal/Struct.	135	1008		85	133	99	88
Spillway	1302		585		248	372	104
tor Change (Mm3)	1	38	-40	635	23	5	412
IN-OUT-STO	0	-1	-2	2	0	0	-1

ote:
Peak inflows and outflows cannot simply be added because they may occur at different times.

Table 4.7
Summary of Peak Flows and Volumes
Storm: WINTER
Centre: GRANITE
Routing Duration: 6 days

Basin	Long Pond	Round Pond	Upper Salmon	Meel-paeg	Granite Lake	Burnt Pond	Victoria Lake
Drainage Area (km2)	830	944	902	971	502	678	1057
Precip (mm)	593.3	593.3	619.3	723.3	744.5	706.3	731.7
es. elev (m)							
- Start	180.29	185.00	241.95	266.33	311.20	313.94	323.40
- Peak	181.94	188.95	241.68	268.27	312.44	315.23	326.53
Peaks :							
Inflow (m3/s)							
Local	1417	1699	1381	2268	1211	1425	2235
Upstream	2744	1257	189	192	154	194	
Outflow (m3/s)							
Canal/Struct.	174	2744		189	192	154	194
- Spillway	2319		1257		1062	1088	191
olumes:							
Inflow (Mm3)							
- Local	373	436	389	566	302	372	592
Upstream	802	460	37	91	64	38	
Outflow (Mm3)							
Canal/Struct.	90	802		37	91	64	38
Spillway	827		468		241	343	58
Stor Change (Mm3)	258	95	-40	619	35	4	496
IN-OUT-STO	0	-1	-2	1	-1	-1	0

ote:
Peak inflows and outflows cannot simply be added because they may occur at different times.

Table 4.8 (a)
Summary of Peak Flows and Volumes
Storm: WINTER
Centre: BURNT (VICT CTRL CLOSED)
Routing Duration: 5 days

Basin	Long Pond	Round Pond	Upper Salmon	Meel-paeg	Granite Lake	Burnt Pond	Victoria Lake
Drainage Area (km2)	830	944	902	971	502	678	1057
Precip (mm)	544.2	518.2	544.2	617.3	693.5	742.5	721.3
es. elev (m)							
- Start	180.29	185.00	241.95	266.33	311.20	313.94	323.40
- Peak	181.56	188.67	241.71	267.88	312.40	315.51	326.48
eaks :							
Inflow (m3/s)							
Local	1289	1462	1195	1900	1121	1512	2206
Upstream	2461	1244	189	191	177		
utflow (m3/s)							
Canal/Struct.	174	2461		189	191	177	
- Spillway	2180		1244		995	1117	185
olumes:							
nflow (Mm3)							
- Local	313	359	300	461	271	366	533
Upstream	603	373	44	75	58		
Outflow (Mm3)							
Canal/Struct.	75	603		44	75	58	
Spillway	605		385		203	290	45
tor Change (Mm3)	237	129	-40	492	51	18	488
IN-OUT-STO	-1	0	-1	0	0	0	0

ote:
Peak inflows and outflows cannot simply be added because they may occur at different times.

Table 4.8 (b)
Summary of Peak Flows and Volumes
Storm: WINTER
Centre: BURNT (VICT CTRL OPEN)
Routing Duration: 5 days

Basin	Long Pond	Round Pond	Upper Salmon	Meel-paeg	Granite Lake	Burnt Pond	Victoria Lake
Drainage Area (km2)	830	944	902	971	502	678	1057
Precip (mm)	544.2	518.2	544.2	617.3	693.5	742.5	721.3
es. elev (m)							
Start	180.29	185.00	241.95	266.33	311.20	313.94	323.40
- Peak	181.56	188.67	241.71	267.88	312.40	315.47	326.38
eaks :							
Inflow (m3/s)							
Local	1289	1462	1195	1900	1121	1512	2206
Upstream	2461	1244	189	190	167	167	
Outflow (m3/s)							
Canal/Struct.	174	2461		189	190	167	167
Spillway	2180		1244		993	1127	180
olumes:							
nflow (Mm3)							
- Local	313	359	300	461	271	366	533
Upstream	603	373	44	75	58	21	
Outflow (Mm3)							
- Canal/Struct.	75	603		44	75	58	21
Spillway	605		385		204	312	42
Stor Change (Mm3)	237	129	-40	492	51	16	470
N-OUT-STO	-1	0	-1	0	-1	1	0

Note:

Peak inflows and outflows cannot simply be added because they may occur at different times.

Table 4.9 (a)
Summary of Peak Flows and Volumes
Storm: WINTER
Centre: VICTORIA (VICT CTRL CLOSED)
Routing Duration: 8 days

Basin	Long Pond	Round Pond	Upper Salmon	Meel-paeg	Granite Lake	Burnt Pond	Victoria Lake
Drainage Area (km2)	830	944	902	971	502	678	1057
Precip (mm)	524.2	550.2	567.3	670.3	699.5	670.3	748.5
es. elev (m)							
- Start	180.29	185.00	241.95	266.33	311.20	313.94	323.40
- Peak	181.59	188.78	241.71	268.14	312.39	315.01	326.83
eaks :							
Inflow (m3/s)							
Local	1219	1546	1239	2066	1121	1334	2281
Upstream	2570	1244	209	190	141		
Outflow (m3/s)							
Canal/Struct.	174	2570		209	190	141	
- Spillway	2192		1244		966	1038	205
olumes:							
nflow (Mm3)							
- Local	334	404	384	520	282	362	636
Upstream	846	486	66	118	81		
Outflow (Mm3)							
Canal/Struct.	120	846		66	118	81	
Spillway	1060		492		222	287	98
Stor Change (Mm3)	1	43	-40	573	23	-6	538
N-OUT-STO	-1	1	-2	-1	0	0	0

ote:
Peak inflows and outflows cannot simply be added because they may occur at different times.

Table 4.9 (b)
Summary of Peak Flows and Volumes
Storm: WINTER
Centre: VICTORIA (VICT CTRL OPEN)
Routing Duration: 8 days

Basin	Long Pond	Round Pond	Upper Salmon	Meel-paeg	Granite Lake	Burnt Pond	Victoria Lake
Drainage Area (km2)	830	944	902	971	502	678	1057
Precip (mm)	524.2	550.2	567.3	670.3	699.5	670.3	748.5
Res. elev (m)							
- Start	180.29	185.00	241.95	266.33	311.20	313.94	323.40
- Peak	181.59	188.78	241.71	268.14	312.38	314.97	326.57
Peaks :							
Inflow (m3/s)							
- Local	1219	1546	1239	2066	1121	1334	2281
- Upstream	2570	1244	209	190	155	194	
Outflow (m3/s)							
- Canal/Struct.	174	2570		209	190	155	194
- Spillway	2192		1244		965	1046	193
Volumes:							
Inflow (Mm3)							
- Local	334	404	384	520	282	362	636
- Upstream	846	486	66	118	83	76	
Outflow (Mm3)							
- Canal/Struct.	120	846		66	118	83	76
- Spillway	1060		492		223	350	92
Stor Change (Mm3)	1	43	-40	573	24	5	469
IN-OUT-STO	-1	1	-2	-1	0	0	-1

Note:

Peak inflows and outflows cannot simply be added because they may occur at different times.

Table 4.9 (c)
Summary of Peak Flows and Volumes
Storm: WINTER
Centre: VICTORIA (VICT CTRL CLOSED)
Routing Duration: 7 days

Basin	Long Pond	Round Pond	Upper Salmon	Meel-paeg	Granite Lake	Burnt Pond	Victoria Lake
Drainage Area (km2)	830	944	902	971	502	678	1057
Precip (mm)	524.2	550.2	567.3	670.3	699.5	670.3	748.5
es. elev (m)							
Start	180.29	185.00	241.95	266.33	311.20	313.94	324.10
- Peak	181.59	188.78	241.71	268.14	312.38	314.96	327.36
eaks :							
Inflow (m3/s)							
- Local	1219	1546	1239	2066	1121	1334	2281
Upstream	2570	1244	209	190	142	0	
Outflow (m3/s)							
Canal/Struct.	174	2570		209	190	142	0
Spillway	2610		1244		965	1046	225
Volumes:							
Inflow (Mm3)							
- Local	334	404	384	520	282	362	636
Upstream	846	486	66	118	80	0	
Outflow (Mm3)							
- Canal/Struct.	120	846		66	118	80	0
Spillway	1060		492		222	288	113
Stor Change (Mm3)	1	45	-40	573	23	-6	523
N-OUT-STO	-1	-1	-2	-1	-1	0	0

Note:

Peak inflows and outflows cannot simply be added because they may occur at different times.

Table 4.9 (d)
Summary of Peak Flows and Volumes
Storm: WINTER
Centre: VICTORIA (VICT CTRL OPEN)
Routing Duration: 7 days

Basin	Long Pond	Round Pond	Upper Salmon	Meelpaeg	Granite Lake	Burnt Pond	Victoria Lake
Drainage Area (km2)	830	944	902	971	502	678	1057
Precip (mm)	522.2	548.2	565.3	668.3	697.5	668.3	746.5
Res. elev (m)							
- Start	180.29	185.00	241.95	266.33	311.20	313.94	324.40
- Peak	181.59	188.78	241.71	268.14	312.38	314.97	327.35
Peaks :							
Inflow (m3/s)							
- Local	1219	1546	1239	2066	1121	1334	2281
Upstream	2570	1307	209	190	155	200	
Outflow (m3/s)							
Canal/Struct.	174	2570		209	190	155	200
Spillway	2192		1307		965	1046	225
Volumes:							
nflow (Mm3)							
- Local	331	402	372	520	282	359	626
- Upstream	802	453	48	104	72	61	
Outflow (Mm3)							
- Canal/Struct.	105	802		48	104	72	61
Spillway	965		463		222	344	94
Stor Change (Mm3)	64	53	-40	577	27	5	471
N-OUT-STO	-1	0	-3	-1	1	-1	0

Note:
Peak inflows and outflows cannot simply be added because they may occur at different times.

Table 4.9 (e)
Summary of Peak Flows and Volumes
Storm: WINTER
Centre: VICTORIA (VICT CTRL OPEN)
Routing Duration: 7 days

Basin	Long Pond	Round Pond	Upper Salmon	Meel-paeg	Granite Lake	Burnt Pond	Victoria Lake
Drainage Area (km2)	830	944	902	971	502	678	1057
Precip (mm)	522.2	548.2	565.3	668.3	697.5	668.3	746.5
Res. elev (m)							
- Start	180.29	185.00	241.95	266.33	311.20	313.94	324.40
- Peak	181.59	188.78	241.71	268.14	312.38	314.97	325.77
Peaks :							
Inflow (m3/s)							
- Local	1219	1546	1239	2066	1121	1334	2281
- Upstream	2570	1244	193	190	154	189	
Outflow (m3/s)							
- Canal/Struct.	174	2570		193	190	154	189
- Spillway	2192		1244		965	1046	225
Volumes:							
Inflow (Mm3)							
- Local	331	402	372	520	282	359	626
- Upstream	802	453	48	104	71	57	
Outflow (Mm3)							
- Canal/Struct.	105	802		48	104	72	57
- Spillway	965		461		222	339	86
Stor Change (Mm3	64	53	-40	576	27	5	484
IN-OUT-STO	-1	0	-1	0	0	0	-1

Note:
Peak inflows and outflows cannot simply be added because they may occur at different times.

4.4.2 - Excess Volumes

Determination of excess volumes was also a requirement of the study. The excess volume is the amount of excess water which cannot be handled by the combination of existing spillway capacity and storage. With the storm centered over each basin in turn, the spillway capacity for that location only was fixed at existing. All other spillway capacities and starting levels were set as for late winter runs in the flood handling study as outlined in Section 4.3. The results are presented in Table 4.10. No excess volume calculation were required for Meelpaeg or Victoria because floods are handled primarily by storage.

5 - REMEDIAL MEASURES IN SALMON BASIN

5.1 - General

The analyses carried out in Section 4 show that the reservoirs upstream from Salmon Basin, with the exception of the Burnt reservoir (for which a 47% increase in spillway capacity is required) can handle PMF conditions. It is understood that a study to determine the most suitable manner by which to provide increased flood handling capability at Burnt is being undertaken as a separate study.

The flood handling capability of structures in the Salmon Basin during PMF conditions is presently inadequate, as shown in Section 4. Remedial measures are required to alleviate this situation and for this purpose a number of alternative measures were identified. These are as follows.

A - Upper Salmon Basin

(i) Provide storage capability at Island Pond.
(ii) Increase spillway capacity at North Salmon dam.
(iii) Provide spillway capacity at West Salmon dam.
(iv) Raise West Salmon dam, power canal dykes and intake.
(v) Improve the diversion channel capacity between Great Burnt and Cold Spring Pond.

B - Long Pond Basin

(i) Provide storage capability at Round Pond.
(ii) Increase spillway capacity at Salmon Dam.
(iii) Provide spillway capacity at Witch Hazel Hill.
(iv) Raise the Long Pond dams, i.e. Salmon dam, North Cutoff Dam, Power Canal Embankment, Southeast Cutoff Dams and Southwest Cutoff Dam.

A short description of each of these alternatives is given in the following section.

5.2 - Description of Alternatives

5.2.1 - Upper Salmon Basin

(a) Alternative A(i) - Provide Storage Capability at Island Pond

The drainage area at the outlet of Island Pond is 150 km^2 and comprises about 16% of the Upper Salmon Basin area and about 6% of the total Salmon Basin area. The construction of a control structure at the outlet of Island Pond would provide storage of floodwaters and attenuation of flow releases into North Salmon River. Earlier studies carried out by ACRES in 1979[6] addressed the feasibility of constructing a hydropower development at the outlet of Island Pond, incorporating a concrete bulkhead dam section and fill dikes. The control structure envisaged in the present study would initially be constructed for flood control purposes only, but could be designed in such a way that it could facilitate future redevelopment for power generation.

(b) Alternative A(ii) - Increase Spillway Capacity at North Salmon Dam

The existing North Salmon dam was built on North Salmon River as part of the Upper Salmon development to redirect flows through a diversion channel into Cold Spring Pond for supply to the Godaleich hydropower station. The existing spillway structure consists of three vertical sliding gates with gate hoist structures, monorail and standby generator. In Alternative A(ii), a fourth gate of the same height would be accommodated alongside the south retaining wall.

(c) Alternative A(iii) - Provide Spillway Capacity at West Salmon Dam

A new bypass spillway structure could be constructed along the western end of West Salmon dam. Flood flows would be discharged into an existing creek, which at present also forms the outlet of the minimum flow control structure built as part of the Upper Salmon project.

(d) Alternative A(iv) - Raise West Salmon Dam, Dykes and Intake.

With the maximum allowable flood level in the Upper Salmon system being governed by the top of core elevation of West Salmon dam (see Section 4), an alternative measure is to raise the levels of the dam, dyke, and other associated structures. Because of the length of the dam and dykes and their specific design conditions, the extent of remedial works is likely to be substantial.

(e) Alternative A(v) - Improve the Diversion Channel Capacity Between Great Burnt Lake and Cold Spring Pond

Since all flood flows in the Upper Salmon Basin are discharged at the North Salmon dam spillway, the flood inflows into Cold Spring Pond must be discharged through the diversion channel between Cold Spring Pond and Great Burnt. The level in Cold Spring Pond will rise above that in Great Burnt during the flood because of the head losses in the diversion channel. These losses could be reduced if channel improvements were carried out, and a higher MFL in Great Burnt could be allowed.

Note that if Godaleich power plant is operating, it alleviates the situation, but substantial flow still must occur from Cold Spring to Great Burnt.

5.2.2 - Long Pond Basin

(a) Alternative B(i) - Provide Storage Capability at Round Pond

To reduce and attenuate the flood discharge from Upper Salmon Basin into Long Pond, a control structure could be constructed at the outlet of Round Pond to increase the natural flood levels. The height of such a structure must be carefully selected to prevent tailrace flooding of the Godaleich power plant.

(b) Alternative B(ii) - Increase Spillway Capacity at Salmon Dam

The existing Salmon dam spillway structure is the only floodwater outlet from Long Pond reservoir. It consists of three vertical lift gates with screw hoisting equipment. A new bypass spillway would be constructed along the east abutment of the dam, without interfering with the operation of the present spillway. Alternatively, to prevent large excavation and structural and mechanical works, the center gate of the existing spillway could be replaced by a much deeper gate, permitting more discharge due to increased head.

(c) Alternative B(iii) - Provide Spillway Capacity at Witch Hazel Hill

An entirely new spillway could be provided near Witch Hazel Hill, where a small topographic saddle contains Long Pond reservoir. The spillway would be an overflow weir type, discharging floodwaters into an open channel excavated through the saddle. The outlet of the channel would be located at an existing streambed which conveys the floodwaters into the lower reaches of Salmon River.

(d) Alternative B(iv) - Raising of Long Pond Dams

Instead of constructing additional spillway capability, excess flood volume could be stored in Long Pond reservoir if the top of core levels of the existing containment dams were raised correspondingly. It is noted that existing concrete structures, such as the power intake of the Bay d'Espoir generating station and the Salmon dam spillway, also need to be raised.

5.3 - Hydraulic Requirements

The hydraulic requirements for the various alternatives were established using the same ARSP routing model as in the flood analysis. The alternative structure was introduced into the data files, and a series of runs were carried out to determine the effect of the new structure on flood handling.

The resulting discharge requirements at maximum flood level for the various alternatives are as follows.

Alternative	Maximum required discharge (m^3/s) at peak reservoir level		
	Existing	Additional	Total
North Salmon Extension	1020	300	1320
Salmon Dam Bypass	1520	1090	2610
Salmon Dam Centre Gate	1520	980	2500
Witch Hazel Hill Spillway	1520	1950	3470
Raising of Long Pond Dams	1770	-	1770

The required additional discharge varies with the sill elevation of the alternative structure. With a low sill, more head is available when the reservoir is low, and consequently more water is discharged throughout the flood. The alternative with the lowest total discharge requirement is the centre gate replacement, because the low sill allows large discharges as reservoir levels rise during the first few days of the flood. The Witch Hazel Hill spillway, on the other hand, has a sill elevation of 181.0, 0.25 m above FSL. It does not begin discharging until the middle of the third day of the flood, and the maximum head on it is 1.73 m, compared with over 18 m for the centre gate option. Consequently, it must be very long in order to have enough discharge capacity as water levels approach MFL.

5.4 - Ranking and Selection of Most Promising Alternatives

5.4.1 - Upper Salmon Basin

A number of alternative measures which will alleviate the anticipated flooding in Upper Salmon Basin were identified as discussed in Sections 5.1 and 5.2. Because of lack of field data and because the preparation of detailed layouts and cost estimates for all of the alternatives was not part of the terms of reference for the study, a qualitative evaluation of the alternatives was undertaken.

Although the Island Pond storage alternative appears to be attractive, because any work done could be incorporated in a possible future power project, a rough cost estimate for the road and dykes indicates that costs could be in excess of $12 million. In addition, the structure would not control enough of the drainage basin to handle all the excess flow and additional measures would be required. Therefore, this scheme is economically not promising for flood handling only. Nevertheless, the scheme could be assessed in more detail, and layouts and estimates prepared, in order to assign benefits to a power project.

The raising of the West Salmon Dam, power canals and intake is estimated to be a very costly alternative due to the length of earth structures involved.

Improving the diversion channel between Cold Spring Pond and Great Burnt Lake can be expected to reduce flood levels in Cold Spring significantly, but this may not be sufficient to eliminate the flooding problems. In addition, no data are available to determine the extent of improvement possible. Excavation works would be extensive with possible interference with the operation of the Godaleich Power Plant. This alternative therefore has a number of practical concerns which cannot be addressed without further study, but which will likely render it unattractive if carried out by itself.

A more attractive option is the construction of a new spillway facility at West Salmon Dam. As discussed in Section 4.3.2, the allowable level in Great Burnt must be kept low in order to keep Cold Spring levels below the top of the core at West Salmon dam. If Cold Spring Pond had its own spillway at West Salmon, Great Burnt could be allowed to rise. Because of the extra water stored in Great Burnt, peak discharge to Long Pond would be reduced. Less additional spillway capacity would therefore be required at Long Pond. However, it is also noted that this alternative has environmental concerns as the natural discharge channel is insufficient to accept large floods.

A second attractive option is an additional gate at the North Salmon Dam spillway structure. This option would involve a simple design and construction effort, as very limited field investigation would be required and the additional gate could be made identical to the existing gates. Access is available and auxiliary equipment exists.

It is noted that an additional alternative would be the construction of a fuse plug in one of the dams of the Upper Salmon Basin. However, considering that the resulting large outflow would also have to be handled in the Long Pond Basin and the fact that most of the storage volume in Cold Spring Pond and Great Burnt Lake would be lost, this alternative was not further considered.

In order to obtain a representative estimate of the construction cost of remedial measures in the Upper Salmon Basin, one alternative was selected for preparation of a conceptual layout and representative cost estimate. The selection was based on a judgment of technical feasibility and economic viability. After discussions with NLH, the North Salmon dam spillway structure extension was adopted, on the grounds that although other options might also be attractive, they would not be less expensive.

5.4.2 - Long Pond Reservoir

The results of the reservoir routings for the Round Pond flood storage alternative indicate that the effect of this alternative in reducing flood flows into Long Pond is limited, even with a high control dam constructed at the outlet of Round Pond. In addition such a structure would be costly, and excessively high levels in Round Pond would adversely affect the tailrace of the Godaleich power plant. In view of these considerations, this alternative was not further considered.*

All other alternatives in Long Pond Basin are acceptable from a hydraulic point of view. The layout studies are described in the following section.

(*A study of the hydroelectric power potential of this site was undertaken simultaneously with the present study and has been reported on separately.)

5.5 - Layout Studies

Layouts were prepared for the 5 alternatives identified in Section 5.4, one at Upper Salmon and 4 at Long Pond.

5.5.1 - Data Collection

Topographic and geotechnical information for preparation of conceptual layouts of the alternative measures was obtained as follows.

- North Salmon dam spillway -	available information from design and construction records.
- Salmon dam spillway and Witch Hazel Hill new spillway -	1:1000 scale topographic mapping with 1 m contour interval prepared for this study. Geotechnical information from site visit.
- Raising of Long Pond dams -	this part of the study was carried out by ShawMont during April, May and June 1985.

The descriptions of the topographic and geotechnical conditions are given as follows for each of the alternative sites. Hydraulic requirements are based on the results of the reservoir routing runs. A key plan of the proposed alternative measures is shown on Plate 1.

5.5.2 - North Salmon Dam Spillway Extension

The topography and geology at the existing North Salmon dam spillway were studied extensively during design and construction.

In this alternative a fourth gate would be constructed at the existing 3-gate spillway structure to obtain a 29% increase in discharge capacity at all elevations. The increased outflow capability of the structure would permit the discharge of excess flood flows without compromising the present design criteria of the Great Burnt-Cold Spring storage system.

The proposed extension would be located alongside the right abutment of the existing structure and consists of the installation of a gate and hoisting equipment identical to the existing installation as shown on Plate 2. Construction would be carried out in the dry and to facilitate the removal of the existing south retaining wall, a cellular cofferdam would be placed in line with the southern middle pier. This arrangement would permit the use of 2 gates of the existing structure, if required during construction. Excavation for the fourth gate would be carried out mainly in the dry with removal of a small quantity in the wet at completion of construction works. Existing fill material would be reused to the maximum extent possible; however, it would still be necessary to reopen borrow areas and quarry pits used for previous construction.

The existing standby generator and stoplog storage area would be relocated alongside the new abutment.

5.5.3 - Salmon Dam Bypass Spillway

Topography at the site is well defined; only the left bank offers a real possibility for the construction of a bypass channel. The right abutment is extremely steep whereas the left abutment, at least in the vicinity of the dam and spillway, is somewhat gentler. An indentation in the shoreline upstream from the dam offers an inlet location, and a creek bed downstream offers an outlet. A small hummock, downstream from the spillway below the existing road, could serve as the downstream limit of a rock-fill training groin or disposal area.

The existing spillway on the left abutment is founded on and in bedrock and has in general performed well, with a modest degree of rock erosion downstream from the structure being occasioned by the end-on presentation of the cleavage joints to flows. Above the spillway, at deck level, the road cut exhibits till-like overburden which is likely to be 2-m to 3-m deep. Rock is not visible above the road cut, and only reappears as a high cut some 100 m downstream from the spillway on the south side of the road. No rock exposure is then visible until seen in the riverbed. The overburden thickness high above the dam on the left side is unknown.

The proposed new bypass spillway would be located the left abutment of the existing Salmon dam. The resulting additional outflow capability of Long Pond reservoir, amounting to a total of over 2600 m^3/s at MFL, would permit the discharge of excess flood flows without interference with the present operating procedures of the Bay d'Espoir power plant. Present top of core levels of the cutoff dams and intake dikes would be maintained.

Based on the available data, no particular problems would expected with excavation of the proposed channel, if blasting were done carefully. Additional instrumentation would have to be installed well in advance of construction to monitor the effects, if any, of the blasting on the dam and grout curtain.

The layout of the proposed bypass spillway is shown on Plate 3. It consists of a 3-gate spillway structure with an intake channel, a downstream concrete apron and a rock-cut spillway chute. The location of the new structure was selected on the basis of continuous availability of the existing spillway structure for flood flow discharge, the need to avoid difficult cofferdamming arrangements near the existing structure, and consideration of the effects of blasting on the existing grout curtain and concrete structures.

The sill elevation of the new structure is set equal to that of the existing spillway structure. Access to the new structure will be provided by relocating the existing access road parallel to the proposed new structure. Access to the existing structure will be by means of a bridge deck alongside the hoisting equipment for the new structure.

5.5.4 - Salmon Dam-Center Gate Modification

An alternative solution to the bypass spillway alternative is to replace the center gate of the existing Salmon dam spillway structure by a new gate, set at an elevation about 10 m below the present spillway crest level. The advantage of such a low gate setting is that discharge is substantially increased due to increased head.

The ogee-shaped spillway crest and chute of the existing center gate would be demolished in order to accommodate the new gate setting as shown on Plate 4. Cofferdamming would be required for construction of civil works and to install the guides for the new gate and stoplogs. This would be achieved by placing a semicircular cofferdam against the center piers of the structure and sealing off the bottom and sides. Outside water pressure would aid the sealing mechanisms after dewatering of the structure was accomplished.

The dimension of the new gate would be about 9 m wide by 19.5 m high, which is about twice the height of the gates now installed on the spillway. Two types of gates were considered,

a) a conventional vertical lift gate which would require a hoist tower and bridge structure approximately twice the height of the hoist deck of the existing vertical screw hoists

(b) a double leaf gate which would reduce the hoist tower height closer to that of the present structure, but which has a number of technical complications which could not be resolved within the scope of this study.

For either gate, the increased hoisting capacity and larger resultant tower structure would require the complete replacement of the towers on the two center piers. Thus in each alternative, costs have been included for replacing the towers and bridges, as well as hoists for the two outside gates. In addition, costs for a new stoplog handling system have been included.

The large single-leaf gate would be a conventional wheeled vertical-lift design with wire rope hoist. The gate would be insulated and clad on the downstream face and internally heated to allow operation during freezing conditions. Each section of the double-leaf gate would be wheeled and likely have its own wire rope hoist. Technical details for this type of gate are not readily available and the principal concern would be with winter operation. Further detailed investigations are required to prove the feasibility of such a gate in this application.

For cost estimates, allowance has been made for installation of a vertical lift gate. The difference in cost between the two types of gates is less than 10 percent, and the ultimate selection of the most economic and practical gate design requires more detailed investigations during design stage.

5.5.5 - Witch Hazel Hill- New Spillway

This area is a topographic saddle between the second most southerly area of Long Pond reservoir and the Salmon River valley. The saddle consists of a broad undulating area of bog, ponds, hummocks of till and boulders and is crossed by the Upper Salmon access road and the Upper Salmon to Bay d'Espoir pole line. The height of land of the saddle is located between the road and the arm of Long Pond.

Bedrock in this area is relatively close to the surface (less than 1 m of overburden) and is visible in a number of flat surface outcrops. The bedrock is a granite, known as North Bay Granite, and has a massive structure given the size of boulders present on the surface in the boulder fields and the size of ice-wedged fragments disassociated from outcrop (commonly 8 m^3).

The Witch Hazel Hill spillway alternative would require the construction of an ungated overflow weir and discharge channel near Witch Hazel Hill. Due to the high setting of the weir, the head on the weir would be low, and discharge per unit length would be consequently low, resulting in a large discharge requirement at MFL. The proposed weir would be about 430 m long as shown on Plate 5. The discharge channel would be 30 m wide and about 2200 m long. Local topography would cause unfavorable channel depths to occur (with a maximum depth of about 30 m) resulting in large quantities of excavation.

Flow from the proposed channel would be discharged into a tributary the of Salmon River. There may be environmental concerns associated with this alternative, particularly as the deep flow channel would create an unsafe barrier to animal passage.

5.5.6 - Raising of Long Pond Dams

Based on the results of the reservoir routing runs, excess flood volume can be stored in Long Pond reservoir if the present dams of this reservoir are raised by 1.3 m. This includes the effect of increased discharge over the existing spillway due to higher heads. A study was carried out by ShawMont to investigate the costs of this measure for various height increases and a report was issued in July 1985[7]. For a height increase of 1.3 m, the corresponding construction cost for raising the earth structures was calculated from ShawMont's estimates, as accepted by Hydro. It is noted that a review of ShawMont's report was not carried out as this was not part of the Terms of Reference.

The cost of raising the concrete structures in Long Pond reservoir was not estimated by ShawMont. The two structures of concern are the intake for the Bay d'Espoir power plant and Salmon dam spillway. The present study did not include estimating the cost of raising these structures, but this could be substantial.

The stability analysis of the raised dams[7] does not assume a maximum water level corresponding to the top of core. Normally, a relatively small increase in head (about 1 m) would not be expected to endanger the stability of the dams. No review was undertaken.

5.5.7 - Cost Estimates and Schedules

(a) Basis of Comparative Estimate Costs

Generally, it was assumed that for any alternative, one contract would be awarded to a civil works contractor and the supply of all required mechanical equipment would be handled directly with such manufacturers. For the four Long Pond basin alternatives, it is assumed all workers would travel back and forth from their homes or temporary residences each day. The estimate for the North Salmon dam and spillway remedial work includes an allowance for the accommodation and related facilities necessary for workers.

Unit costs for civil works are derived from cost parameters obtained from recently executed projects such as Upper Salmon and from prices tendered for other domestic projects. The estimate for the raising-of-dams alternative was obtained by applying a linear interpolation of the costs used in the ShawMont Newfoundland Limited study. It has been assumed that the ShawMont unit prices for fill materials are based on recent work such as Cat Arm. No review was undertaken.

Major mechanical and electrical equipment items were estimated from appropriate cost curves and from quotations received recently on similar work.

Allowances for contingencies for unforeseen conditions which could cause an overrun in quantities of a premium on unit costs and for work unforeseen have been added.

A percentage was added to the total estimated construction cost for engineering and supervision by the consultant and a percentage for owner's costs.

Excluded from the comparative estimate prices are

- any land acquisition costs
- escalation beyond September 1985 price levels
- interest during construction.

(b) Summary of Estimates

The results of the comparative estimates for all alternatives are as follows.

Upper Salmon Basin

- North Salmon dam and spillway	$ 6,880,000

Long Pond Basin

- Salmon Dam-Centre gate modification	$ 5,750,000
- New bypass spillway	$12,100,000
- Witch Hazel Hill canal and overflow spillway	$32,085,000
- Raising of dams	$ 7,515,000*

*Excluding cost of raising concrete structures and associated mechanical modifications.

(c) Scheduling Aspects

Although formal schedules have not been prepared, the following approximate time frames have been assumed for the alternatives.

North Salmon Dam Spillway Extension:

It has been assumed that the stoplogs, gate and hoist would be fabricated over a 6-month period, and that all field construction (civil works) would be completed during one 8-month construction season. Allowing lead time to set up accommodation facilities at the site and for preparation of specifications, tendering and award contracts, the overall time frame is estimated to be between 1 and 1 1/2 years.

Salmon Dam Centre Gate Modification:

Allowing lead-time for preparation of specifications, tendering and award of contractss, 9 to 12 months from award of gate fabrication contract to delivery, and another 2 to 3 months for gate installation and commissioning, the total time frame for this option is also estimated to be about 1 1/2 years.

Salmon Dam Bypass Spillway:

It has been assumed that the new gates and hoists would be fabricated over a 6-month period. The excavation and civil works would be completed during one construction season. The overall time frame is estimated at 1 to 1 1/2 years.

Witch Hazel Hill New Spillway:

Two construction seasons would be required for the field construction associated with this project. Including lead time for preparation of tender documents, tendering, and award, the total time frame is about 2 years.

Raising of Long Pond Dams:

The estimates for this work were based on the ShawMont report[7], and no schedule was prepared. Raising of the fill dams should be possible within one construction season, but no assessment of the time required for concrete or mechanical works can be made until the extent of these works is known.

5.5.8 - Summary of Layout Study Results

Upper Salmon: The extension to the North Salmon spillway was selected for layout and costing, having being judged the most likely alternative. Technically, there appears to be no major concern regarding the installation of a fourth gate at the south abutment of the existing North Salmon dam spillway structure. The cost of installing such a gate is estimated at $6.88 million, expressed in September 1985 dollars and excluding IDC and escalation.

It is noted that comparison studies with other alternative remedial measures, described in Sections 5.1 and 5.2, must be undertaken to determine the most suitable manner of handling the PMF flows considering operational, technical and economical aspects. The brief review carried out for this study, however, indicated that other alternatives are more likely to present technical difficulties, and to be more expensive.

Long Pond: A total of four alternative measures in Long Pond Basin were studied. Each of these measures presents a hydraulically acceptable way to handle excess flood volumes during PMF flow conditions. The new Witch Hazel Hill spillway structure, however, appears to be unsuitable due to economic, practical and environmental concerns.

The Salmon Dam Bypass Spillway is technically acceptable, but is costly to implement and is therefore less attractive.

Of the two most promising alternatives, the centergate modification alternative is more attractive from an economic standpoint being about $1.8 million (30%) less costly than the dam raising alternative. The actual cost difference between the two options is larger, however, when the cost of raising of the concrete structures is taken into account. Layouts and cost estimates for this were not prepared, but additional cost could be in excess of $0.7 million. It is noted that the raising of concrete structures may not be without technical problems. For example, the seal between the raised concrete section and the gates would be difficult to achieve. On the other hand, the unusual dimensions of the centergate modification may require additional engineering.

Other aspects also need to be considered. Raising the intakes of the Bay d'Espoir power plant may interfere with powerplant operations. Furthermore, the effect of flood forecasting will be more beneficial for the centergate modification as the extent of prespilling is larger at the low setting of the centergate, resulting in higher permissible operating levels and corresponding energy benefits.

In summary, the centergate modification appears to be economically more attractive than the dam raising alternative. In addition there are practical and operational benefits which can be credited to the centergate modification. It is therefore concluded that the centergate modification is the most promising alternative for eliminating the flooding problems in Long Pond reservoirs.

TABLE 5.1

UPPER SALMON BASIN - NORTH SALMON DAM SPILLWAY EXTENSION

Summary of Cost Estimate

	Amount ($1985)
A - Civil Works	
1 - Mobilization	$ 100,000
2 - Site Accommodation of Workers	520,000
3 - Cofferdams and Water Control	392,000
4 - Equipment Preparations	13,000
5 - Existing Dam	280,000
6 - Rock Excavation	166,000
7 - Foundation Preparation (for concrete)	65,000
8 - Spillway Structure Concrete	2,409,000
Subtotal Civil Works Without Contingencies	3,945,000
Contingencies (20%)	790,000
TOTAL CIVIL WORKS	$4,735,000
B - Mechanical/Electrical	
1 - Gates, Guides, Stoplogs, Hoist Tower etc	1,000,000
Contingencies (10%)	100,000
TOTAL MECHANICAL/ELECTRICAL	$1,100,000
TOTAL COSTS INCLUDING CONTINGENCIES	$5,835,000
Engineering and Construction Management (13%)	755,000
Owner's Costs (5%)	290,000
TOTAL ESTIMATED COST (without IDC and escalation)	$ 6,880,000

TABLE 5.2

LONG POND BASIN - SALMON DAM BYPASS SPILLWAY

Summary of Cost Estimate

	Amount ($1985)
A - Civil Works	
1 - Mobilization, Clearing, Stripping, Site Preparation	$ 200,000
2 - Roads	30,000
3 - Channel and Spillway Excavation	2,260,000
4 - Water Control	25,000
5 - Foundation Preparation (for concrete)	85,000
6 - Spillway Structure	2,835,000
Subtotal Civil Works Without Contingencies	5,435,000
Contingencies (20%)	1,085,000
TOTAL CIVIL	$6,520,000
B - Mechanical/Electrical	
1 - Supply and Installation of Three New Gates, Guides, Stoplogs, Hoists etc	3,400,000
Contingencies (10%)	340,000
TOTAL MECHANICAL/ELECTRICAL	$3,740,000
TOTAL COSTS INCLUDING CONTINGENCIES	$10,260,000
Engineering and Construction Management (13%)	1,330,000
Owner's Costs (5%)	510,000
TOTAL ESTIMATED COST (without IDC and escalation)	$ 12,100,000

TABLE 5.3

LONG POND BASIN - SALMON DAM CENTER GATE MODIFICATIONS

Summary of Cost Estimate

	Amount ($1985)
A - Civil Works	
1 - Mobilization	$ 50,000
2 - Bulkhead Cofferdam	500,000
3 - Demolition of Upper Rollway 2	120,000
4 - Demolition for New Gate and Guides	23,000
5 - New Concrete	60,000
Subtotal Civil Works Without Contingencies	753,000
Contingencies (20%)	150,000
TOTAL CIVIL WORKS	$903,000
B - Mechanical/Electrical	
1 - Supply and Installation of One New Gate, Hoist and Auxiliaries	$3,600,000
Contingencies (15%)	540,000
TOTAL MECHANICAL/ELECTRICAL	$4,140,000
TOTAL COSTS INCLUDING CONTINGENCIES	$5,043,000
Engineering and Construction Management (10%)	504,000
Owner's Costs (4%)	203,000
TOTAL ESTIMATED COST (without IDC and escalation)	$5,750,000

TABLE 5.4

LONG POND BASIN - WITCH HAZEL HILL NEW SPILLWAY

Summary of Cost Estimates

	Amount ($1985)
Civil Works	
1 - Mobilization	$ 500,000
2 - Roads	550,000
3 - Canal Excavation	19,625,000
4 - Overflow Spillway Concrete	1,983,000
Subtotal Civil Works Without Contingencies	22,658,000
Contingencies (20%)	4,532,000
TOTAL COST INCLUDING CONTINGENCIES	$27,190,000
Engineering and Construction Management (13%)	3,535,000
Owner's Costs (5%)	1,360,000
TOTAL ESTIMATED COST	$ 32,085,000

(without IDC and escalation)

TABLE 5.5

LONG POND BASIN - RAISING OF LONG POND DAMS

Costs Based on "Study of Dam Raising for Long Pond Reservoir" by ShawMont Newfoundland Limited, July 1985

Dam Height Increase = 1.3 m

Linear Interpolation of Costs (Between 1 m and 2 m) Including 10% Contingency	Amount ($1985)
Salmon River Dam (Table 1A)	$ 431,000
North Cutoff Dam (Table 1B)	1,265,000
Power Canal Embankment (Table 1C)	2,794,000
Southeast Cutoff Dams (Table 1D)	639,000
Southwest Cutoff Dam (Table 1E)	660,000
Total	$5,789,000
Add Additional 10% Contingency to Parallel Other Schemes	$ 579,000
TOTAL COST INCLUDING 20% CONTINGENCY	$6,368,000
Engineering and Construction Management (13%)	828,000
Owner's Costs (5%)	319,000
TOTAL ESTIMATED COST (without IDC and escalation)	$7,515,000

Note: Cost of raising concrete structures is not included.

LIST OF REFERENCES

1. Bay d'Espoir Hydrology Studies, Probable Maximum Precipitation, November 1984, Acres.

2. HEC-1 Flood Hydrograph Package Hydrologic Engineering Center U.S. Army Corps of Engineers, January 1983.

3. Bay d'Espoir Development Probable Maximum Floods Final Report, December 1965, Montreal Engineering Co. Ltd.

4. Handbook on the Principles of Hydrology, Water Information Center, Inc. 1973, D.M. Gray.

5. Historical Rainstorm Analysis and Estimation of Maximum Storm Rainfall in Southern Newfoundland, September 1965, Department of Transport, Government of Canada.

6. Appendix C, Feasibility Study, Upper Salmon Development, February 1979, Acres.

7. Study of Dam Raising for Long Pond Reservoir, ShawMont Newfoundland Limited, July 1985.

PLATES

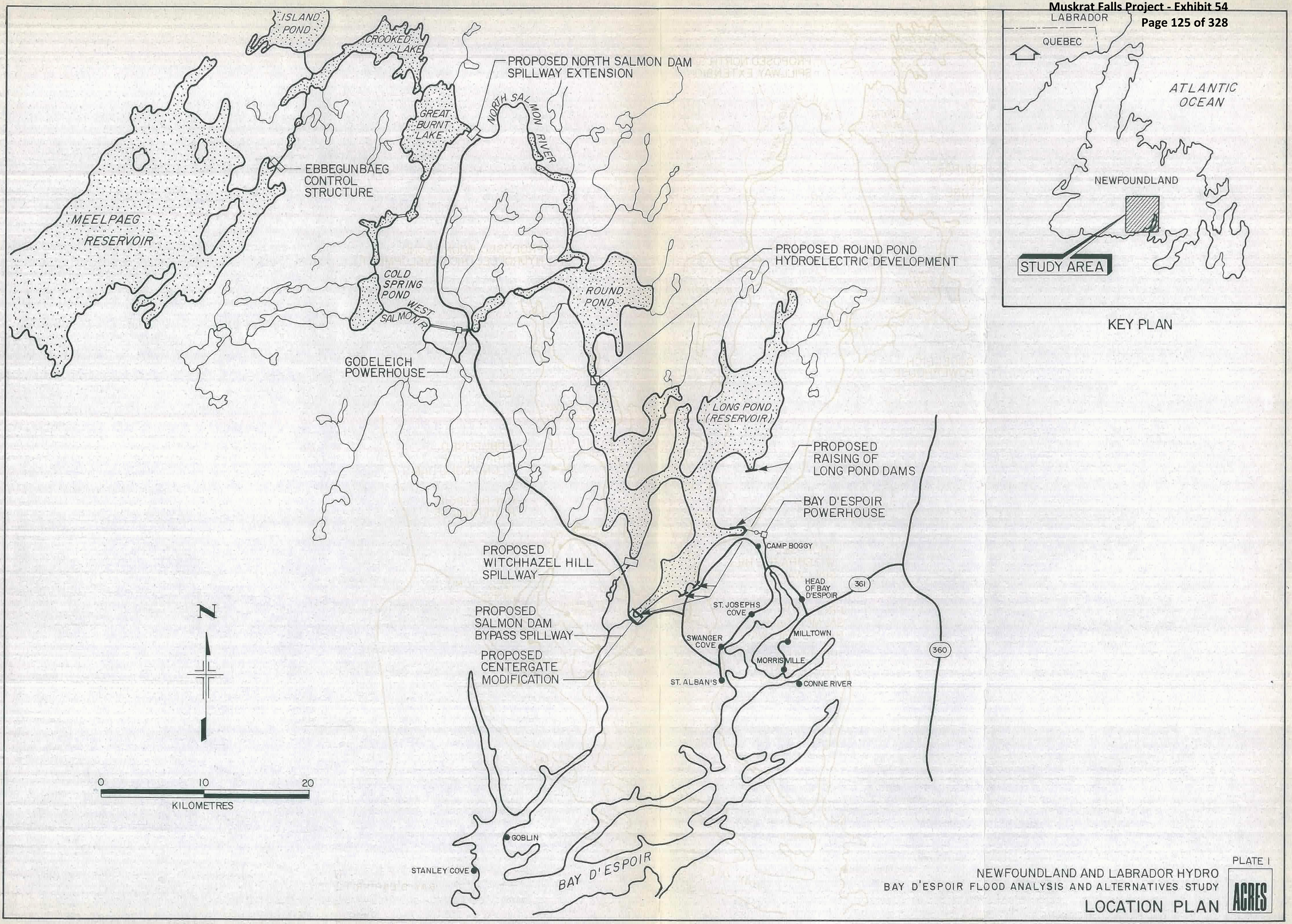
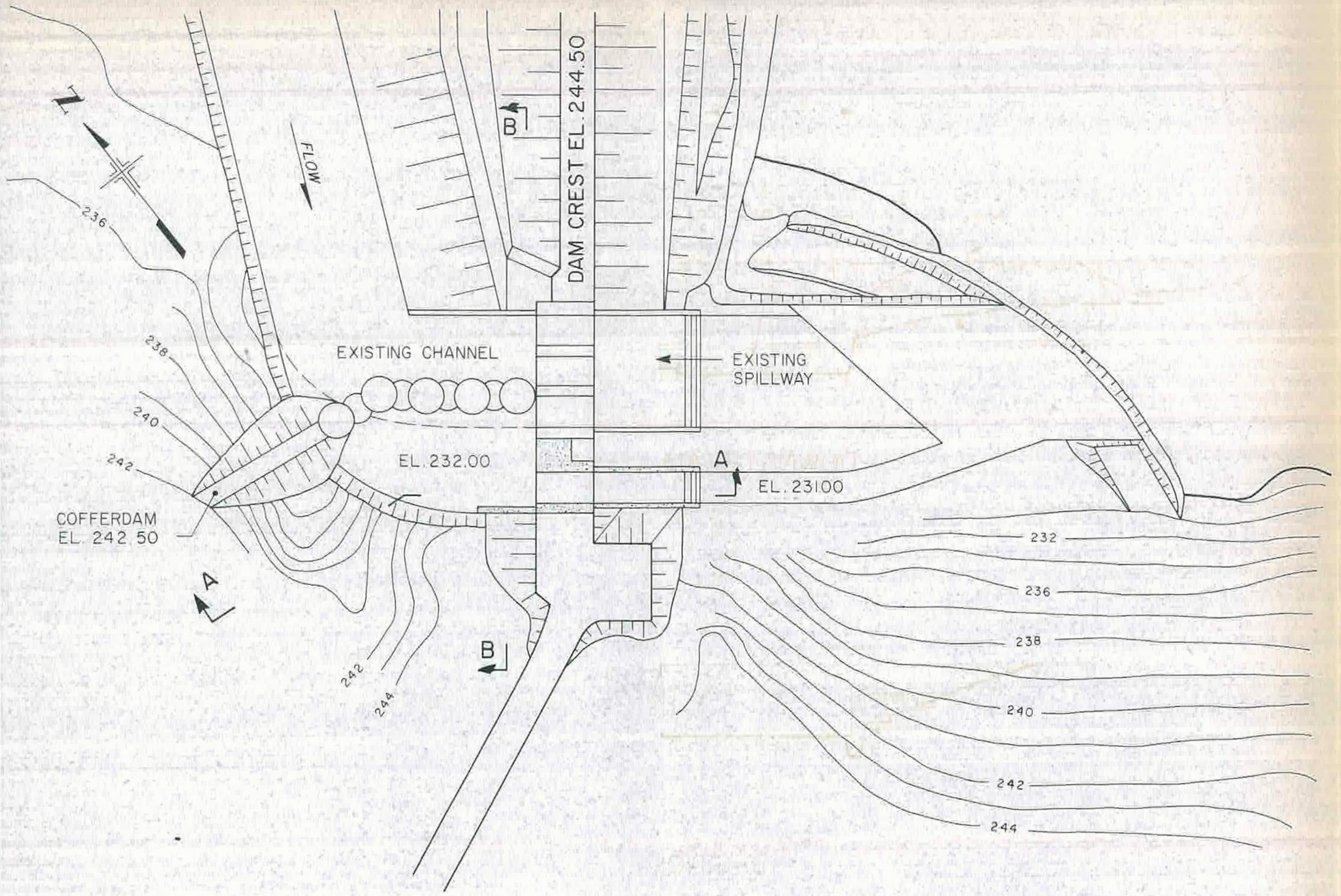


PLATE I

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY

LOCATION PLAN

ACRES



PLAN

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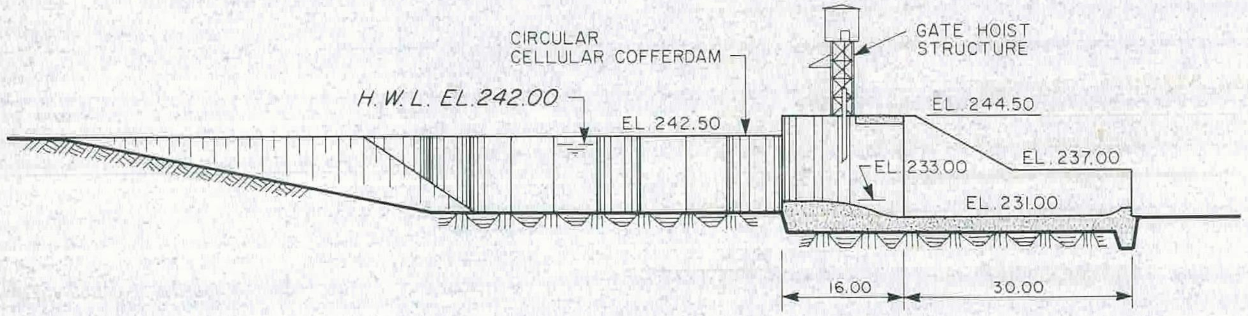

SECTION A-A

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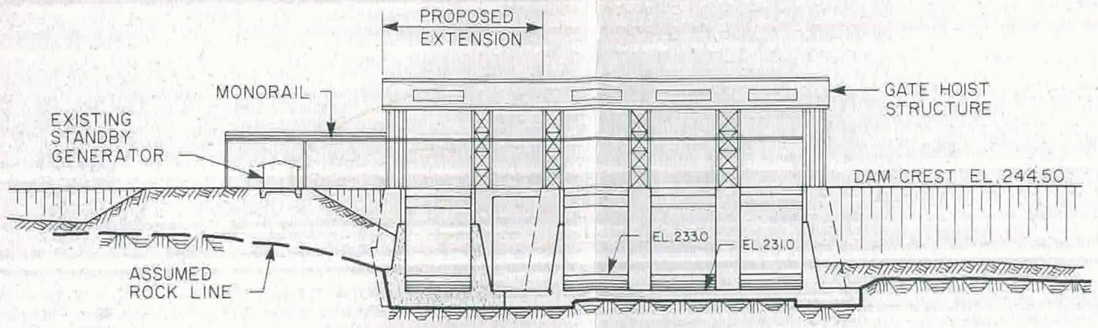
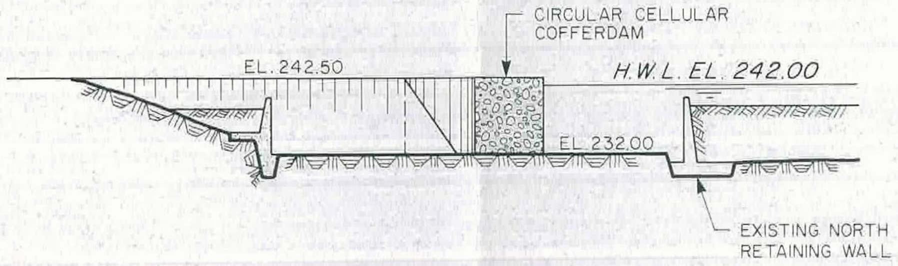
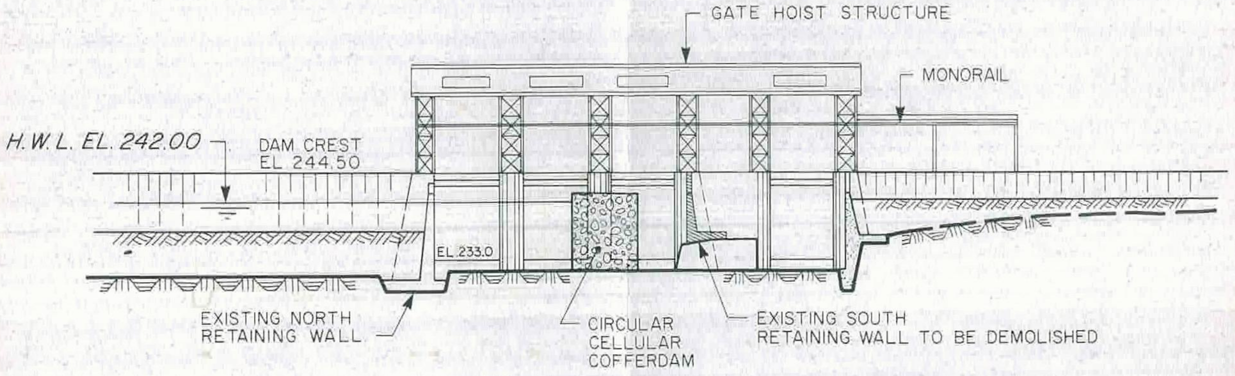


DOWNSTREAM ELEVATION



SECTION B-B

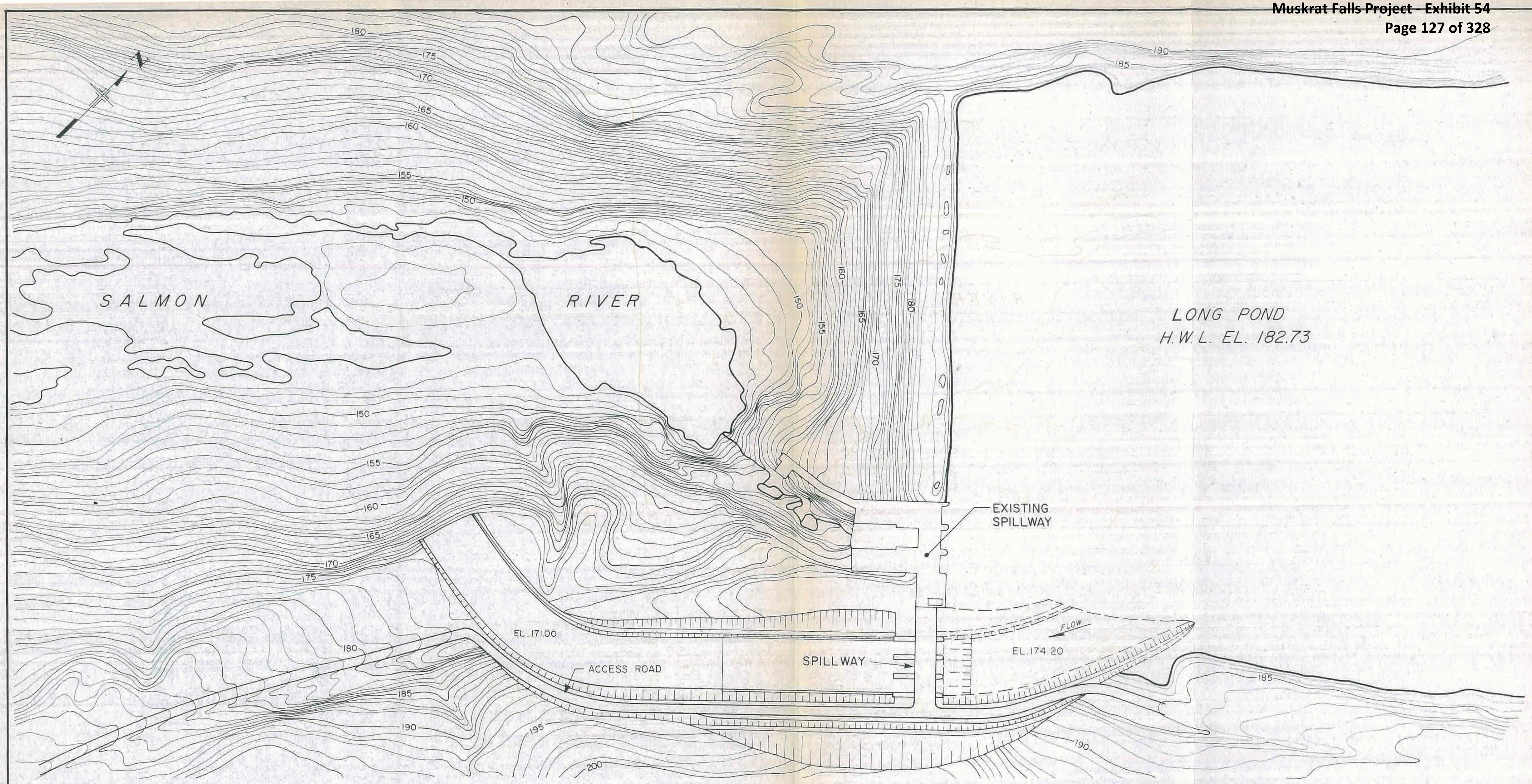


UPSTREAM ELEVATION

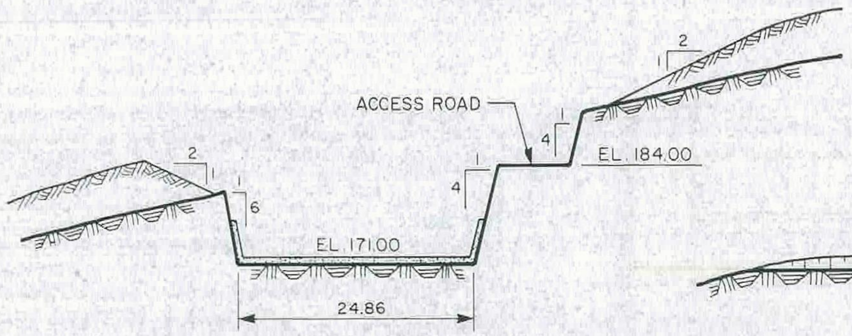
PLATE 2

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY

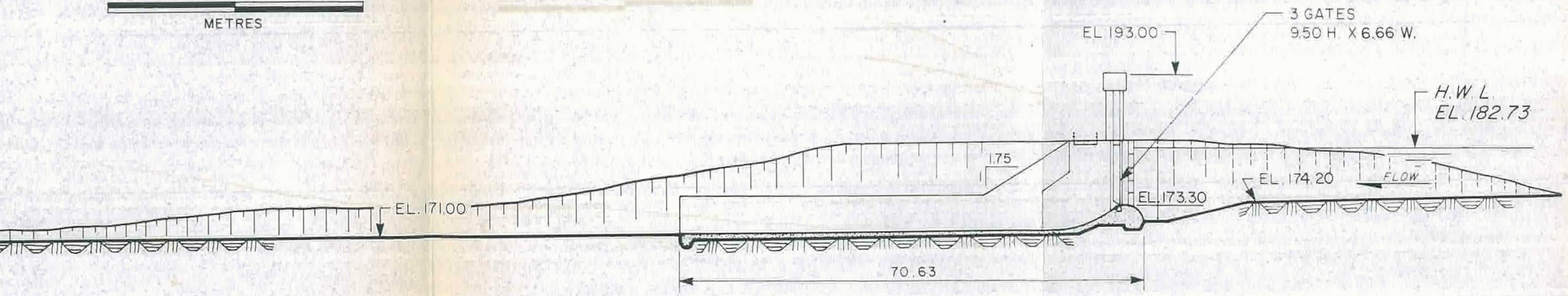
NORTH SALMON DAM SPILLWAY EXTENSION



PLAN



SPILLWAY CHANNEL SECTION



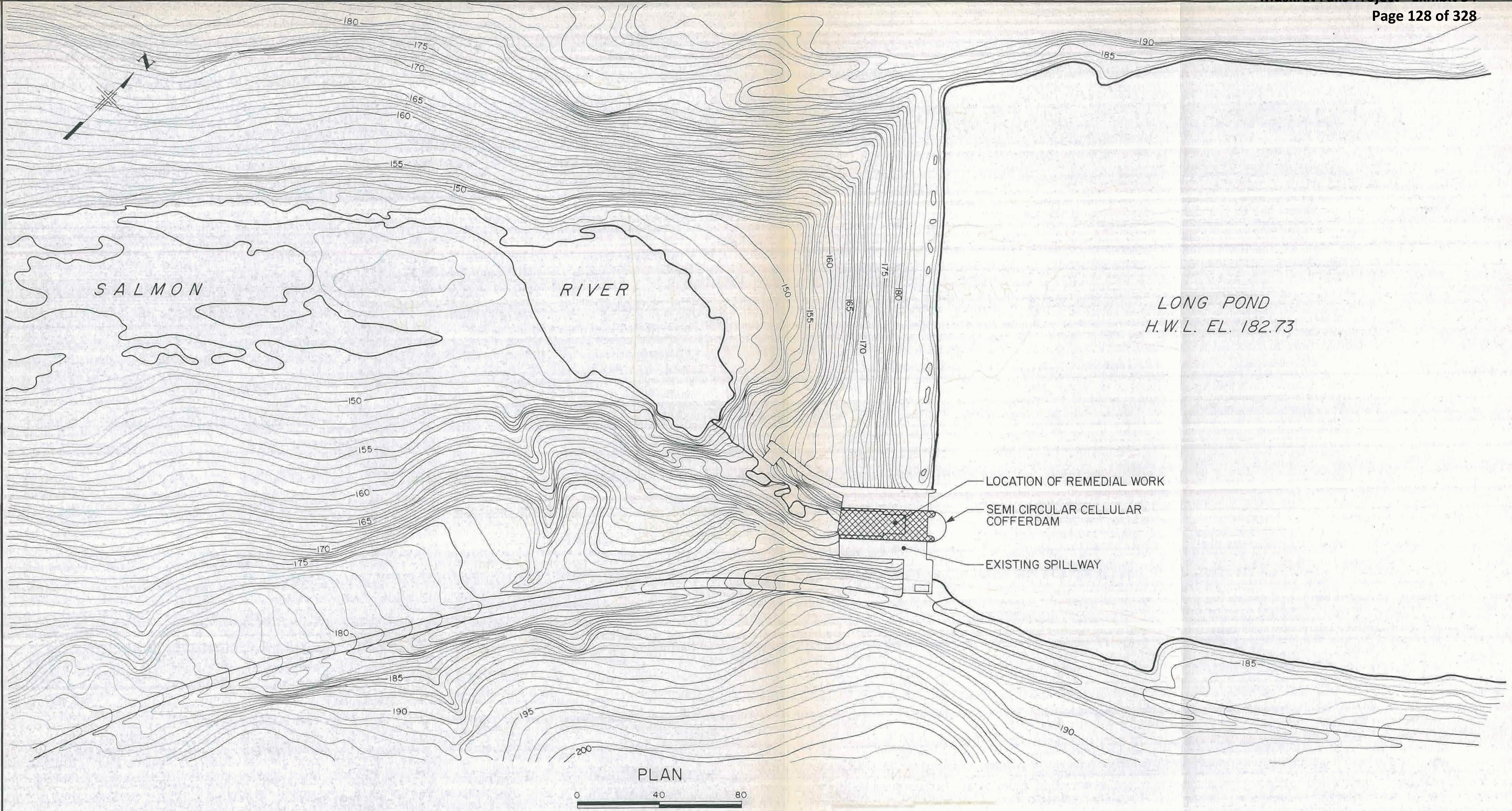
PROFILE ALONG ℄ SPILLWAY AND CHANNEL

PLATE 3

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY

SALMON DAM BYPASS SPILLWAY

ACRES



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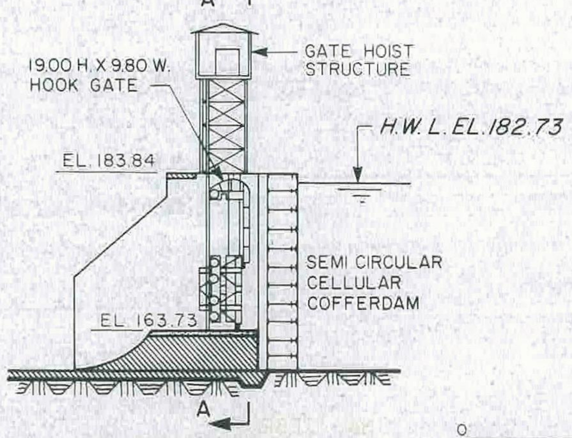
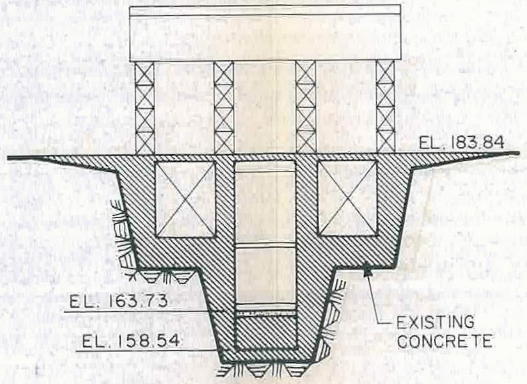


GATE SECTION



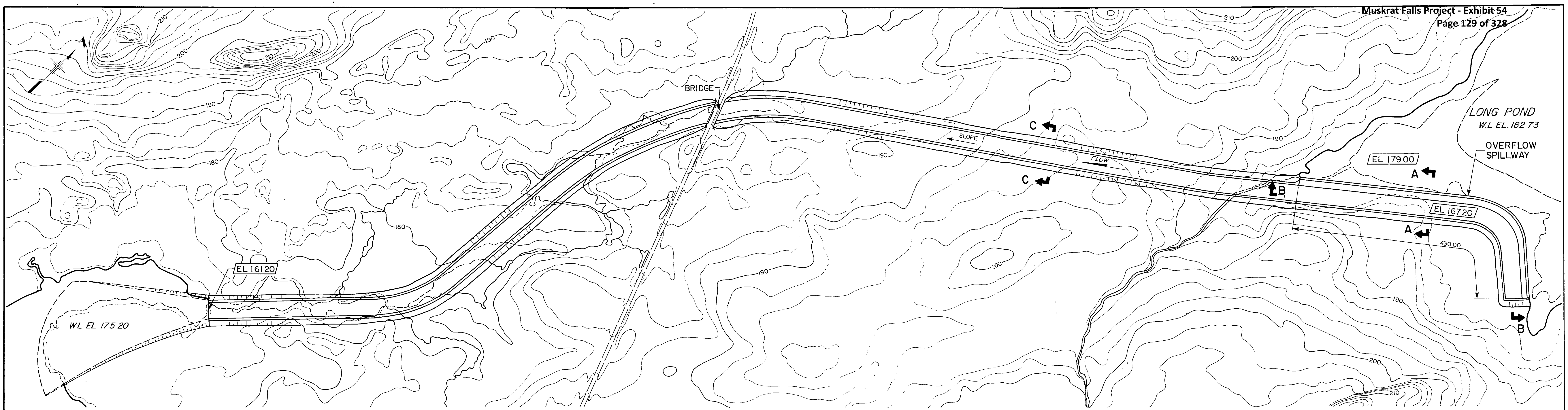
SECTION A-A

PLATE 4

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY

SALMON DAM SPILLWAY CENTERGATE MODIFICATION

ACRES



GENERAL ARRANGEMENT

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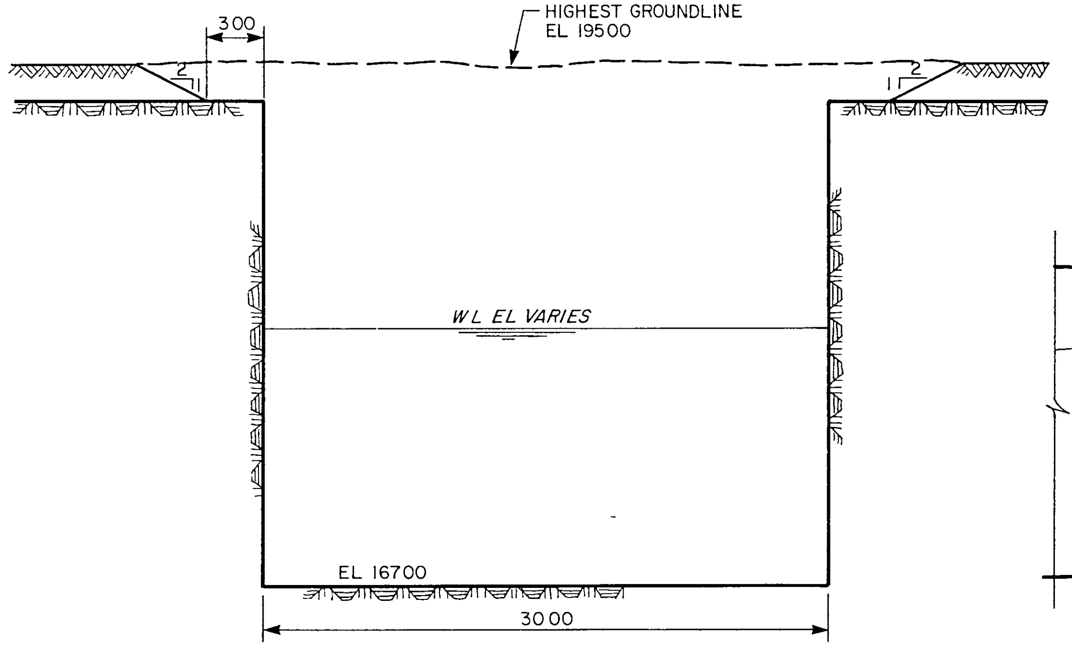
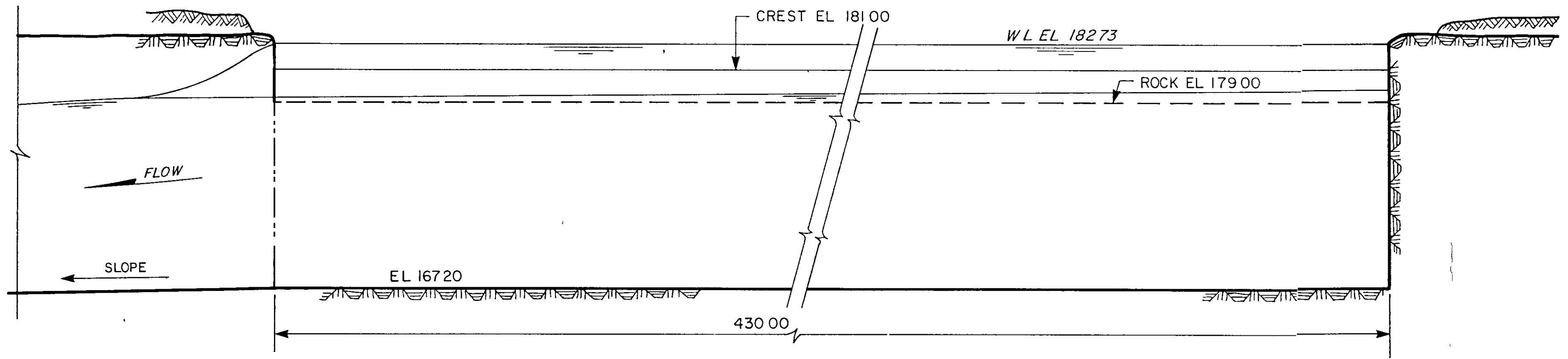


SPILLWAY CANAL SECTION C-C



LONGITUDINAL SECTION B-B

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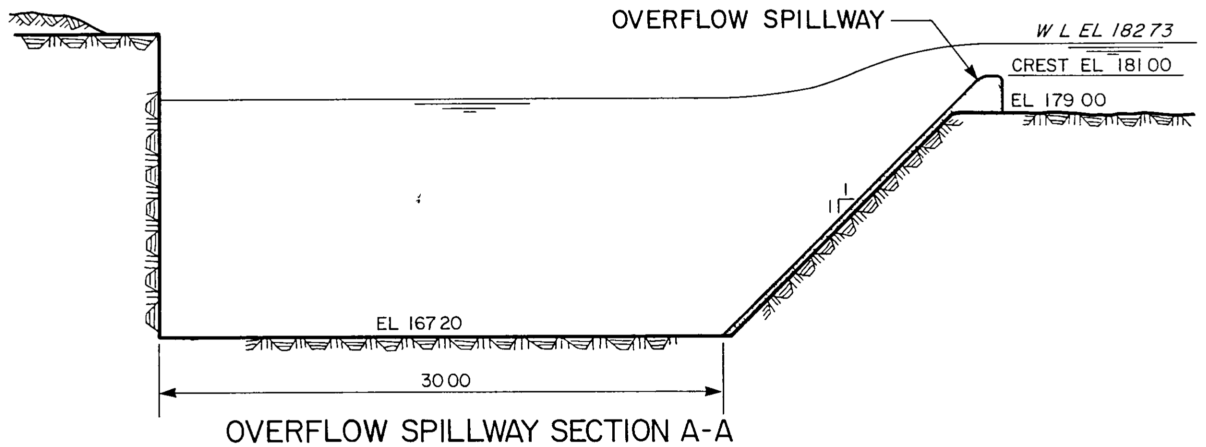

OVERFLOW SPILLWAY SECTION A-A

PLATE 5
NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FLOOD ANALYSIS AND ALTERNATIVES STUDY
WITCHHAZEL HILL NEW SPILLWAY
ACRES

APPENDICES -
FLOOD STUDY

APPENDIX A

DERIVATION OF UNIT HYDROGRAPHS

(16 in.) at Bay d'Espoir. After 24 hours of rain, this snow cover was reduced to 25.4 cm (10 in.) and 15.2 cm (6 in.) at Burnt dam and Bay d'Espoir respectively. All the snow had melted after 2 days. Again, using a water equivalence factor of 1.33 mm water/cm snow, and a melt coefficient of 11 mm/C degree day, the equivalent precipitation was calculated for each 6-h period.

The total precipitation (rainfall and snowmelt) and the resulting inflow hydrographs for each storm in each subbasin for the two storms is presented in Tables A.1 to A.13. Upper Salmon and Round Pond were not computed in 1978 because the Upper Salmon project had not been constructed as discussed below.

(b) Observed Inflow Hydrographs

Individual inflow hydrographs for both historic floods were calculated for seven subbasins

- Victoria
- Burnt Pond
- Granite Lake
- Meelpaeg
- Upper Salmon
- Round Pond
- Long Pond.

These were evaluated separately because of the controlled or uncontrolled restrictions at the outlet of each, which regulated outflow to the downstream subbasin. The method of inflow calculation to each of the subbasins is discussed below.

TABLE A.1

PRECIPITATION AND INFLOW HYDROGRAPHS - 1978 STORM: LONG POND SUBBASIN

Date		Precipitation (Rainfall and Snowmelt) (mm)	Inflow (m^3/s)
14 Jan	0600	0.00	23.
	1200	0.00	20.
	1800	0.00	20.
15 Jan	0000	23.00	20.
	0600	10.30	22.
	1200	18.40	30.
	1800	43.20	42.
16 Jan	0000	53.40	67.
	0600	16.80	150.
	1200	0.00	400.
	1800	0.00	350.
17 Jan	0000	0.00	306.
	0600	0.00	225.
	1200	0.00	175.
	1800	0.00	130.
18 Jan	0000	0.00	93.
	0600	0.00	63.
	1200	0.00	41.
	1800	0.00	25.
19 Jan	0000	0.00	32.

TABLE A.2

PRECIPITATION AND INFLOW HYDROGRAPHS - 1978 STORM: MEELPAEG SUBBASIN

Date		Precipitation (Rainfall and Snowmelt) (mm)	Inflow (m^3/s)
14 Jan	0600	0.00	0.
	1200	0.00	0.
	1800	0.00	0.
15 Jan	0000	23.00	26.
	0600	12.50	33.
	1200	20.60	99.
	1800	50.80	244.
16 Jan	0000	44.30	409.
	0600	13.80	515.
	1200	1.60	482.
	1800	0.00	330.
17 Jan	0000	0.00	224.
	0600	0.00	195.
	1200	0.00	178.
	1800	0.00	172.
18 Jan	0000	0.00	158.
	0600	0.00	145.
	1200	0.00	139.
	1800	0.00	132.
19 Jan	0000	0.00	125.

TABLE A.3

PRECIPITATION AND INFLOW HYDROGRAPHS - 1978 STORM: GRANITE LAKE SUBBASIN

Date		Precipitation (Rainfall and Snowmelt) (mm)	Inflow (m^3/s)
14 Jan	0600	0.00	0.
	1200	0.00	0.
	1800	0.00	0.
15 Jan	0000	23.00	0.
	0600	12.50	14.
	1200	20.60	17.
	1800	50.80	51.
16 Jan	0000	44.30	126.
	0600	13.80	211.
	1200	1.60	265.
	1800	0.00	248.
17 Jan	0000	0.00	170.
	0600	0.00	116.
	1200	0.00	100.
	1800	0.00	92.
18 Jan	0000	0.00	88.
	0600	0.00	82.
	1200	0.00	75.
	1800	0.00	71.
19 Jan	0000	0.00	68.

TABLE A.4

PRECIPITATION AND INFLOW HYDROGRAPHS - 1978 STORM: BURNT POND SUBBASIN

Date		Precipitation (Rainfall and Snowmelt) (mm)	Inflow (m^3/s)
14 Jan	0600	0.00	0.
	1200	0.00	0.
	1800	0.00	25.
15 Jan	0000	23.00	60.
	0600	14.70	105.
	1200	22.80	150.
	1800	58.30	240.
16 Jan	0000	35.20	450.
	0600	10.70	550.
	1200	3.10	520.
	1800	0.00	435.
17 Jan	0000	0.00	350.
	0600	0.00	280.
	1200	0.00	230.
	1800	0.00	205.
18 Jan	0000	0.00	190.
	0600	0.00	170.
	1200	0.00	165.
	1800	0.00	160.
19 Jan	0000	0.00	155.

TABLE A.5

PRECIPITATION AND INFLOW HYDROGRAPHS - 1978 STORM: VICTORIA SUBBASIN

Date		Precipitation (Rainfall and Snowmelt) (mm)	Inflow (m^3/s)
14 Jan	0600	0.00	30.
	1200	0.00	30.
	1800	0.00	30.
15 Jan	0000	23.00	30.
	0600	14.70	30.
	1200	22.80	50.
	1800	58.30	100.
16 Jan	0000	35.20	250.
	0600	10.70	650.
	1200	3.10	600.
	1800	0.00	400.
17 Jan	0000	0.00	280.
	0600	0.00	230.
	1200	0.00	200.
	1800	0.00	175.
18 Jan	0000	0.00	155.
	0600	0.00	140.
	1200	0.00	125.
	1800	0.00	110.
19 Jan	0000	0.00	100.

TABLE A.6

PRECIPITATION AND INFLOW HYDROGRAPHS - 1983 STORM: LONG POND SUBBASIN

Date		Precipitation (Rainfall and Snowmelt) (mm)	Inflow (m^3/s)
11 Jan	0600	0.00	0.
	1200	1.75	9.
	1800	5.50	40.
12 Jan	0000	11.00	80.
	0600	46.00	151.
	1200	30.00	239.
	1800	36.60	319.
13 Jan	0000	12.60	417.
	0600	32.30	576.
	1200	21.50	687.
	1800	52.00	754.
14 Jan	0000	34.00	1029.
	0600	22.00	1029.
	1200	0.00	798.
	1800	0.00	603.
15 Jan	0000	0.00	479.
	0600	0.00	390.
	1200	0.00	337.
	1800	0.00	284.
16 Jan	0000	0.00	248.
	0600	0.00	222.
	1200	0.00	191.
	1800	0.00	173.
17 Jan	0000	0.00	157.

TABLE A.7

PRECIPITATION AND INFLOW HYDROGRAPHS - 1983 STORM: ROUND POND SUBBASIN

Date		Precipitation (Rainfall and Snowmelt) (mm)	Inflow (m^3/s)
11 Jan	0600	0.00	0.
	1200	1.00	0.
	1800	5.00	0.
12 Jan	0000	11.00	90.
	0600	40.00	170.
	1200	23.00	270.
	1800	24.00	360.
13 Jan	0000	25.00	470.
	0600	12.00	650.
	1200	39.00	775.
	1800	32.00	850.
14 Jan	0000	47.00	1160.
	0600	32.00	1160.
	1200	3.00	900.
	1800	2.00	680.
15 Jan	0000	2.00	540.
	0600	2.00	440.
	1200	0.00	380.
	1800	0.00	320.
16 Jan	0000	0.00	280.
	0600	0.00	250.
	1200	0.00	215.
	1800	0.00	195.
17 Jan	0000	0.00	180.

TABLE A.8

PRECIPITATION AND INFLOW HYDROGRAPHS - 1983 STORM: UPPER SALMON SUBBASIN

Date		Precipitation (Rainfall and Snowmelt) (mm)	Inflow (m^3/s)
11 Jan	0600	0.00	0.
	1200	1.00	0.
	1800	5.00	0.
12 Jan	0000	11.00	20.
	0600	40.00	180.
	1200	23.00	290.
	1800	24.00	420.
13 Jan	0000	25.00	420.
	0600	12.00	370.
	1200	39.00	430.
	1800	32.00	670.
14 Jan	0000	47.00	600.
	0600	32.00	680.
	1200	3.00	660.
	1800	2.00	500.
15 Jan	0000	2.00	400.
	0600	2.00	330.
	1200	0.00	280.
	1800	0.00	250.
16 Jan	0000	0.00	220.
	0600	0.00	190.
	1200	0.00	170.

TABLE A.9

PRECIPITATION AND INFLOW HYDROGRAPHS - 1983 STORM: MEELPAEG SUBBASIN

Date		Precipitation (Rainfall and Snowmelt) (mm)	Inflow (m^3/s)
11 Jan	0600	0.00	224.
	1200	1.00	198.
	1800	5.00	185.
12 Jan	0000	11.00	178.
	0600	40.00	224.
	1200	23.00	264.
	1800	24.00	337.
13 Jan	0000	25.00	416.
	0600	12.00	554.
	1200	39.00	792.
	1800	32.00	1056.
14 Jan	0000	47.00	1142.
	0600	32.00	1102.
	1200	3.00	647.
	1800	2.00	455.
15 Jan	0000	2.00	356.
	0600	2.00	284.
	1200	0.00	234.
	1800	0.00	198.
16 Jan	0000	0.00	172.
	0600	0.00	145.
	1200	0.00	132.

TABLE A.10

PRECIPITATION AND INFLOW HYDROGRAPHS - 1983 STORM: GRANITE LAKE SUBBASIN

Date		Precipitation (Rainfall and Snowmelt) (mm)	Inflow (m^3/s)
11 Jan	0600	0.00	116.
	1200	1.00	102.
	1800	5.00	95.
12 Jan	0000	11.00	92.
	0600	40.00	116.
	1200	23.00	136.
	1800	24.00	173.
13 Jan	0000	25.00	214.
	0600	12.00	286.
	1200	39.00	408.
	1800	32.00	544.
14 Jan	0000	47.00	588.
	0600	32.00	568.
	1200	3.00	333.
	1800	2.00	235.
15 Jan	0000	2.00	184.
	0600	2.00	146.
	1200	0.00	121.
	1800	0.00	102.
16 Jan	0000	0.00	88.
	0600	0.00	75.
	1200	0.00	68.

TABLE A.11

PRECIPITATION AND INFLOW HYDROGRAPHS - 1983 STORM: VICTORIA SUBBASIN

Date		Precipitation (Rainfall and Snowmelt) (mm)	Inflow (m^3/s)
11 Jan	0600	0.00	0.
	1200	0.00	0.
	1800	4.33	0.
12 Jan	0000	21.43	0.
	0600	33.80	105.
	1200	32.37	155.
	1800	13.50	220.
13 Jan	0000	10.00	300.
	0600	10.00	410.
	1200	35.30	545.
	1800	35.10	700.
14 Jan	0000	9.30	870.
	0600	9.30	800.
	1200	3.10	600.
	1800	0.00	470.
15 Jan	0000	0.00	380.
	0600	0.00	320.
	1200	0.00	270.
	1800	0.00	230.
16 Jan	0000	0.00	190.
	0600	0.00	160.
	1200	0.00	135.
	1800	1.30	110.
17 Jan	0000	4.00	90.

TABLE A.12

PRECIPITATION AND INFLOW HYDROGRAPHS - 1983 STORM: BURNT POND SUBBASIN

Date		Precipitation (Rainfall and Snowmelt) (mm)	Inflow (m^3/s)
11 Jan	0600	0.0	0.
	1200	0.0	0.
	1800	0.0	0.
12 Jan	0000	4.33	0.
	0600	21.43	0.
	1200	33.80	0.
	1800	32.37	0.
13 Jan	0000	13.50	0.
	0600	10.00	20.
	1200	10.00	45.
	1800	35.30	75.
14 Jan	0000	35.10	110.
	0600	9.30	155.
	1200	9.30	215.
	1800	3.10	315.
15 Jan	0000	0.0	425.
	0600	0.0	525.
	1200	0.0	630.
	1800	0.0	755.
16 Jan	0000	0.0	700.
	0600	0.0	600.
	1200	0.0	520.
	1800	0.0	460.
17 Jan	0000	1.30	410.
	0600	4.00	360.
	1200	4.00	310.
	1800	2.00	260.
18 Jan	0000	0.70	205.
	0600	0.0	155.
	1200	0.0	120.
	1800	0.0	100.

TABLE A.13

SUMMARY OF UNIT HYDROGRAPH PARAMETERS

Basin	Drainage Area (km^2)	Net Drainage Area (km^2)	Snyder		Clark	
			TP (h)	Cp	Tc (h)	R (h)
Victoria	1057	897	15.6	0.42	14.4	28.4
Burnt	678	650	14.7	0.44	13.8	25.1
Granite	502	485	8.95	0.41	6.39	17.8
Meelpaeg	971	621	8.94	0.41	6.35	17.8
Upper Salmon	902	792	10.2	0.23	6.45	41.8
Round Pond	944	894	9.33	0.37	6.42	21.3
Long Pond	830	644	18.0	0.48	20.0	24.9

Victoria - Backrouted inflows were computed on a daily basis from the NLH standard operating hydraulic data sheets. Determining the inflows was simply a matter of plotting the daily data and interpolating to 6-h values.

Burnt Pond - The Burnt Pond inflow hydrograph was calculated from the following equation.

$$Q_{local} = Q_{spill} + Q_{BSHC} - Q_v + S$$

where

Q_{local} = local inflow (Mm^3)
Q_V = controlled inflow from Victoria canal (Mm^3)
Q_{BSHC} = uncontrolled outflow down Burnt Sidehill canal (Mm^3)
Q_{spill} = controlled spill down the White Bear River
S = increase in storage (Mm^3) in Burnt Pond as measured at bridge

Most of the local flow is routed through Spruce Pond, before it reaches Burnt Pond itself. There is no information on the levels of Spruce Pond or the geometry of the hydraulics of the outlet control, however, the importance of Spruce Pond can be seen by comparing the observed time when peak runoff occurs. In 1978, it occurs 1.5 days after the start of the storm; in 1983, it occurs 4 days after the start.

The best explanation for the discrepancy is that, in 1978, pond and reservoir levels throughout the system were quite high due to a wet fall and a heavy rain in December 1977. In 1983, by contrast, pond and reservoir levels were low due to a dry fall and high load demand on the hydro units. The extra lag time required in 1983 includes the time it took for Spruce Pond to fill and to start discharging flood flows to Burnt Pond. Even in 1983, the inflow volume calculated by backrouting may not be entirely correct, because it does not include any change in storage in Spruce Pond.

<u>Granite Lake/Meelpaeg</u> - Granite Lake and Meelpaeg inflows were also calculated by backrouting. The inflows as calculated on the NLH hydraulic data sheets could not be used because they assume that all water released from Victoria, except spill down the White Bear River, arrives instantaneously in Meelpaeg. A routing model was therefore developed to separate Granite and Meelpaeg inflows. The model assumes that the inflows to Meelpaeg and Granite are proportioned according to their drainage areas, i.e., 34% of the total inflow is to Granite and 66% is inflow to Meelpaeg. The model then takes recorded flows in Burnt Sidehill canal and an assumed local inflow to Granite Lake, and routes these inflows through Granite Lake using the Granite canal discharge curve prepared by Acres in 1982. The resulting Granite canal flows are added to assumed local Meelpaeg inflow, and Ebbe outflows are subtracted. The resulting change in storage in Meelpaeg is compared to the measured value. If the change in storage is correct, the assumed inflows are also assumed to be correct. If they are not, the inflows are adjusted iteratively until satisfactory results are obtained.

Upper Salmon - An inflow flood hydrograph could not be obtained for the Upper Salmon subbasin for the 1978 storm because the project did not exist. In the 1983 event, the inflow hydrographs were obtained by backrouting the outflow data from Upper Salmon powerhouse and the North Salmon dam through Great Burnt Lake. Since some of the elevations of the hydraulic data sheets were incorrect due to problems with the gauge, the outflow discharges had to be recalculated from the information on gate openings before the backrouting could be done.

Round Pond/Long Pond - Inflow hydrographs for Round Pond and Long Pond were developed using a routing model similar to that developed for Granite/Meelpaeg. A Round Pond volume/elevation curve was prepared from 1:50 000 topographic maps and the Water Survey of Canada stage/discharge curve at Round Pond Rapids was used for the rating of the uncontrolled outlet.

This calculation procedure could not be used for the 1978 event because Upper Salmon inflows could not be excluded.

A2 - UNIT HYDROGRAPHS

The optimized unit hydrographs and loss rate parameters were developed in a series of steps using the HEC-1 model. Both storms were examined in all subbasins (except Upper Salmon in 1978).

In the first steps, the four loss parameters were determined for the Bay d'Espoir Basin as a whole. They were optimized individually for each subbasin and then averaged since the parameters are not be expected to vary significantly in regions of similar physiography.

The two parameters which represent the antecedent soil moisture conditions and infiltration capacity (DLTKR and STRKR) were different for the two storms. This is not unexpected, since the cold temperatures in late 1982 and early 1983 probably kept the ground frozen. Just before the 1978 event, in contrast, a heavy rainfall had melted all the snow, and presumably thawed the ground. The rainfall was immediately followed by a snow cover (635 mm [25 in.] on the ground within 6 days at Burnt dam), which would have insulated the ground against refreezing. The ground was thus able to absorb more water in the 1978 event than in the frozen conditions of 1983. The loss rate parameters for the 1983 event were therefore used, because they produced more conservative results. They were averaged for the entire basin, and the unit hydrographs were then optimized for each subbasin for the 1983 event. Only in the case of Burnt Pond was the 1978 event used, because the effect of Spruce Pond made the 1983 results unreliable.

This final optimization fixed the lag and storage characteristics for each subbasin by determining the Clark and Snyder coefficients which are needed as input to the HEC-1 model.

The Clark and Snyder unit hydrograph variables are given in Table A.13 for each subbasin and a full definition of their significance is given in the HEC-1 manual.[3] The 25-mm, 6-h unit hydrographs for each of the subbasins are illustrated in Figure A.1.

Figure A.2, (a) to (g), shows the inflow hydrographs for the design storm as observed and as computed for each subbasin using the unit hydrograph definitions. Note that these are local subbasin inflows only, and do not include routed outflows from upstream basins. The January 1978 event is presented for Burnt Pond; all others are January 1983.

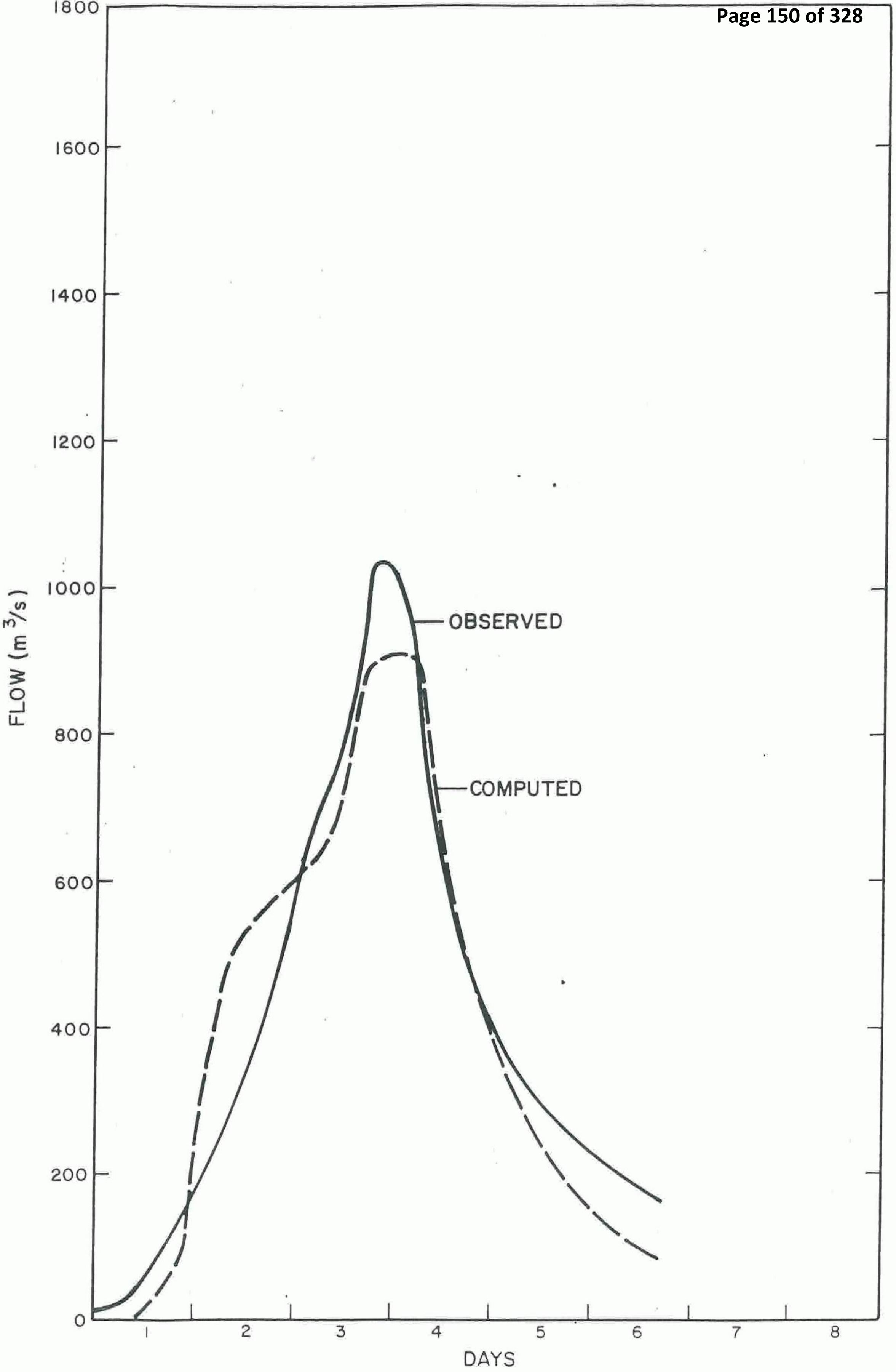

FIG.A.2(a)

NEWFOUNDLAND AND LABRADOR HYDRO
SPILLWAY CAPACITY AND FLOOD HANDLING STUDY

ACRES

LONG POND HYDROGRAPH - JANUARY 1983 STORM

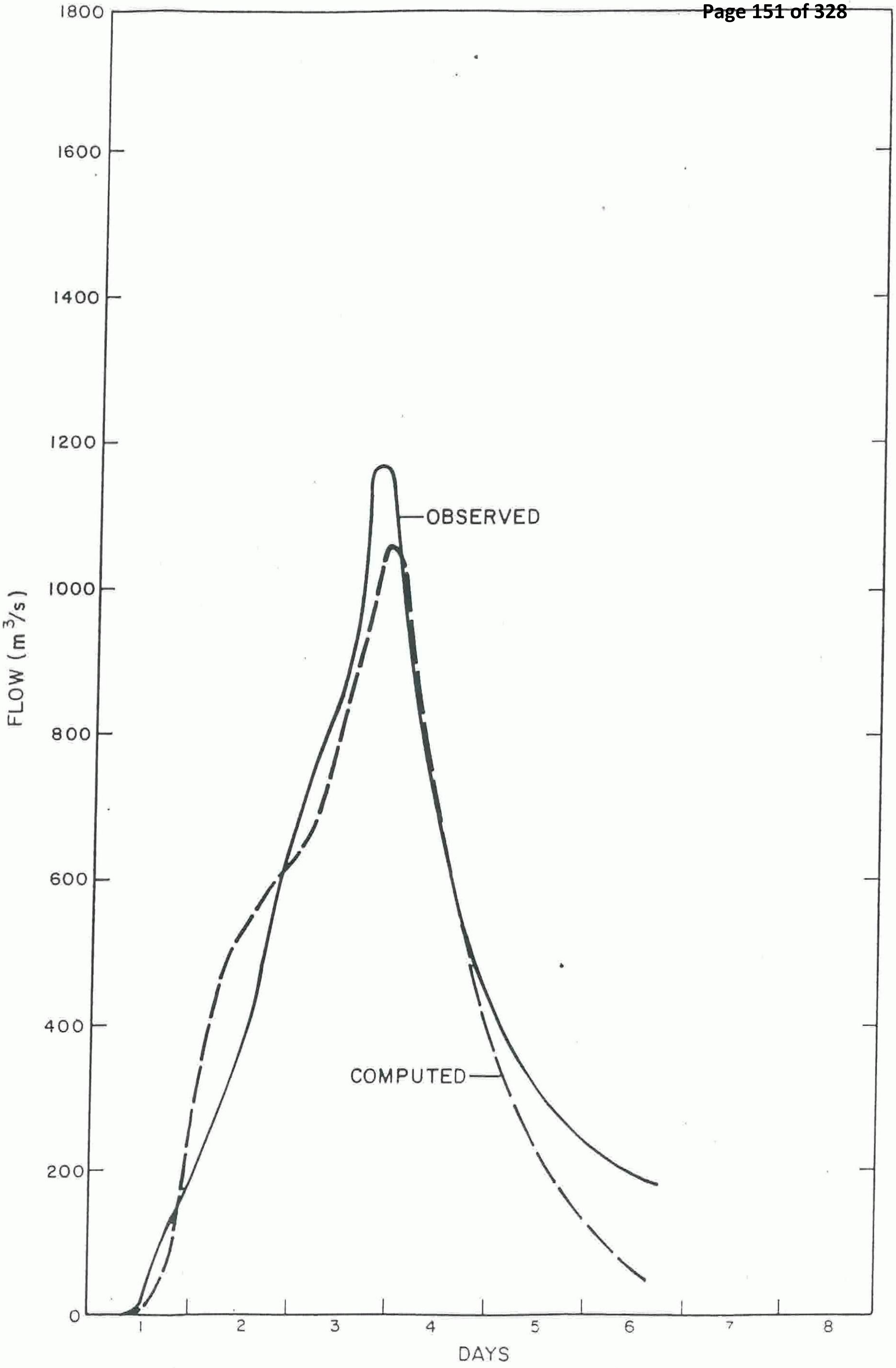

FIG A2(b

NEWFOUNDLAND AND LABRADOR HYDRO
SPILLWAY CAPACITY AND FLOOD HANDLING STUDY

ROUND POND HYDROGRAPH- JANUARY 1983 STORM

ACRES

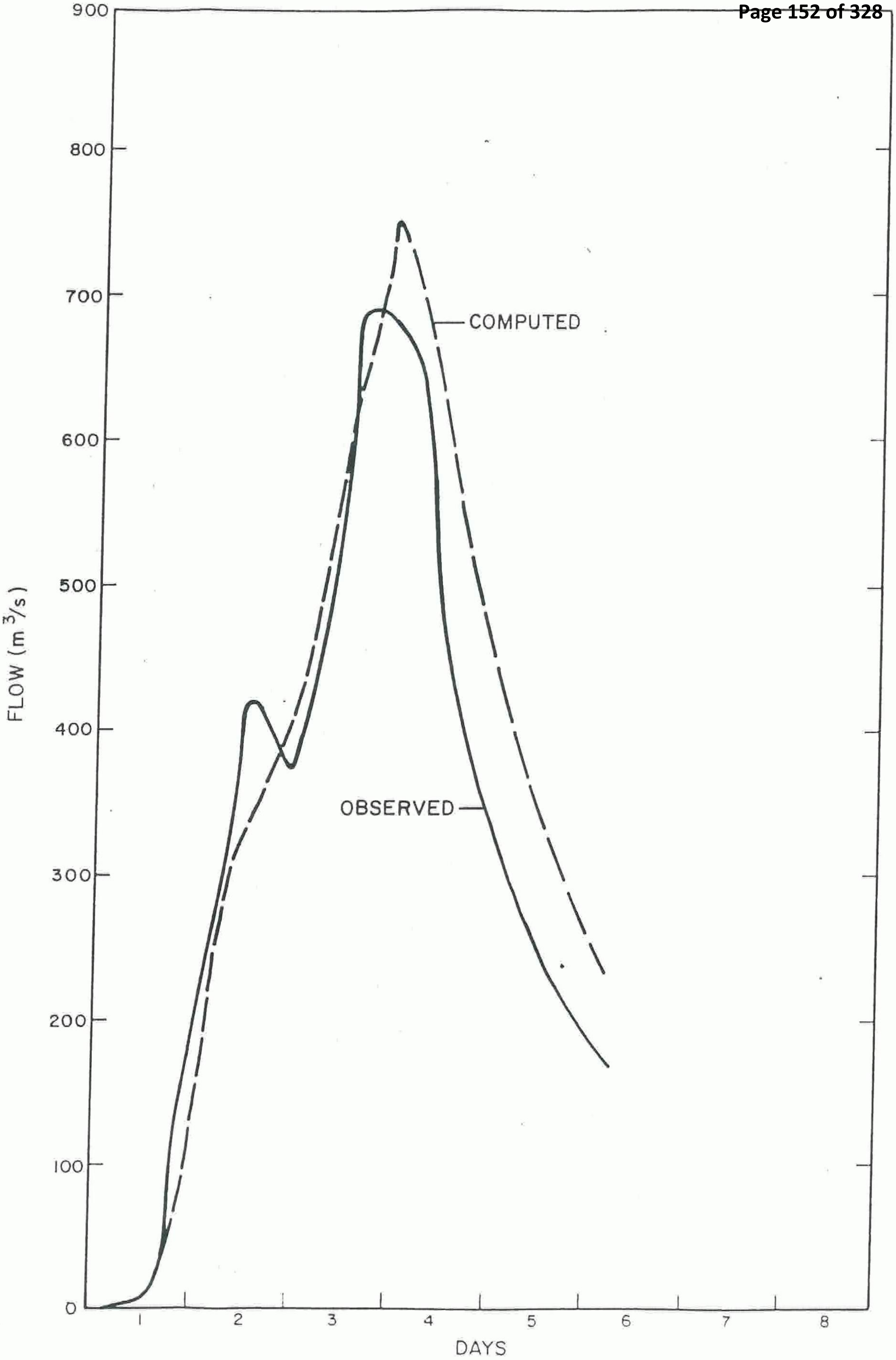

FIG A.2 c

NEWFOUNDLAND AND LABRADOR HYDRO
SPILLWAY CAPACITY AND FLOOD HANDLING STUDY

ACRES

UPPER SALMON HYDROGRAPH - JANUARY 1983 STORM

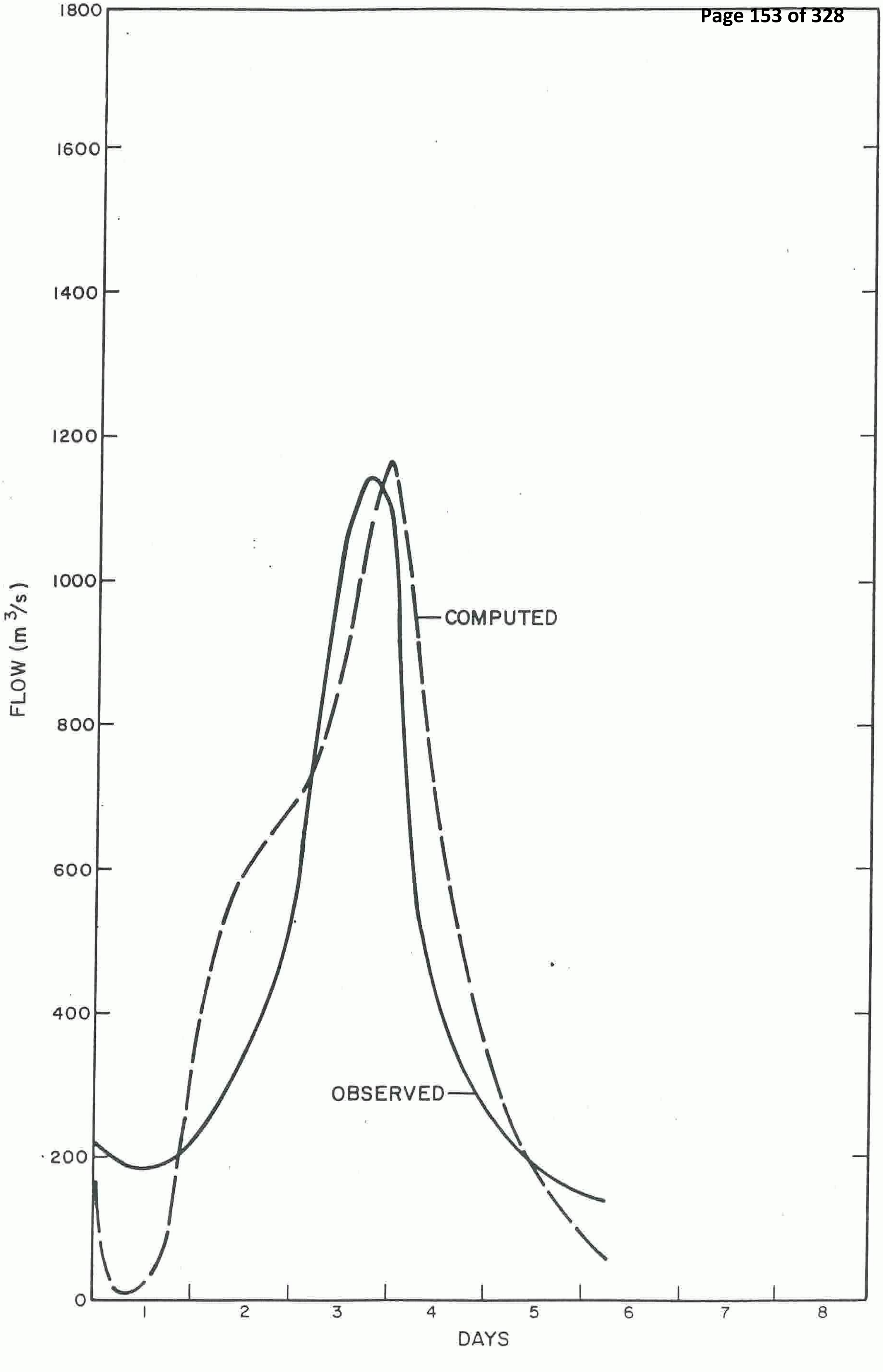

FIG.A.2(d)

NEWFOUNDLAND AND LABRADOR HYDRO
SPILLWAY CAPACITY AND FLOOD HANDLING STUDY

ACRES

MEELPAEG HYDROGRAPH - JANUARY 1983 STORM

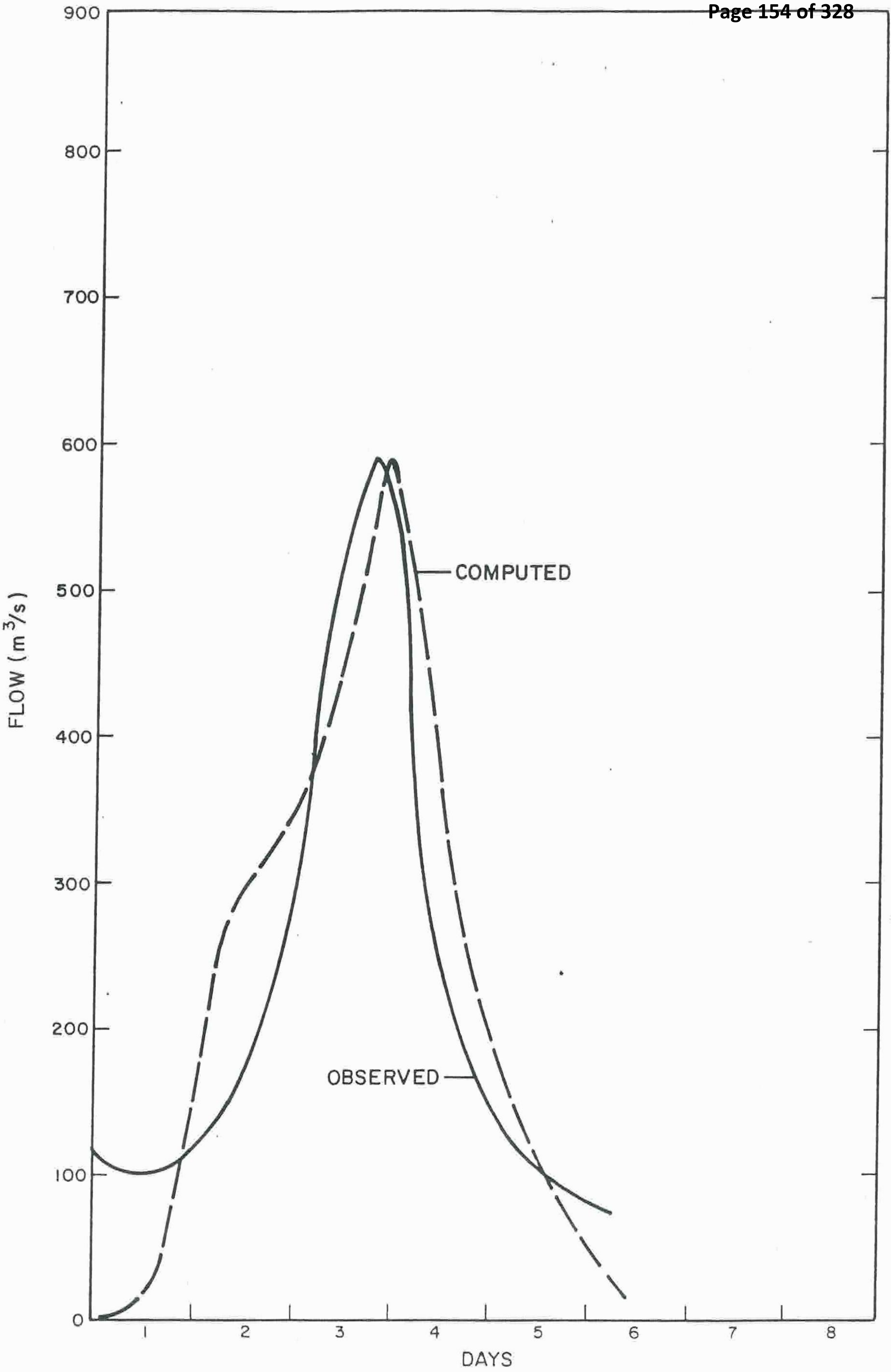

FIG A2(e)

NEWFOUNDLAND AND LABRADOR HYDRO
SPILLWAY CAPACITY AND FLOOD HANDLING STUDY

GRANITE HYDROGRAPH - JANUARY 1983 STORM

ACRES

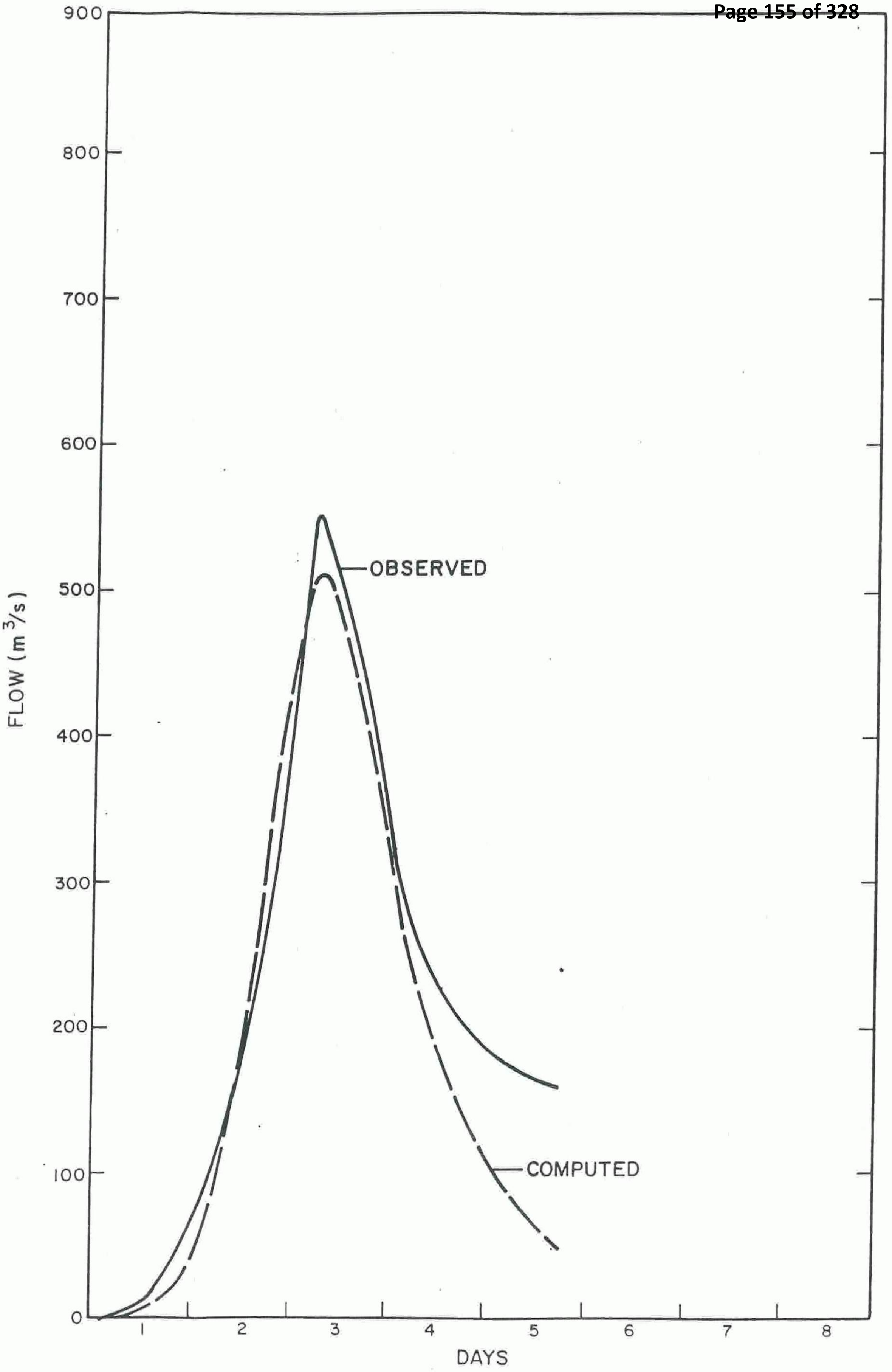

FIG A.2(f)

NEWFOUNDLAND AND LABRADOR HYDRO
SPILLWAY CAPACITY AND FLOOD HANDLING STUDY

AGRES

BURNT POND HYDROGRAPH – JANUARY 1978 STORM

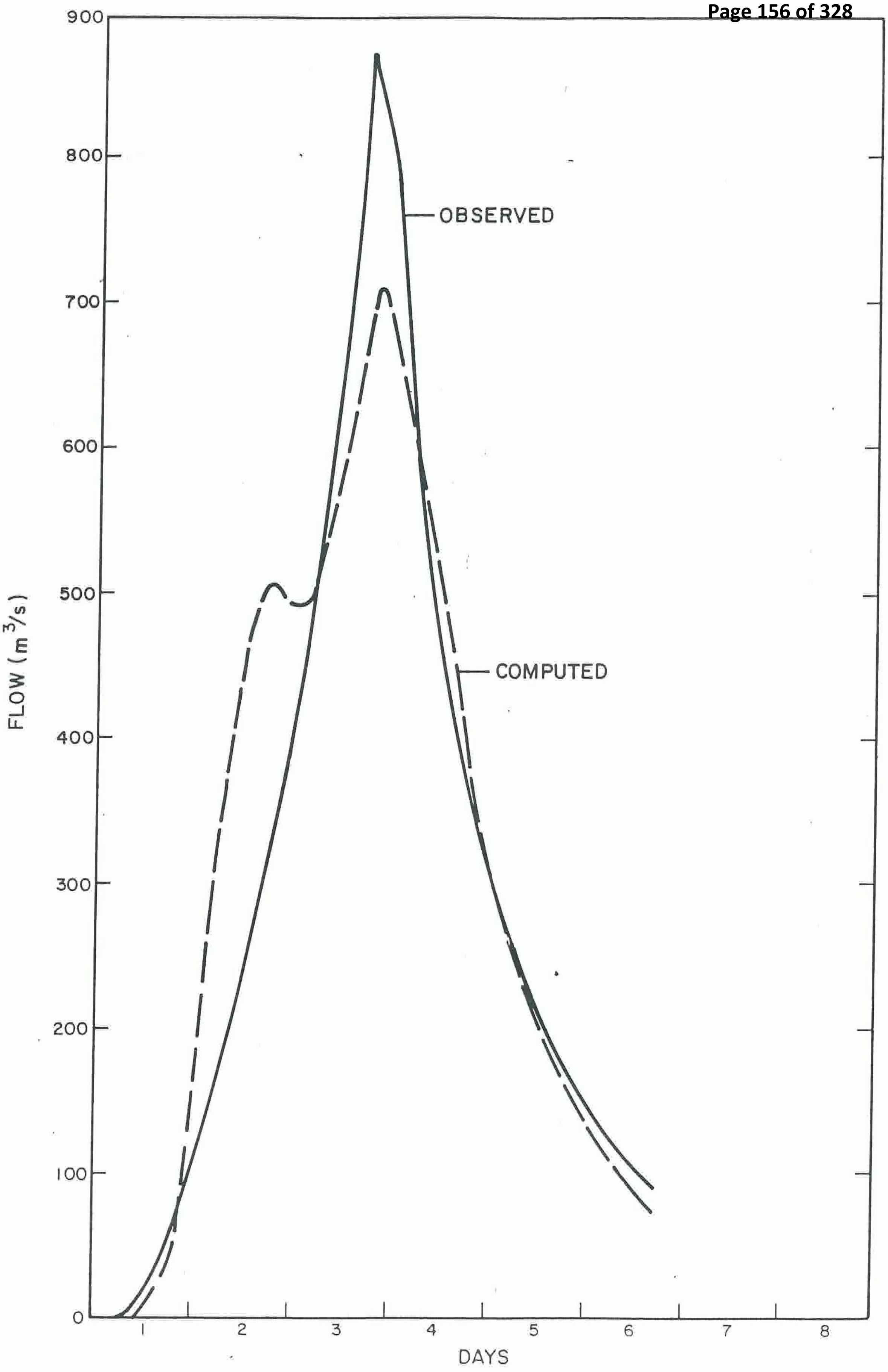

FIG. A.2(g)

NEWFOUNDLAND AND LABRADOR HYDRO
SPILLWAY CAPACITY AND FLOOD HANDLING STUDY

VICTORIA HYDROGRAPH - JANUARY 1983 STORM

ACRES

APPENDIX B
ELEVATION-AREA AND STAGE-DISCHARGE CURVES

TABLE B.1

ELEVATION-AREA CURVES

Long Pond Reservoir

Elevation (m)	Area (ha)
170.0	12735.0
175.3	15130.0
178.3	17200.0
179.8	18600.0
181.4	20500.0
184.4	22840.0

Round Pond

Elevation (m)	Area (ha)
181.5	4480.0
186.5	5027.0
191.5	5573.0
196.5	6951.0
201.5	7471.0

Great Burnt Lake

Elevation (m)	Area (ha)
240.0	11000.0
241.0	11600.0
242.0	12200.0
242.5	12500.0

Meelpaeg Reservoir

Elevation (m)	Area (ha)
262.0	22558.0
265.0	29349.0
266.5	32000.0
268.1	34375.0
268.5	35000.0

TABLE B.1 (continued)

Granite Lake

Elevation (m)	Area (ha)
308.4	5309.0
310.2	6123.0
312.2	7782.0
313.0	7746.0
313.5	8036.0

Burnt Pond

Elevation (m)	Area (ha)
306.0	2114.0
309.0	2480.0
310.0	2602.0
311.0	2724.0
312.0	2846.0
313.0	2967.0
314.0	3089.0
315.0	3211.0
316.0	3333.0

Victoria Reservoir

Elevation (m)	Area (ha)
319.3	12022.0
320.8	13044.0
322.3	14290.0
323.8	15552.0
325.4	16800.0
327.3	18282.0
327.4	18360.0

TABLE B.2

STAGE-DISCHARGE CURVE

Salmon Spillway

Elevation (m)	Discharge (m^3/s)
173.170	.00
174.000	42.00
175.000	133.00
176.000	255.00
177.000	410.00
178.000	590.00
181.000	1158.00
181.720	1300.00
182.730	1520.00

Round Pond Discharge

Elevation (m)	Discharge (m^3/s)
183.700	.00
184.700	56.50
185.500	240.00
185.900	408.00
186.500	750.00
187.000	1020.00
187.500	1380.00
188.000	1800.00
189.000	2810.00
189.500	3360.00

North Salmon Spillway

Elevation (m)	Discharge (m^3/s)
240.000	750.00
240.500	810.00
241.000	885.00
241.500	950.00
242.000	1020.00
242.500	1095.00

TABLE B2 (continued)

Ebbegunbaeg Control Structure

Elevation (m)	Discharge (m^3/s)
259.820	.00
261.420	82.50
261.990	105.00
262.870	126.00
263.420	138.00
264.070	150.00
265.020	165.00
267.080	197.00
269.300	223.00

Granite Canal

Elevation (m)	Discharge (m^3/s)
306.030	.00
307.030	20.00
308.030	45.00
309.030	73.00
310.030	105.00
311.030	140.00
312.080	180.70
313.370	220.00

Granite Spillway

Elevation (m)	Discharge (m^3/s)
311.610	.00
311.900	248.00
311.970	309.00
312.080	448.00
312.500	1161.23
313.000	2252.93
313.370	3202.69

TABLE B2 (continued)

Burnt Sidehill Canal

Elevation (m)	Discharge (m^3/s)
311.630	.00
312.160	20.00
312.575	40.00
312.925	60.00
313.200	80.00
313.575	110.00
313.940	147.25
314.500	210.80
315.000	279.50
315.500	359.00

White Bear Spillway

Elevation (m)	Discharge (m^3/s)
309.000	124.00
311.000	275.00
312.000	360.00
312.300	400.00
312.600	450.00
313.940	593.60
314.000	600.50
314.500	657.70
314.900	704.70
315.500	770.00

Victoria Control Structure

Elevation (m)	Discharge (m^3/s)
318.820	81.50
320.040	109.20
321.260	132.50
322.480	152.90
323.700	169.00
324.920	182.20
325.040	183.60
327.370	200.00

TABLE B2 (continued)

Victoria River Spillway

Elevation (m)	Discharge (m^3/s)
323.000	52.00
324.000	91.00
325.000	130.40
326.200	176.50
326.800	203.50
327.400	226.50

APPENDIX C
TABLES OF RESULTS

LIST OF TABLES

TABLE	CENTRE	CASE	DATA
C-1(a)	Long Pond		P (Precipitation Data)
C-1(b)	Long Pond		I (Inflow Hydrographs)
C-1(c)	Long Pond	1	O (Outflow Hydrographs)
C-1(d)	Long Pond		R (Reservoir Trajectories)
C-2(a)	Round Pond		P
C-2(b)	Round Pond		I
C-2(c)	Round Pond	1	O
C-2(d)	Round Pond		R
C-3(a)	Upper Salmon		P
C-3(b)	Upper Salmon		I
C-3(c)	Upper Salmon	1	O
C-3(d)	Upper Salmon		R
C-4(a)	Meelpaeg		P
C-4(b)	Meelpaeg		I
C-4(c)	Meelpaeg	1	O
C-4(d)	Meelpaeg		R
C-5(c)	Meelpaeg	2	O
C-5(d)	Meelpaeg		R
C-6(a)	Granite Lake		P
C-6(b)	Granite Lake		I
C-6(c)	Granite Lake	1	O
C-6(d)	Granite Lake		R
C-7(a)	Burnt Pond		P
C-7(b)	Burnt Pond		I
C-7(c)	Burnt Pond	1	O
C-7(d)	Burnt Pond		R
C-8(c)	Burnt Pond	2	O
C-8(d)	Burnt Pond		R

List of Tables Continued

Table C-1 (a)

PMP (RAIN + SNOW) IN MM
CENTER : LONG POND EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL- PAEG	GRAN- ITE	BURNT POND	VIC- TORIA
15	MAR	0	.00	.00	.00	.00	.00	.00	.00
15	MAR	6	30.90	30.50	30.50	29.40	27.10	25.40	24.90
15	MAR	12	30.90	30.50	30.50	29.40	27.10	25.40	24.90
15	MAR	18	30.90	30.50	30.50	29.40	27.10	25.40	24.90
16	MAR	0	30.90	30.50	30.50	29.40	27.10	25.40	24.90
16	MAR	6	47.80	47.20	47.20	45.50	41.90	39.30	38.50
16	MAR	12	69.30	68.20	68.20	65.00	58.30	53.40	51.90
16	MAR	18	70.40	69.20	69.20	65.90	59.10	54.10	52.50
17	MAR	0	68.80	67.60	67.60	64.50	57.90	53.00	51.50
17	MAR	6	59.70	58.60	58.60	55.60	49.10	44.30	42.90
17	MAR	12	65.50	64.30	64.30	60.80	53.50	48.10	46.50
17	MAR	18	65.50	64.30	64.30	60.80	53.50	48.10	46.50
18	MAR	0	66.00	64.80	64.80	61.30	53.90	48.50	46.80
18	MAR	6	52.00	50.80	50.80	47.30	39.90	34.50	32.80
18	MAR	12	52.00	50.80	50.80	47.30	39.90	34.50	32.80
18	MAR	18	.20	.20	.20	.20	.20	.20	.20
19	MAR	0	.20	.20	.20	.20	.20	.20	.20
19	MAR	6	.50	.50	.50	.50	.50	.50	.50
19	MAR	12	.50	.50	.50	.50	.50	.50	.50
19	MAR	18	.50	.50	.50	.50	.50	.50	.50
20	MAR	0	.50	.50	.50	.50	.50	.50	.50
20	MAR	6	.50	.50	.50	.50	.50	.50	.50
20	MAR	12	.50	.50	.50	.50	.50	.50	.50
20	MAR	18	.50	.50	.50	.50	.50	.50	.50
21	MAR	0	.50	.50	.50	.50	.50	.50	.50
21	MAR	6	.50	.50	.50	.50	.50	.50	.50
21	MAR	12	.50	.50	.50	.50	.50	.50	.50
21	MAR	18	.50	.50	.50	.50	.50	.50	.50
22	MAR	0	.50	.50	.50	.50	.50	.50	.50
22	MAR	6	.50	.50	.50	.50	.50	.50	.50
22	MAR	12	.50	.50	.50	.50	.50	.50	.50
22	MAR	18	.50	.50	.50	.50	.50	.50	.50
23	MAR	0	.50	.50	.50	.50	.50	.50	.50
23	MAR	6	.50	.50	.50	.50	.50	.50	.50
23	MAR	12	.50	.50	.50	.50	.50	.50	.50
23	MAR	18	.50	.50	.50	.50	.50	.50	.50
TOTAL			750.50	737.70	737.70	701.50	625.30	569.30	552.20

Table C-1 (b)

PMP INFLOW HYDROGRAPHS (m3/s)
CENTER : LONG POND EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	0.	0.	0.	0.	0.	0.	0.
15	MAR	6	15.	82.	43.	94.	43.	16.	20.
15	MAR	12	78.	271.	145.	308.	142.	76.	98.
15	MAR	18	196.	459.	258.	513.	240.	169.	225.
16	MAR	0	336.	602.	356.	660.	309.	260.	354.
16	MAR	6	476.	788.	482.	857.	403.	350.	483.
16	MAR	12	647.	1112.	686.	1205.	562.	477.	661.
16	MAR	18	880.	1466.	920.	1575.	730.	643.	891.
17	MAR	0	1146.	1733.	1123.	1838.	849.	802.	1120.
17	MAR	6	1378.	1882.	1271.	1965.	903.	918.	1294.
17	MAR	12	1543.	1977.	1391.	2032.	928.	987.	1405.
17	MAR	18	1660.	2076.	1509.	2110.	959.	1036.	1486.
18	MAR	0	1756.	2154.	1613.	2169.	982.	1080.	1558.
18	MAR	6	1826.	2147.	1669.	2132.	958.	1099.	1596.
18	MAR	12	1849.	2073.	1682.	2023.	898.	1076.	1575.
18	MAR	18	1788.	1793.	1577.	1696.	749.	995.	1475.
19	MAR	0	1606.	1356.	1369.	1211.	535.	843.	1280.
19	MAR	6	1332.	1022.	1186.	862.	381.	669.	1048.
19	MAR	12	1053.	770.	1027.	612.	271.	526.	848.
19	MAR	18	827.	580.	890.	435.	192.	414.	686.
20	MAR	0	649.	437.	770.	308.	136.	325.	555.
20	MAR	6	509.	328.	667.	218.	96.	256.	449.
20	MAR	12	400.	246.	578.	153.	68.	201.	363.
20	MAR	18	314.	185.	501.	106.	47.	158.	294.
21	MAR	0	246.	138.	434.	73.	32.	124.	238.
21	MAR	6	193.	102.	375.	49.	22.	97.	192.
21	MAR	12	150.	74.	325.	33.	14.	76.	156.
21	MAR	18	117.	54.	282.	21.	9.	59.	126.
22	MAR	0	91.	38.	244.	12.	5.	46.	101.
22	MAR	6	70.	26.	211.	6.	3.	35.	81.
22	MAR	12	53.	17.	183.	3.	1.	27.	65.
22	MAR	18	39.	11.	158.	0.	0.	20.	52.
23	MAR	0	28.	6.	137.	0.	0.	14.	41.
23	MAR	6	20.	2.	119.	0.	0.	10.	31.
23	MAR	12	14.	0.	103.	0.	0.	7.	23.
23	MAR	18	9.	0.	89.	0.	0.	4.	17.
TOTAL Mm3			503.	562.	526.	546.	248.	300.	451.

day, the value reported in the original Stage I and Stage II design and a typical rate which is given in the literature[4] for the time of year and the assumed temperatures. During the storm, the snowmelt coefficient of 11 mm/C degree day obtained from the 1978 and 1983 records was used as discussed in Appendix A. The snowmelt resulting from the critical temperature sequence during a PMP event is given in Table 3.1.

TABLE 3.1

SNOWMELT DURING MARCH CRITICAL TEMPERATURE SEQUENCE

Day	Temp (°C)	Snowmelt (mm water equivalent)
1	1.1	2.0
2	1.1	2.0
3	1.1	2.0
4	1.1	2.0
5	1.1	2.0
6	1.1	2.0
7	0.4	0.7
8	0.4	0.7
9	5.5	10.1
10	5.5	60.5
11	8.4	92.4
12	5.5	59.4
13	0.4	2.6
14	1.1	2.0
15	1.1	2.0
16	1.1	2.0
17	1.1	2.0
18	1.1	2.0
TOTAL		248.4

Note: Storm starts Day 10.

APPENDIX A

DERIVATION OF UNIT HYDROGRAPHS

A1 - BASIC INPUT DATA

(a) Precipitation

The basic data used were taken from AES records for St. Alban's, NLH climatological data for the Bay d'Espoir powerhouse and Burnt dam, and Acres records for Upper Salmon. Hourly values were available for St. Alban's but not for the other sites. It was assumed that although the total precipitation might vary, the distribution of the rainfall during the storm would be approximately the same at the other sites as at St. Alban's. The shape of the St. Alban's mass curve was therefore used as the basis for the shape of the mass curves at the other locations.

The snowmelt was calculated as described in Section 2.2. In 1983, climatological records show that 31 cm of snow melted in one day at Burnt dam. At Bay d'Espoir, 28 cm melted in one day, 6 cm of it from 08:00 to 16:00 on January 11. The resulting additional water input was calculated using a water equivalent factor of 1.33 mm of water/cm of snow (determined by AES for the January 1983 flood in central Newfoundland) and a melt coefficient of 11 mm/C degree day.

For the 1978 event, climatological records show 55.9 cm (22 in.) of snow on the ground at Burnt dam and 40.6 cm

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For the 1978 event, climatological records show 55.9 cm (22 in.) of snow on the ground at Burnt dam and 40.6 cm

Table C-1 (c)

ROUTED OUTFLOW HYDROGRAPHS (m3/s)
CENTER : LONG POND EVENT : WINTER

DayMthHr	Bay dEspr Plant	Salmon Splwy	Salmon River @ RdPd	North Salmon Splwy	Ebbe Cntrl Gate	Gran-ite Canal	Gran-ite Splwy	Burnt SH Canal	White Bear Splwy	Vic-toria Ctrl.	Vic-toria Splwy
15 MAR 0	174.	0.	121.	1307.	0.	147.	0.	142.	0.	0.	0.
15 MAR 6	174.	0.	186.	801.	186.	147.	0.	133.	0.	20.	0.
15 MAR 12	174.	214.	336.	331.	186.	148.	0.	131.	0.	98.	0.
15 MAR 18	174.	478.	456.	444.	186.	150.	0.	140.	0.	165.	60.
16 MAR 0	174.	731.	569.	542.	186.	154.	0.	154.	64.	165.	68.
16 MAR 6	174.	1020.	718.	669.	187.	159.	0.	152.	362.	165.	68.
16 MAR 12	174.	1371.	898.	874.	188.	165.	55.	140.	491.	166.	70.
16 MAR 18	174.	1761.	1178.	1109.	189.	172.	199.	126.	670.	167.	72.
17 MAR 0	174.	1765.	1584.	1244.	121.	178.	355.	110.	900.	168.	76.
17 MAR 6	174.	1795.	2048.	1244.	0.	182.	531.	94.	896.	0.	81.
17 MAR 12	174.	1850.	2445.	1244.	0.	184.	650.	84.	887.	0.	88.
17 MAR 18	174.	1924.	2737.	1249.	0.	186.	726.	81.	889.	0.	95.
18 MAR 0	174.	2012.	2969.	1258.	0.	187.	782.	81.	897.	0.	103.
18 MAR 6	174.	2112.	3133.	1270.	0.	187.	814.	82.	909.	0.	111.
18 MAR 12	174.	2208.	3223.	1283.	0.	187.	817.	85.	922.	0.	119.
18 MAR 18	174.	2311.	3214.	1297.	0.	187.	777.	86.	930.	0.	127.
19 MAR 0	174.	2411.	3076.	1306.	0.	185.	681.	86.	927.	0.	134.
19 MAR 6	174.	2493.	2852.	1308.	0.	182.	547.	87.	907.	182.	140.
19 MAR 12	174.	2553.	2617.	1304.	0.	180.	415.	89.	708.	186.	144.
19 MAR 18	174.	2590.	2391.	1295.	0.	177.	318.	92.	600.	186.	147.
20 MAR 0	174.	2608.	2184.	1281.	0.	174.	252.	95.	442.	187.	149.
20 MAR 6	174.	2610.	2002.	1264.	0.	171.	197.	100.	311.	187.	150.
20 MAR 12	174.	2600.	1845.	593.	0.	169.	149.	107.	262.	187.	150.
20 MAR 18	174.	2579.	1620.	501.	0.	167.	110.	113.	177.	187.	150.
21 MAR 0	174.	2546.	1350.	434.	0.	166.	79.	122.	55.	187.	150.
21 MAR 6	174.	2502.	1145.	375.	0.	165.	55.	130.	112.	187.	150.
21 MAR 12	174.	2449.	983.	325.	0.	164.	37.	134.	132.	187.	149.
21 MAR 18	174.	2390.	864.	282.	0.	164.	23.	135.	112.	187.	148.
TOTAL Mm3	105.	1121.	1053.	571.	31.	103.	185.	67.	293.	68.	63.

Table C-1 (d)

RESERVOIR TRAJECTORIES (m)
CENTER : LONG POND   EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	180.28	184.97	241.71	266.34	311.20	313.84	323.40
15	MAR	6	180.29	185.55	241.60	266.34	311.21	313.77	323.40
15	MAR	12	180.29	185.90	241.60	266.36	311.25	313.80	323.40
15	MAR	18	180.29	186.06	241.60	266.40	311.33	313.94	323.40
16	MAR	0	180.29	186.29	241.60	266.45	311.44	314.09	323.42
16	MAR	6	180.29	186.58	241.60	266.51	311.58	314.09	323.46
16	MAR	12	180.29	186.96	241.60	266.59	311.75	314.10	323.52
16	MAR	18	180.30	187.46	241.60	266.69	311.92	314.11	323.62
17	MAR	0	180.40	188.00	241.60	266.82	312.07	314.08	323.75
17	MAR	6	180.57	188.46	241.61	266.96	312.17	314.03	323.93
17	MAR	12	180.79	188.79	241.63	267.11	312.22	314.04	324.11
17	MAR	18	181.06	189.04	241.68	267.27	312.26	314.08	324.30
18	MAR	0	181.36	189.23	241.75	267.43	312.29	314.16	324.50
18	MAR	6	181.64	189.35	241.82	267.58	312.30	314.23	324.71
18	MAR	12	181.92	189.40	241.90	267.73	312.29	314.28	324.91
18	MAR	18	182.19	189.34	241.95	267.86	312.26	314.27	325.10
19	MAR	0	182.41	189.16	241.96	267.95	312.18	314.15	325.26
19	MAR	6	182.57	188.93	241.94	268.03	312.10	314.05	325.36
19	MAR	12	182.67	188.70	241.88	268.08	312.02	313.99	325.43
19	MAR	18	182.71	188.48	241.81	268.12	311.94	313.92	325.47
20	MAR	0	182.72	188.29	241.71	268.15	311.87	313.90	325.50
20	MAR	6	182.69	188.12	241.60	268.17	311.81	313.92	325.51
20	MAR	12	182.63	187.98	241.60	268.19	311.76	313.94	325.52
20	MAR	18	182.55	187.62	241.60	268.21	311.72	313.98	325.51
21	MAR	0	182.43	187.31	241.60	268.23	311.69	314.07	325.50
21	MAR	6	182.29	187.05	241.60	268.24	311.66	314.10	325.48
21	MAR	12	182.13	186.82	241.60	268.25	311.64	314.10	325.46
21	MAR	18	181.97	186.61	241.60	268.26	311.63	314.10	325.43
AVG			181.50	187.73	241.69	267.44	311.84	314.04	324.58

Note: Victoria Control Structure OPEN and Godaleich Generating Station CLOSED throughout simulation.

Table C-2 (a)

PMP (RAIN + SNOW) IN MM
CENTER : ROUND POND   EVENT : WINTER

DAY MTH HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15 MAR 0	.00	.00	.00	.00	.00	.00	.00
15 MAR 6	29.40	30.90	30.90	29.40	27.90	27.40	25.80
15 MAR 12	29.40	30.90	30.90	29.40	27.90	27.40	25.80
15 MAR 18	29.40	30.90	30.90	29.40	27.90	27.40	25.80
16 MAR 0	29.40	30.90	30.90	29.40	27.90	27.40	25.80
16 MAR 6	45.50	47.80	47.80	45.50	43.20	42.40	39.80
16 MAR 12	65.00	69.30	69.30	65.00	60.80	59.30	54.40
16 MAR 18	65.90	70.40	70.40	65.90	61.60	60.10	55.10
17 MAR 0	64.50	68.80	68.80	64.50	60.30	58.90	54.10
17 MAR 6	55.60	59.70	59.70	55.60	51.50	50.00	45.40
17 MAR 12	60.80	65.50	65.50	60.80	56.20	54.60	49.30
17 MAR 18	60.80	65.50	65.50	60.80	56.20	54.60	49.30
18 MAR 0	61.30	66.00	66.00	61.30	56.60	55.00	49.60
18 MAR 6	47.30	52.00	52.00	47.30	42.60	41.00	35.60
18 MAR 12	47.30	52.00	52.00	47.30	42.60	41.00	35.60
18 MAR 18	.20	.20	.20	.20	.20	.20	.20
19 MAR 0	.20	.20	.20	.20	.20	.20	.20
19 MAR 6	.50	.50	.50	.50	.50	.50	.50
19 MAR 12	.50	.50	.50	.50	.50	.50	.50
19 MAR 18	.50	.50	.50	.50	.50	.50	.50
20 MAR 0	.50	.50	.50	.50	.50	.50	.50
20 MAR 6	.50	.50	.50	.50	.50	.50	.50
20 MAR 12	.50	.50	.50	.50	.50	.50	.50
20 MAR 18	.50	.50	.50	.50	.50	.50	.50
21 MAR 0	.50	.50	.50	.50	.50	.50	.50
21 MAR 6	.50	.50	.50	.50	.50	.50	.50
21 MAR 12	.50	.50	.50	.50	.50	.50	.50
21 MAR 18	.50	.50	.50	.50	.50	.50	.50
22 MAR 0	.50	.50	.50	.50	.50	.50	.50
22 MAR 6	.50	.50	.50	.50	.50	.50	.50
22 MAR 12	.50	.50	.50	.50	.50	.50	.50
22 MAR 18	.50	.50	.50	.50	.50	.50	.50
23 MAR 0	.50	.50	.50	.50	.50	.50	.50
23 MAR 6	.50	.50	.50	.50	.50	.50	.50
23 MAR 12	.50	.50	.50	.50	.50	.50	.50
23 MAR 18	.50	.50	.50	.50	.50	.50	.50
TOTAL	701.50	750.50	750.50	701.50	653.10	636.40	581.30

Table C-2 (b)

PMP INFLOW HYDROGRAPHS (m3/s)
CENTER : ROUND POND   EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEELPAEG	GRANITE	BURNT POND	VICTORIA
15	MAR	0	0.	0.	0.	0.	0.	0.	0.
15	MAR	6	14.	84.	43.	94.	45.	18.	21.
15	MAR	12	72.	276.	148.	308.	148.	84.	103.
15	MAR	18	183.	466.	262.	513.	248.	187.	236.
16	MAR	0	316.	611.	362.	660.	320.	286.	370.
16	MAR	6	449.	800.	489.	857.	417.	384.	505.
16	MAR	12	610.	1129.	697.	1205.	584.	524.	689.
16	MAR	18	828.	1491.	935.	1575.	760.	710.	932.
17	MAR	0	1075.	1763.	1142.	1838.	886.	891.	1174.
17	MAR	6	1289.	1916.	1294.	1965.	944.	1024.	1360.
17	MAR	12	1441.	2014.	1417.	2032.	973.	1107.	1481.
17	MAR	18	1546.	2116.	1538.	2110.	1007.	1168.	1570.
18	MAR	0	1631.	2196.	1644.	2169.	1033.	1224.	1650.
18	MAR	6	1692.	2191.	1702.	2132.	1011.	1252.	1694.
18	MAR	12	1709.	2117.	1717.	2023.	952.	1235.	1677.
18	MAR	18	1646.	1833.	1611.	1696.	796.	1152.	1577.
19	MAR	0	1475.	1386.	1398.	1211.	569.	980.	1371.
19	MAR	6	1222.	1044.	1211.	862.	405.	778.	1122.
19	MAR	12	966.	787.	1049.	612.	288.	611.	908.
19	MAR	18	758.	593.	908.	435.	204.	481.	735.
20	MAR	0	595.	446.	787.	308.	145.	378.	594.
20	MAR	6	467.	336.	681.	218.	102.	297.	481.
20	MAR	12	367.	252.	590.	153.	72.	234.	389.
20	MAR	18	288.	189.	511.	106.	50.	184.	315.
21	MAR	0	226.	141.	443.	73.	34.	144.	255.
21	MAR	6	177.	105.	383.	49.	23.	113.	206.
21	MAR	12	138.	76.	332.	33.	15.	88.	167.
21	MAR	18	107.	55.	288.	21.	10.	69.	135.
22	MAR	0	83.	39.	249.	12.	6.	54.	109.
22	MAR	6	64.	27.	216.	6.	3.	41.	87.
22	MAR	12	48.	18.	187.	3.	1.	31.	70.
22	MAR	18	36.	11.	162.	0.	0.	23.	56.
23	MAR	0	26.	6.	140.	0.	0.	17.	44.
23	MAR	6	19.	3.	121.	0.	0.	12.	34.
23	MAR	12	13.	0.	105.	0.	0.	8.	25.
23	MAR	18	8.	0.	91.	0.	0.	5.	19.
TOTAL Mm3			466.	573.	537.	546.	260.	341.	479.

Table C-2 (c)

ROUTED OUTFLOW HYDROGRAPHS (m3/s)
CENTER : ROUND POND EVENT : WINTER

DayMthHr	Bay dEspr Plant	Salmon Splwy	Salmon River @ RdPd	North Salmon Splwy	Ebbe Cntrl Gate	Gran-ite Canal	Gran-ite Splwy	Burnt SH Canal	White Bear Splwy	Vic-toria Ctrl.	Vic-toria Splwy
15 MAR 0	174.	0.	121.	1307.	0.	147.	0.	142.	0.	0.	0.
15 MAR 6	174.	0.	186.	801.	186.	147.	0.	133.	0.	21.	0.
15 MAR 12	174.	208.	337.	334.	186.	148.	0.	132.	0.	103.	0.
15 MAR 18	174.	468.	459.	448.	186.	150.	0.	142.	0.	165.	68.
16 MAR 0	174.	716.	573.	548.	186.	154.	0.	154.	121.	165.	68.
16 MAR 6	174.	1000.	725.	676.	187.	159.	0.	151.	395.	165.	68.
16 MAR 12	174.	1344.	908.	885.	188.	166.	67.	139.	539.	166.	70.
16 MAR 18	174.	1761.	1196.	1124.	189.	172.	216.	124.	738.	167.	73.
17 MAR 0	174.	1764.	1611.	1244.	102.	179.	383.	109.	864.	97.	77.
17 MAR 6	174.	1792.	2083.	1244.	0.	183.	569.	97.	866.	0.	83.
17 MAR 12	174.	1845.	2481.	1245.	0.	185.	690.	93.	872.	0.	90.
17 MAR 18	174.	1917.	2775.	1251.	0.	187.	773.	94.	888.	0.	97.
18 MAR 0	174.	2002.	3010.	1261.	0.	188.	835.	97.	909.	0.	105.
18 MAR 6	174.	2099.	3176.	1274.	0.	188.	874.	102.	934.	0.	114.
18 MAR 12	174.	2193.	3267.	1288.	0.	188.	882.	108.	959.	0.	122.
18 MAR 18	174.	2292.	3259.	1302.	0.	188.	846.	114.	979.	0.	131.
19 MAR 0	174.	2388.	3119.	1313.	0.	186.	749.	117.	985.	0.	139.
19 MAR 6	174.	2468.	2890.	1316.	0.	184.	616.	117.	971.	0.	145.
19 MAR 12	174.	2526.	2649.	1312.	0.	181.	469.	110.	935.	0.	150.
19 MAR 18	174.	2562.	2420.	1303.	0.	178.	357.	104.	741.	188.	154.
20 MAR 0	174.	2580.	2209.	1290.	0.	175.	277.	106.	533.	188.	156.
20 MAR 6	174.	2582.	2024.	1273.	0.	172.	219.	109.	412.	188.	157.
20 MAR 12	174.	2571.	1865.	876.	0.	170.	169.	113.	322.	188.	158.
20 MAR 18	174.	2551.	1679.	511.	0.	168.	127.	119.	221.	188.	158.
21 MAR 0	174.	2521.	1429.	443.	0.	167.	93.	126.	139.	188.	158.
21 MAR 6	174.	2480.	1201.	383.	0.	165.	66.	131.	176.	188.	157.
21 MAR 12	174.	2430.	1020.	332.	0.	165.	45.	133.	146.	188.	157.
21 MAR 18	174.	2373.	893.	288.	0.	164.	29.	135.	124.	188.	156.
TOTAL Mm3	105.	1111.	1071.	580.	30.	104.	202.	72.	319.	59.	65.

Table C-2 (d)

RESERVOIR TRAJECTORIES (m)
CENTER : ROUND POND EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	180.28	184.97	241.71	266.34	311.20	313.84	323.40
15	MAR	6	180.29	185.55	241.60	266.34	311.21	313.77	323.40
15	MAR	12	180.29	185.90	241.60	266.36	311.26	313.81	323.40
15	MAR	18	180.29	186.07	241.60	266.40	311.34	313.96	323.40
16	MAR	0	180.29	186.30	241.60	266.45	311.45	314.09	323.42
16	MAR	6	180.29	186.59	241.60	266.51	311.60	314.09	323.46
16	MAR	12	180.29	186.98	241.60	266.59	311.77	314.10	323.53
16	MAR	18	180.30	187.48	241.60	266.69	311.95	314.11	323.64
17	MAR	0	180.39	188.03	241.60	266.82	312.10	314.12	323.79
17	MAR	6	180.55	188.50	241.61	266.97	312.19	314.16	323.97
17	MAR	12	180.77	188.83	241.64	267.12	312.25	314.26	324.16
17	MAR	18	181.03	189.08	241.69	267.27	312.29	314.39	324.37
18	MAR	0	181.32	189.27	241.77	267.43	312.32	314.54	324.58
18	MAR	6	181.59	189.39	241.85	267.59	312.34	314.69	324.80
18	MAR	12	181.87	189.44	241.93	267.74	312.33	314.81	325.02
18	MAR	18	182.13	189.38	241.98	267.86	312.30	314.85	325.22
19	MAR	0	182.34	189.20	242.00	267.96	312.22	314.76	325.39
19	MAR	6	182.49	188.97	241.98	268.03	312.14	314.55	325.51
19	MAR	12	182.59	188.73	241.93	268.08	312.05	314.24	325.61
19	MAR	18	182.64	188.51	241.86	268.12	311.97	314.12	325.66
20	MAR	0	182.64	188.31	241.76	268.15	311.90	314.07	325.69
20	MAR	6	182.62	188.14	241.65	268.18	311.84	314.04	325.71
20	MAR	12	182.56	188.00	241.60	268.20	311.78	314.04	325.71
20	MAR	18	182.48	187.73	241.60	268.21	311.74	314.06	325.71
21	MAR	0	182.37	187.40	241.60	268.23	311.70	314.11	325.70
21	MAR	6	182.24	187.12	241.60	268.24	311.67	314.10	325.68
21	MAR	12	182.08	186.88	241.60	268.25	311.65	314.10	325.66
21	MAR	18	181.92	186.66	241.60	268.27	311.64	314.10	325.63
AVG			181.46	187.76	241.71	267.44	311.86	314.21	324.69

Note: Victoria Control Structure OPEN and Godaleich Generating Station CLOSED throughout simulation.

Table C-3 (a)

PMP (RAIN + SNOW) IN MM
CENTER : UPPER SALMON   EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	.00	.00	.00	.00	.00	.00	.00
15	MAR	6	30.50	30.90	30.90	29.70	29.40	28.50	27.10
15	MAR	12	30.50	30.90	30.90	29.70	29.40	28.50	27.10
15	MAR	18	30.50	30.90	30.90	29.70	29.40	28.50	27.10
16	MAR	0	30.50	30.90	30.90	29.70	29.40	28.50	27.10
16	MAR	6	47.20	47.80	47.80	46.00	45.50	44.10	41.90
16	MAR	12	68.20	69.30	69.30	66.00	65.00	62.40	58.30
16	MAR	18	69.20	70.40	70.40	66.90	65.90	63.30	59.10
17	MAR	0	67.60	68.80	68.80	65.50	64.50	62.00	57.90
17	MAR	6	58.60	59.70	59.70	56.50	55.60	53.10	49.10
17	MAR	12	64.30	65.50	65.50	61.90	60.80	58.00	53.50
17	MAR	18	64.30	65.50	65.50	61.90	60.80	58.00	53.50
18	MAR	0	64.80	66.00	66.00	62.30	61.30	58.50	53.90
18	MAR	6	50.80	52.00	52.00	48.30	47.30	44.50	39.90
18	MAR	12	50.80	52.00	52.00	48.30	47.30	44.50	39.90
18	MAR	18	.20	.20	.20	.20	.20	.20	.20
19	MAR	0	.20	.20	.20	.20	.20	.20	.20
19	MAR	6	.50	.50	.50	.50	.50	.50	.50
19	MAR	12	.50	.50	.50	.50	.50	.50	.50
19	MAR	18	.50	.50	.50	.50	.50	.50	.50
20	MAR	0	.50	.50	.50	.50	.50	.50	.50
20	MAR	6	.50	.50	.50	.50	.50	.50	.50
20	MAR	12	.50	.50	.50	.50	.50	.50	.50
20	MAR	18	.50	.50	.50	.50	.50	.50	.50
21	MAR	0	.50	.50	.50	.50	.50	.50	.50
21	MAR	6	.50	.50	.50	.50	.50	.50	.50
21	MAR	12	.50	.50	.50	.50	.50	.50	.50
21	MAR	18	.50	.50	.50	.50	.50	.50	.50
22	MAR	0	.50	.50	.50	.50	.50	.50	.50
22	MAR	6	.50	.50	.50	.50	.50	.50	.50
22	MAR	12	.50	.50	.50	.50	.50	.50	.50
22	MAR	18	.50	.50	.50	.50	.50	.50	.50
23	MAR	0	.50	.50	.50	.50	.50	.50	.50
23	MAR	6	.50	.50	.50	.50	.50	.50	.50
23	MAR	12	.50	.50	.50	.50	.50	.50	.50
23	MAR	18	.50	.50	.50	.50	.50	.50	.50
TOTAL			737.70	750.50	750.50	712.30	701.50	672.30	625.30

Table C-3 (b)

PMP INFLOW HYDROGRAPHS (m3/s)
CENTER : UPPER SALMON EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	0.	0.	0.	0.	0.	0.	0.
15	MAR	6	15.	84.	43.	96.	49.	19.	23.
15	MAR	12	76.	276.	148.	312.	159.	89.	110.
15	MAR	18	192.	466.	262.	520.	265.	196.	251.
16	MAR	0	331.	611.	362.	668.	341.	300.	393.
16	MAR	6	469.	800.	489.	868.	443.	402.	535.
16	MAR	12	637.	1129.	697.	1221.	622.	549.	733.
16	MAR	18	867.	1491.	935.	1599.	814.	746.	995.
17	MAR	0	1128.	1763.	1142.	1867.	950.	938.	1258.
17	MAR	6	1355.	1916.	1294.	1997.	1015.	1081.	1461.
17	MAR	12	1516.	2014.	1417.	2067.	1050.	1171.	1595.
17	MAR	18	1630.	2116.	1538.	2148.	1091.	1239.	1697.
18	MAR	0	1723.	2196.	1644.	2208.	1121.	1300.	1788.
18	MAR	6	1791.	2191.	1702.	2172.	1102.	1334.	1842.
18	MAR	12	1812.	2117.	1717.	2063.	1046.	1321.	1834.
18	MAR	18	1751.	1833.	1611.	1730.	877.	1236.	1733.
19	MAR	0	1572.	1386.	1398.	1236.	627.	1053.	1510.
19	MAR	6	1304.	1044.	1211.	879.	446.	836.	1237.
19	MAR	12	1031.	787.	1049.	625.	317.	657.	1001.
19	MAR	18	809.	593.	908.	443.	225.	517.	810.
20	MAR	0	635.	446.	787.	314.	160.	406.	655.
20	MAR	6	498.	336.	681.	223.	113.	319.	530.
20	MAR	12	391.	252.	590.	157.	79.	251.	429.
20	MAR	18	307.	189.	511.	109.	55.	197.	347.
21	MAR	0	241.	141.	443.	75.	38.	155.	281.
21	MAR	6	189.	105.	383.	50.	26.	122.	227.
21	MAR	12	147.	76.	332.	34.	17.	95.	184.
21	MAR	18	115.	55.	288.	21.	11.	74.	149.
22	MAR	0	89.	39.	249.	13.	6.	58.	120.
22	MAR	6	68.	27.	216.	6.	3.	44.	96.
22	MAR	12	51.	18.	187.	3.	1.	33.	77.
22	MAR	18	38.	11.	162.	0.	0.	25.	61.
23	MAR	0	28.	6.	140.	0.	0.	18.	48.
23	MAR	6	20.	3.	121.	0.	0.	13.	37.
23	MAR	12	14.	0.	105.	0.	0.	9.	28.
23	MAR	18	9.	0.	91.	0.	0.	6.	21.
TOTAL Mm3			494.	573.	537.	556.	282.	363.	520.

Table C-3 (c)

ROUTED OUTFLOW HYDROGRAPHS (m3/s)
CENTER : UPPER SALMON EVENT : WINTER

DayMthHr	Bay dEspr Plant	Salmon Splwy	Salmon River @ RdPd	North Salmon Splwy	Ebbe Cntrl Gate	Granite Canal	Granite Splwy	Burnt SH Canal	White Bear Splwy	Victoria Ctrl.	Victoria Splwy
15 MAR 0	174.	0.	121.	1307.	0.	147.	0.	142.	0.	0.	0.
15 MAR 6	174.	0.	186.	801.	186.	147.	0.	133.	0.	23.	0.
15 MAR 12	174.	213.	337.	334.	186.	148.	0.	132.	0.	110.	0.
15 MAR 18	174.	477.	459.	448.	186.	151.	0.	143.	0.	165.	68.
16 MAR 0	174.	731.	573.	548.	186.	155.	0.	154.	157.	165.	68.
16 MAR 6	174.	1020.	725.	676.	187.	160.	1.	150.	413.	165.	69.
16 MAR 12	174.	1371.	908.	885.	188.	167.	92.	137.	565.	166.	70.
16 MAR 18	174.	1761.	1196.	1124.	189.	174.	246.	122.	776.	167.	73.
17 MAR 0	174.	1765.	1611.	1244.	102.	180.	437.	104.	901.	0.	78.
17 MAR 6	174.	1796.	2083.	1244.	0.	184.	629.	91.	893.	0.	85.
17 MAR 12	174.	1851.	2481.	1245.	0.	186.	751.	88.	905.	0.	92.
17 MAR 18	174.	1926.	2775.	1251.	0.	188.	840.	90.	925.	0.	100.
18 MAR 0	174.	2014.	3010.	1261.	0.	189.	908.	94.	952.	0.	109.
18 MAR 6	174.	2114.	3176.	1274.	0.	190.	952.	100.	982.	0.	118.
18 MAR 12	174.	2210.	3267.	1288.	0.	190.	965.	107.	1012.	0.	128.
18 MAR 18	174.	2313.	3259.	1302.	0.	189.	929.	113.	1037.	0.	137.
19 MAR 0	174.	2413.	3119.	1313.	0.	187.	826.	118.	1046.	0.	145.
19 MAR 6	174.	2496.	2890.	1316.	0.	185.	682.	120.	1034.	0.	152.
19 MAR 12	174.	2556.	2649.	1312.	0.	182.	528.	113.	995.	0.	157.
19 MAR 18	174.	2594.	2420.	1303.	0.	179.	394.	105.	930.	189.	162.
20 MAR 0	174.	2612.	2209.	1290.	0.	176.	300.	103.	576.	189.	164.
20 MAR 6	174.	2614.	2024.	1273.	0.	173.	237.	106.	446.	190.	165.
20 MAR 12	174.	2604.	1865.	876.	0.	171.	183.	111.	347.	190.	166.
20 MAR 18	174.	2583.	1679.	511.	0.	169.	138.	115.	262.	190.	167.
TOTAL Mm3	90.	908.	972.	549.	30.	90.	217.	60.	327.	41.	53.

Table C-3 (d)

RESERVOIR TRAJECTORIES (m)
CENTER : UPPER SALMON   EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	180.28	184.97	241.71	266.34	311.20	313.84	323.40
15	MAR	6	180.29	185.55	241.60	266.34	311.21	313.77	323.40
15	MAR	12	180.29	185.90	241.60	266.37	311.26	313.82	323.40
15	MAR	18	180.29	186.07	241.60	266.40	311.35	313.98	323.40
16	MAR	0	180.29	186.30	241.60	266.45	311.47	314.09	323.43
16	MAR	6	180.29	186.59	241.60	266.51	311.62	314.09	323.47
16	MAR	12	180.29	186.98	241.60	266.59	311.80	314.10	323.55
16	MAR	18	180.30	187.48	241.60	266.70	311.98	314.11	323.66
17	MAR	0	180.40	188.03	241.60	266.83	312.14	314.06	323.84
17	MAR	6	180.57	188.50	241.61	266.98	312.23	314.13	324.03
17	MAR	12	180.80	188.83	241.64	267.13	312.29	314.25	324.24
17	MAR	18	181.07	189.08	241.69	267.28	312.33	314.41	324.46
18	MAR	0	181.36	189.27	241.77	267.45	312.37	314.59	324.69
18	MAR	6	181.64	189.39	241.85	267.61	312.38	314.76	324.93
18	MAR	12	181.93	189.44	241.93	267.76	312.38	314.90	325.17
18	MAR	18	182.19	189.38	241.98	267.89	312.35	314.97	325.39
19	MAR	0	182.41	189.20	242.00	267.98	312.27	314.89	325.57
19	MAR	6	182.57	188.97	241.98	268.06	312.18	314.67	325.70
19	MAR	12	182.67	188.73	241.93	268.11	312.08	314.35	325.81
19	MAR	18	182.72	188.51	241.86	268.15	312.00	314.12	325.87
20	MAR	0	182.73	188.31	241.76	268.18	311.92	314.06	325.91
20	MAR	6	182.70	188.14	241.65	268.20	311.86	314.03	325.93
20	MAR	12	182.65	188.00	241.60	268.22	311.80	314.02	325.94
20	MAR	18	182.57	187.73	241.60	268.24	311.75	314.03	325.94
AVG			181.39	187.89	241.72	267.32	311.93	314.25	324.63

Note: Victoria Control Structure OPEN and Godaleich Generating Station CLOSED throughout simulation.

Table C-4 (a)

PMP (RAIN + SNOW) IN MM
CENTER : MEELPAEG EVENT : WINTER

DAY MTH HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15 MAR 0	.00	.00	.00	.00	.00	.00	.00
15 MAR 6	27.90	27.10	27.90	30.90	30.90	29.70	29.70
15 MAR 12	27.90	27.10	27.90	30.90	30.90	29.70	29.70
15 MAR 18	27.90	27.10	27.90	30.90	30.90	29.70	29.70
16 MAR 0	27.90	27.10	27.90	30.90	30.90	29.70	29.70
16 MAR 6	43.20	41.90	43.20	47.80	47.80	46.00	46.00
16 MAR 12	60.80	58.30	60.80	69.30	69.30	66.00	66.00
16 MAR 18	61.60	59.10	61.60	70.40	70.40	66.90	66.90
17 MAR 0	60.30	57.90	60.30	68.80	68.80	65.50	65.50
17 MAR 6	51.50	49.10	51.50	59.70	59.70	56.50	56.50
17 MAR 12	56.20	53.50	56.20	65.50	65.50	61.90	61.90
17 MAR 18	56.20	53.50	56.20	65.50	65.50	61.90	61.90
18 MAR 0	56.60	53.90	56.60	66.00	66.00	62.30	62.30
18 MAR 6	42.60	39.90	42.60	52.00	52.00	48.30	48.30
18 MAR 12	42.60	39.90	42.60	52.00	52.00	48.30	48.30
18 MAR 18	.20	.20	.20	.20	.20	.20	.20
19 MAR 0	.20	.20	.20	.20	.20	.20	.20
19 MAR 6	.50	.50	.50	.50	.50	.50	.50
19 MAR 12	.50	.50	.50	.50	.50	.50	.50
19 MAR 18	.50	.50	.50	.50	.50	.50	.50
20 MAR 0	.50	.50	.50	.50	.50	.50	.50
20 MAR 6	.50	.50	.50	.50	.50	.50	.50
20 MAR 12	.50	.50	.50	.50	.50	.50	.50
20 MAR 18	.50	.50	.50	.50	.50	.50	.50
21 MAR 0	.50	.50	.50	.50	.50	.50	.50
21 MAR 6	.50	.50	.50	.50	.50	.50	.50
21 MAR 12	.50	.50	.50	.50	.50	.50	.50
21 MAR 18	.50	.50	.50	.50	.50	.50	.50
22 MAR 0	.50	.50	.50	.50	.50	.50	.50
22 MAR 6	.50	.50	.50	.50	.50	.50	.50
22 MAR 12	.50	.50	.50	.50	.50	.50	.50
22 MAR 18	.50	.50	.50	.50	.50	.50	.50
23 MAR 0	.50	.50	.50	.50	.50	.50	.50
23 MAR 6	.50	.50	.50	.50	.50	.50	.50
23 MAR 12	.50	.50	.50	.50	.50	.50	.50
23 MAR 18	.50	.50	.50	.50	.50	.50	.50
TOTAL	653.10	625.30	653.10	750.50	750.50	712.30	712.30

Table C-4 (b)

PMP INFLOW HYDROGRAPHS (m3/s)
CENTER : MEELPAEG EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	0.	0.	0.	0.	0.	0.	0.
15	MAR	6	13.	69.	37.	101.	52.	20.	27.
15	MAR	12	67.	231.	129.	329.	170.	94.	125.
15	MAR	18	171.	397.	231.	545.	282.	207.	283.
16	MAR	0	296.	522.	320.	701.	362.	316.	440.
16	MAR	6	421.	687.	434.	908.	469.	422.	597.
16	MAR	12	573.	961.	615.	1280.	661.	577.	819.
16	MAR	18	777.	1253.	820.	1682.	869.	787.	1119.
17	MAR	0	1006.	1474.	998.	1967.	1016.	992.	1423.
17	MAR	6	1203.	1592.	1126.	2106.	1089.	1145.	1660.
17	MAR	12	1341.	1658.	1227.	2185.	1130.	1243.	1822.
17	MAR	18	1435.	1729.	1325.	2275.	1176.	1319.	1950.
18	MAR	0	1509.	1784.	1412.	2343.	1211.	1387.	2064.
18	MAR	6	1562.	1761.	1453.	2312.	1195.	1425.	2138.
18	MAR	12	1570.	1675.	1453.	2206.	1141.	1416.	2145.
18	MAR	18	1506.	1439.	1357.	1855.	959.	1330.	2042.
19	MAR	0	1345.	1088.	1178.	1325.	686.	1134.	1786.
19	MAR	6	1113.	820.	1020.	943.	488.	901.	1463.
19	MAR	12	880.	618.	884.	670.	347.	708.	1184.
19	MAR	18	691.	465.	765.	475.	246.	557.	958.
20	MAR	0	542.	351.	663.	337.	175.	438.	775.
20	MAR	6	425.	263.	574.	239.	124.	344.	627.
20	MAR	12	334.	198.	497.	168.	87.	271.	507.
20	MAR	18	262.	148.	431.	117.	60.	213.	410.
21	MAR	0	206.	111.	373.	80.	42.	167.	332.
21	MAR	6	161.	82.	323.	54.	28.	131.	269.
21	MAR	12	126.	59.	280.	36.	19.	102.	217.
21	MAR	18	98.	43.	242.	23.	12.	80.	176.
22	MAR	0	76.	30.	210.	14.	7.	62.	142.
22	MAR	6	58.	21.	182.	7.	4.	48.	114.
22	MAR	12	44.	14.	157.	3.	2.	36.	91.
22	MAR	18	32.	8.	136.	0.	0.	27.	73.
23	MAR	0	23.	4.	118.	0.	0.	19.	57.
23	MAR	6	17.	2.	102.	0.	0.	14.	44.
23	MAR	12	11.	0.	89.	0.	0.	10.	33.
23	MAR	18	7.	0.	77.	0.	0.	6.	25.
TOTAL Mm3			430.	466.	459.	589.	305.	388.	603.

Table C-4 (c)

ROUTED OUTFLOW HYDROGRAPHS (m3/s)
CENTER : MEELPAEG EVENT : WINTER

DayMthHr	Bay dEspr Plant	Salmon Splwy	Salmon River @ RdPd	North Salmon Splwy	Ebbe Cntrl Gate	Gran-ite Canal	Gran-ite Splwy	Burnt SH Canal	White Bear Splwy	Vic-toria Ctrl.	Vic-toria Splwy
15 MAR 0	174.	0.	121.	1307.	0.	147.	0.	142.	0.	0.	0.
15 MAR 6	174.	0.	185.	795.	186.	147.	0.	133.	0.	27.	0.
15 MAR 12	174.	194.	330.	315.	186.	148.	0.	134.	0.	125.	0.
15 MAR 18	174.	431.	434.	417.	186.	151.	0.	145.	0.	165.	68.
16 MAR 0	174.	651.	529.	507.	187.	155.	0.	154.	206.	165.	68.
16 MAR 6	174.	907.	660.	621.	187.	161.	5.	148.	433.	166.	69.
16 MAR 12	174.	1223.	824.	803.	188.	168.	116.	134.	595.	166.	71.
16 MAR 18	174.	1647.	1044.	1010.	190.	175.	278.	119.	820.	167.	75.
17 MAR 0	174.	1761.	1372.	1189.	191.	181.	494.	102.	901.	0.	80.
17 MAR 6	174.	1777.	1755.	1244.	118.	185.	688.	91.	900.	0.	87.
17 MAR 12	174.	1815.	2129.	1244.	17.	187.	818.	90.	918.	0.	96.
17 MAR 18	174.	1871.	2414.	1244.	0.	189.	913.	93.	946.	0.	106.
18 MAR 0	174.	1940.	2621.	1246.	0.	190.	988.	99.	979.	0.	116.
18 MAR 6	174.	2017.	2760.	1252.	0.	191.	1038.	106.	1016.	0.	126.
18 MAR 12	174.	2101.	2834.	1259.	0.	192.	1062.	139.	1052.	0.	137.
18 MAR 18	174.	2178.	2823.	1265.	0.	191.	1033.	138.	1076.	0.	148.
19 MAR 0	174.	2250.	2713.	1268.	0.	189.	926.	145.	1088.	0.	157.
19 MAR 6	174.	2315.	2536.	1265.	0.	187.	773.	152.	1078.	0.	165.
19 MAR 12	174.	2360.	2340.	1257.	0.	184.	611.	125.	1042.	0.	171.
19 MAR 18	174.	2388.	2149.	791.	0.	181.	449.	113.	987.	0.	176.
20 MAR 0	174.	2398.	1890.	663.	0.	177.	335.	106.	693.	192.	181.
20 MAR 6	174.	2393.	1616.	574.	0.	174.	261.	108.	483.	193.	183.
20 MAR 12	174.	2372.	1386.	497.	0.	172.	203.	112.	377.	193.	185.
20 MAR 18	174.	2340.	1202.	431.	0.	170.	155.	117.	294.	193.	185.
21 MAR 0	174.	2298.	1042.	373.	0.	168.	115.	123.	186.	193.	186.
21 MAR 6	174.	2250.	923.	323.	0.	166.	83.	128.	186.	193.	185.
21 MAR 12	174.	2201.	818.	280.	0.	165.	58.	131.	167.	193.	185.
21 MAR 18	174.	2150.	716.	242.	0.	164.	39.	134.	142.	193.	184.
TOTAL Mm3	105.	1042.	911.	512.	35.	105.	247.	75.	358.	55.	73.

Table C-4 (d)

RESERVOIR TRAJECTORIES (m)
CENTER : MEELPAEG   EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	180.28	184.97	241.71	266.34	311.20	313.84	323.40
15	MAR	6	180.29	185.54	241.60	266.35	311.21	313.77	323.40
15	MAR	12	180.29	185.88	241.60	266.37	311.27	313.84	323.40
15	MAR	18	180.29	186.01	241.60	266.40	311.36	314.00	323.41
16	MAR	0	180.29	186.21	241.60	266.45	311.49	314.09	323.44
16	MAR	6	180.29	186.46	241.60	266.52	311.65	314.09	323.49
16	MAR	12	180.29	186.79	241.60	266.60	311.83	314.10	323.58
16	MAR	18	180.29	187.23	241.60	266.71	312.02	314.11	323.71
17	MAR	0	180.34	187.71	241.60	266.85	312.17	314.10	323.91
17	MAR	6	180.46	188.15	241.60	266.99	312.26	314.21	324.13
17	MAR	12	180.63	188.48	241.60	267.15	312.33	314.37	324.37
17	MAR	18	180.84	188.72	241.62	267.32	312.38	314.57	324.62
18	MAR	0	181.07	188.89	241.65	267.49	312.42	314.79	324.89
18	MAR	6	181.32	189.00	241.68	267.66	312.44	315.00	325.17
18	MAR	12	181.55	189.04	241.72	267.82	312.44	315.15	325.45
18	MAR	18	181.76	188.99	241.74	267.96	312.41	315.23	325.69
19	MAR	0	181.93	188.83	241.72	268.06	312.32	315.16	325.90
19	MAR	6	182.05	188.64	241.67	268.13	312.23	314.94	326.07
19	MAR	12	182.12	188.44	241.60	268.19	312.13	314.62	326.20
19	MAR	18	182.15	188.26	241.60	268.23	312.03	314.24	326.30
20	MAR	0	182.14	187.94	241.60	268.26	311.95	314.12	326.35
20	MAR	6	182.08	187.64	241.60	268.29	311.88	314.08	326.38
20	MAR	12	182.00	187.38	241.60	268.31	311.82	314.06	326.40
20	MAR	18	181.89	187.14	241.60	268.33	311.77	314.06	326.40
21	MAR	0	181.76	186.92	241.60	268.34	311.72	314.10	326.40
21	MAR	6	181.62	186.72	241.60	268.36	311.69	314.10	326.38
21	MAR	12	181.46	186.54	241.60	268.37	311.67	314.10	326.36
21	MAR	18	181.30	186.35	241.60	268.38	311.65	314.10	326.33
AVG			181.17	187.46	241.63	267.51	311.92	314.32	325.05

Note: Victoria Control Structure OPEN and Godaleich Generating Station CLOSED throughout simulation.

Table C-5(c)

ROUTED OUTFLOW HYDROGRAPHS (m3/s)
CENTER : MEELPAEG EVENT : WINTER

DayMthHr	Bay dEspr Plant	Salmon Splwy	Salmon River @ RdPd	North Salmon Splwy	Ebbe Cntrl Gate	Gran-ite Canal	Gran-ite Splwy	Burnt SH Canal	White Bear Splwy	Vic-toria Ctrl.	Vic-toria Splwy
15 MAR 0	174.	0.	121.	1307.	0.	147.	0.	142.	0.	0.	0.
15 MAR 6	174.	0.	185.	774.	164.	147.	0.	133.	0.	27.	0.
15 MAR 12	174.	192.	328.	293.	164.	148.	0.	134.	0.	125.	0.
15 MAR 18	174.	424.	427.	396.	165.	151.	0.	145.	0.	165.	68.
16 MAR 0	174.	641.	519.	485.	165.	155.	0.	154.	206.	165.	68.
16 MAR 6	174.	894.	646.	600.	166.	161.	5.	148.	433.	166.	69.
16 MAR 12	174.	1210.	811.	782.	167.	168.	116.	134.	595.	166.	71.
16 MAR 18	174.	1630.	1026.	989.	169.	175.	278.	119.	820.	167.	75.
17 MAR 0	174.	1761.	1351.	1169.	171.	181.	494.	102.	901.	0.	80.
17 MAR 6	174.	1777.	1731.	1244.	118.	185.	688.	91.	900.	0.	87.
17 MAR 12	174.	1814.	2107.	1244.	17.	187.	818.	90.	918.	0.	96.
17 MAR 18	174.	1869.	2400.	1244.	0.	189.	913.	93.	946.	0.	106.
18 MAR 0	174.	1937.	2612.	1246.	0.	190.	988.	99.	979.	0.	116.
18 MAR 6	174.	2014.	2755.	1252.	0.	191.	1038.	106.	1016.	0.	126.
18 MAR 12	174.	2098.	2830.	1259.	0.	192.	1062.	139.	1052.	0.	137.
18 MAR 18	174.	2175.	2820.	1265.	0.	191.	1033.	138.	1076.	0.	148.
19 MAR 0	174.	2247.	2711.	1268.	0.	189.	926.	145.	1088.	0.	157.
19 MAR 6	174.	2311.	2535.	1265.	0.	187.	773.	152.	1078.	0.	165.
19 MAR 12	174.	2357.	2339.	1257.	0.	184.	611.	125.	1042.	0.	171.
19 MAR 18	174.	2384.	2148.	791.	0.	181.	449.	113.	987.	0.	176.
20 MAR 0	174.	2396.	1890.	663.	0.	177.	335.	106.	693.	192.	181.
20 MAR 6	174.	2390.	1616.	574.	0.	174.	261.	108.	483.	193.	183.
20 MAR 12	174.	2369.	1386.	497.	0.	172.	203.	112.	377.	193.	185.
20 MAR 18	174.	2337.	1202.	561.	130.	170.	155.	117.	294.	193.	185.
21 MAR 0	174.	2296.	1058.	570.	197.	168.	115.	123.	171.	193.	186.
21 MAR 6	174.	2248.	968.	520.	197.	166.	83.	129.	201.	193.	185.
21 MAR 12	174.	2201.	894.	477.	197.	165.	58.	131.	166.	193.	185.
21 MAR 18	174.	2152.	823.	439.	197.	164.	39.	134.	142.	193.	184.
22 MAR 0	174.	2101.	754.	407.	197.	164.	24.	135.	121.	193.	183.
22 MAR 6	174.	2044.	682.	379.	197.	163.	12.	137.	105.	193.	181.
22 MAR 12	174.	1986.	616.	350.	193.	163.	3.	138.	92.	192.	180.
22 MAR 18	174.	1929.	558.	333.	197.	162.	0.	138.	81.	192.	178.
23 MAR 0	174.	1872.	508.	315.	197.	162.	0.	139.	72.	192.	176.
23 MAR 6	174.	1739.	464.	299.	197.	162.	0.	140.	66.	191.	175.
23 MAR 12	174.	264.	427.	286.	197.	161.	0.	140.	62.	191.	173.
23 MAR 18	174.	231.	398.	274.	197.	161.	0.	141.	57.	191.	172.
TOTAL Mm3	135.	1302.	1008.	585.	85.	133.	248.	99.	372.	88.	104.

Table C-5(d)

RESERVOIR TRAJECTORIES (m)
CENTER : MEELPAEG EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	180.28	184.97	241.71	264.96	311.20	313.84	323.40
15	MAR	6	180.29	185.54	241.60	264.97	311.21	313.77	323.40
15	MAR	12	180.29	185.87	241.60	265.00	311.27	313.84	323.40
15	MAR	18	180.29	185.99	241.60	265.04	311.36	314.00	323.41
16	MAR	0	180.29	186.19	241.60	265.09	311.49	314.09	323.44
16	MAR	6	180.29	186.44	241.60	265.16	311.65	314.09	323.49
16	MAR	12	180.29	186.77	241.60	265.25	311.83	314.10	323.58
16	MAR	18	180.29	187.20	241.60	265.38	312.02	314.11	323.71
17	MAR	0	180.34	187.68	241.60	265.52	312.17	314.10	323.91
17	MAR	6	180.45	188.12	241.60	265.68	312.26	314.21	324.13
17	MAR	12	180.62	188.46	241.60	265.86	312.33	314.37	324.37
17	MAR	18	180.83	188.71	241.62	266.04	312.38	314.57	324.62
18	MAR	0	181.06	188.89	241.65	266.22	312.42	314.79	324.89
18	MAR	6	181.31	189.00	241.68	266.41	312.44	315.00	325.17
18	MAR	12	181.54	189.04	241.72	266.58	312.44	315.15	325.45
18	MAR	18	181.75	188.98	241.74	266.72	312.41	315.23	325.69
19	MAR	0	181.92	188.83	241.72	266.82	312.32	315.16	325.90
19	MAR	6	182.04	188.64	241.67	266.89	312.23	314.94	326.07
19	MAR	12	182.12	188.44	241.60	266.95	312.13	314.62	326.20
19	MAR	18	182.15	188.26	241.60	267.00	312.03	314.24	326.30
20	MAR	0	182.13	187.94	241.60	267.03	311.95	314.12	326.35
20	MAR	6	182.08	187.64	241.60	267.06	311.88	314.08	326.38
20	MAR	12	181.99	187.38	241.60	267.08	311.82	314.06	326.40
20	MAR	18	181.88	187.14	241.60	267.09	311.77	314.06	326.40
21	MAR	0	181.75	186.97	241.60	267.09	311.72	314.11	326.40
21	MAR	6	181.62	186.84	241.60	267.10	311.69	314.10	326.38
21	MAR	12	181.47	186.70	241.60	267.10	311.67	314.10	326.36
21	MAR	18	181.32	186.57	241.60	267.10	311.65	314.10	326.33
22	MAR	0	181.15	186.44	241.60	267.09	311.63	314.10	326.30
22	MAR	6	180.98	186.32	241.60	267.09	311.62	314.10	326.27
22	MAR	12	180.81	186.21	241.60	267.09	311.61	314.10	326.24
22	MAR	18	180.63	186.12	241.60	267.09	311.60	314.10	326.20
23	MAR	0	180.46	186.04	241.60	267.09	311.59	314.10	326.16
23	MAR	6	180.29	185.96	241.60	267.08	311.58	314.10	326.12
23	MAR	12	180.29	185.90	241.60	267.08	311.58	314.10	326.07
23	MAR	18	180.29	185.85	241.60	267.08	311.57	314.09	326.03
AVG			181.04	187.17	241.62	266.41	311.85	314.27	325.30

Note: Victoria Control Structure and Godaleich Generating Station closed throughout simulation.

Table C-6 (a)

PMP (RAIN + SNOW) IN MM
CENTER : GRANITE EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	.00	.00	.00	.00	.00	.00	.00
15	MAR	6	26.30	26.30	27.10	30.20	30.90	29.70	30.50
15	MAR	12	26.30	26.30	27.10	30.20	30.90	29.70	30.50
15	MAR	18	26.30	26.30	27.10	30.20	30.90	29.70	30.50
16	MAR	0	26.30	26.30	27.10	30.20	30.90	29.70	30.50
16	MAR	6	40.70	40.70	41.90	46.80	47.80	46.00	47.20
16	MAR	12	56.00	56.00	58.30	67.50	69.30	66.00	68.20
16	MAR	18	56.80	56.80	59.10	68.50	70.40	66.90	69.20
17	MAR	0	55.60	55.60	57.90	66.90	68.80	65.50	67.60
17	MAR	6	46.90	46.90	49.10	57.90	59.70	56.50	58.60
17	MAR	12	51.00	51.00	53.50	63.50	65.50	61.90	64.30
17	MAR	18	51.00	51.00	53.50	63.50	65.50	61.90	64.30
18	MAR	0	51.40	51.40	53.90	64.00	66.00	62.30	64.80
18	MAR	6	37.40	37.40	39.90	50.00	52.00	48.30	50.80
18	MAR	12	37.40	37.40	39.90	50.00	52.00	48.30	50.80
18	MAR	18	.20	.20	.20	.20	.20	.20	.20
19	MAR	0	.20	.20	.20	.20	.20	.20	.20
19	MAR	6	.50	.50	.50	.50	.50	.50	.50
19	MAR	12	.50	.50	.50	.50	.50	.50	.50
19	MAR	18	.50	.50	.50	.50	.50	.50	.50
20	MAR	0	.50	.50	.50	.50	.50	.50	.50
20	MAR	6	.50	.50	.50	.50	.50	.50	.50
20	MAR	12	.50	.50	.50	.50	.50	.50	.50
20	MAR	18	.50	.50	.50	.50	.50	.50	.50
21	MAR	0	.50	.50	.50	.50	.50	.50	.50
21	MAR	6	.50	.50	.50	.50	.50	.50	.50
21	MAR	12	.50	.50	.50	.50	.50	.50	.50
21	MAR	18	.50	.50	.50	.50	.50	.50	.50
22	MAR	0	.50	.50	.50	.50	.50	.50	.50
22	MAR	6	.50	.50	.50	.50	.50	.50	.50
22	MAR	12	.50	.50	.50	.50	.50	.50	.50
22	MAR	18	.50	.50	.50	.50	.50	.50	.50
23	MAR	0	.50	.50	.50	.50	.50	.50	.50
23	MAR	6	.50	.50	.50	.50	.50	.50	.50
23	MAR	12	.50	.50	.50	.50	.50	.50	.50
23	MAR	18	.50	.50	.50	.50	.50	.50	.50
TOTAL			599.30	599.30	625.30	729.30	750.50	712.30	737.70

Table C-6 (b)

PMP INFLOW HYDROGRAPHS (m3/s)
CENTER : GRANITE   EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	0.	0.	0.	0.	0.	0.	0.
15	MAR	6	12.	66.	36.	98.	52.	20.	28.
15	MAR	12	62.	222.	124.	319.	170.	94.	130.
15	MAR	18	158.	382.	223.	530.	282.	207.	293.
16	MAR	0	275.	504.	309.	682.	362.	316.	455.
16	MAR	6	392.	663.	419.	885.	469.	422.	616.
16	MAR	12	533.	926.	593.	1247.	661.	577.	845.
16	MAR	18	720.	1204.	788.	1636.	869.	787.	1156.
17	MAR	0	929.	1414.	957.	1911.	1016.	992.	1472.
17	MAR	6	1107.	1525.	1079.	2045.	1089.	1145.	1718.
17	MAR	12	1229.	1584.	1173.	2119.	1130.	1243.	1888.
17	MAR	18	1310.	1649.	1264.	2204.	1176.	1319.	2023.
18	MAR	0	1373.	1699.	1345.	2268.	1211.	1387.	2144.
18	MAR	6	1416.	1673.	1381.	2235.	1195.	1425.	2224.
18	MAR	12	1417.	1584.	1377.	2128.	1141.	1416.	2235.
18	MAR	18	1351.	1358.	1285.	1787.	959.	1330.	2133.
19	MAR	0	1202.	1027.	1115.	1276.	686.	1134.	1867.
19	MAR	6	993.	774.	966.	908.	488.	901.	1530.
19	MAR	12	785.	583.	837.	645.	347.	708.	1238.
19	MAR	18	616.	439.	725.	458.	246.	557.	1002.
20	MAR	0	483.	331.	628.	325.	175.	438.	810.
20	MAR	6	379.	249.	544.	230.	124.	344.	656.
20	MAR	12	298.	186.	471.	162.	87.	271.	530.
20	MAR	18	234.	140.	408.	112.	60.	213.	429.
21	MAR	0	183.	104.	353.	77.	42.	167.	347.
21	MAR	6	143.	77.	306.	52.	28.	131.	281.
21	MAR	12	112.	56.	265.	35.	19.	102.	227.
21	MAR	18	87.	40.	229.	22.	12.	80.	184.
22	MAR	0	68.	28.	199.	13.	7.	62.	148.
22	MAR	6	52.	20.	172.	7.	4.	48.	119.
22	MAR	12	39.	13.	149.	3.	2.	36.	95.
22	MAR	18	29.	8.	129.	0.	0.	27.	76.
23	MAR	0	21.	4.	112.	0.	0.	19.	60.
23	MAR	6	15.	2.	97.	0.	0.	14.	46.
23	MAR	12	10.	0.	84.	0.	0.	10.	35.
23	MAR	18	6.	0.	73.	0.	0.	6.	26.
TOTAL Mm3			390.	444.	437.	571.	305.	388.	628.

Table C-6 (c)

ROUTED OUTFLOW HYDROGRAPHS (m3/s)
CENTER : GRANITE EVENT : WINTER

DayMthHr	Bay dEspr Plant	Salmon Splwy	Salmon River @ RdPd	North Salmon Splwy	Ebbe Cntrl Gate	Gran- ite Canal	Gran- ite Splwy	Burnt SH Canal	White Bear Splwy	Vic- toria Ctrl.	Vic- toria Splwy
15 MAR 0	174.	0.	121.	1307.	0.	147.	0.	142.	0.	0.	0.
15 MAR 6	174.	0.	185.	794.	186.	147.	0.	133.	0.	28.	0.
15 MAR 12	174.	186.	328.	310.	186.	148.	0.	134.	0.	130.	0.
15 MAR 18	174.	413.	429.	409.	186.	151.	0.	146.	0.	165.	68.
16 MAR 0	174.	621.	520.	495.	186.	155.	0.	155.	211.	165.	68.
16 MAR 6	174.	863.	645.	606.	187.	161.	5.	148.	433.	166.	69.
16 MAR 12	174.	1164.	805.	781.	188.	168.	116.	134.	596.	166.	72.
16 MAR 18	174.	1558.	1012.	977.	189.	175.	278.	119.	820.	168.	75.
17 MAR 0	174.	1761.	1321.	1148.	191.	181.	494.	102.	901.	0.	80.
17 MAR 6	174.	1772.	1681.	1244.	165.	185.	688.	91.	900.	0.	88.
17 MAR 12	174.	1804.	2041.	1244.	71.	187.	818.	90.	918.	0.	97.
17 MAR 18	174.	1853.	2330.	1244.	0.	189.	913.	93.	946.	0.	107.
18 MAR 0	174.	1914.	2538.	1244.	0.	190.	988.	99.	979.	0.	118.
18 MAR 6	174.	1983.	2676.	1248.	0.	191.	1038.	106.	1016.	0.	129.
18 MAR 12	174.	2059.	2744.	1252.	0.	192.	1062.	139.	1052.	0.	140.
18 MAR 18	174.	2133.	2733.	1256.	0.	191.	1033.	138.	1076.	0.	150.
19 MAR 0	174.	2197.	2628.	1257.	0.	189.	926.	145.	1088.	0.	160.
19 MAR 6	174.	2250.	2459.	1232.	0.	187.	773.	152.	1078.	0.	169.
19 MAR 12	174.	2291.	2268.	837.	0.	184.	611.	125.	1042.	0.	175.
19 MAR 18	174.	2314.	2007.	725.	0.	181.	449.	113.	987.	0.	181.
20 MAR 0	174.	2319.	1723.	628.	0.	177.	335.	106.	694.	193.	186.
20 MAR 6	174.	2308.	1491.	544.	0.	174.	261.	108.	484.	194.	189.
20 MAR 12	174.	2284.	1294.	471.	0.	172.	203.	112.	377.	194.	190.
20 MAR 18	174.	2250.	1128.	408.	0.	170.	155.	117.	295.	194.	191.
TOTAL Mm3	90.	827.	802.	468.	37.	91.	241.	64.	343.	38.	58.

Table C-6 (d)

RESERVOIR TRAJECTORIES (m)
CENTER : GRANITE EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	180.28	184.97	241.71	266.34	311.20	313.84	323.40
15	MAR	6	180.29	185.54	241.60	266.35	311.21	313.77	323.40
15	MAR	12	180.29	185.87	241.60	266.37	311.27	313.84	323.40
15	MAR	18	180.29	186.00	241.60	266.40	311.36	314.00	323.41
16	MAR	0	180.29	186.19	241.60	266.45	311.49	314.09	323.44
16	MAR	6	180.29	186.43	241.60	266.51	311.65	314.09	323.50
16	MAR	12	180.29	186.75	241.60	266.60	311.83	314.10	323.59
16	MAR	18	180.29	187.17	241.60	266.70	312.02	314.11	323.73
17	MAR	0	180.33	187.63	241.60	266.83	312.17	314.10	323.93
17	MAR	6	180.42	188.06	241.60	266.97	312.26	314.21	324.16
17	MAR	12	180.57	188.40	241.60	267.12	312.33	314.37	324.41
17	MAR	18	180.76	188.64	241.60	267.28	312.38	314.57	324.67
18	MAR	0	180.97	188.81	241.62	267.45	312.42	314.79	324.95
18	MAR	6	181.20	188.92	241.65	267.61	312.44	315.00	325.25
18	MAR	12	181.42	188.95	241.67	267.77	312.44	315.15	325.52
18	MAR	18	181.60	188.90	241.68	267.90	312.41	315.23	325.78
19	MAR	0	181.76	188.75	241.65	268.00	312.32	315.16	326.00
19	MAR	6	181.87	188.57	241.60	268.08	312.23	314.94	326.17
19	MAR	12	181.93	188.37	241.60	268.13	312.13	314.62	326.31
19	MAR	18	181.94	188.06	241.60	268.17	312.03	314.24	326.41
20	MAR	0	181.91	187.77	241.60	268.20	311.95	314.12	326.47
20	MAR	6	181.85	187.51	241.60	268.23	311.88	314.08	326.51
20	MAR	12	181.76	187.27	241.60	268.25	311.82	314.06	326.52
20	MAR	18	181.64	187.04	241.60	268.27	311.77	314.06	326.53
AVG			181.01	187.52	241.62	267.33	311.96	314.36	324.89

Note: Victoria Control Structure OPEN and Godaleich Generating Station CLOSED throughout simulation.

Table C-7 (a)

PMP (RAIN + SNOW) IN MM
CENTER : BURNT POND   EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	.00	.00	.00	.00	.00	.00	.00
15	MAR	6	24.90	24.10	24.90	27.10	29.40	30.90	30.20
15	MAR	12	24.90	24.10	24.90	27.10	29.40	30.90	30.20
15	MAR	18	24.90	24.10	24.90	27.10	29.40	30.90	30.20
16	MAR	0	24.90	24.10	24.90	27.10	29.40	30.90	30.20
16	MAR	6	38.50	37.20	38.50	41.90	45.50	47.80	46.80
16	MAR	12	51.90	49.60	51.90	58.30	65.00	69.30	67.50
16	MAR	18	52.50	50.20	52.50	59.10	65.90	70.40	68.50
17	MAR	0	51.50	49.30	51.50	57.90	64.50	68.80	66.90
17	MAR	6	42.90	40.70	42.90	49.10	55.60	59.70	57.90
17	MAR	12	46.50	44.00	46.50	53.50	60.80	65.50	63.50
17	MAR	18	46.50	44.00	46.50	53.50	60.80	65.50	63.50
18	MAR	0	46.80	44.30	46.80	53.90	61.30	66.00	64.00
18	MAR	6	32.80	30.30	32.80	39.90	47.30	52.00	50.00
18	MAR	12	32.80	30.30	32.80	39.90	47.30	52.00	50.00
18	MAR	18	.20	.20	.20	.20	.20	.20	.20
19	MAR	0	.20	.20	.20	.20	.20	.20	.20
19	MAR	6	.50	.50	.50	.50	.50	.50	.50
19	MAR	12	.50	.50	.50	.50	.50	.50	.50
19	MAR	18	.50	.50	.50	.50	.50	.50	.50
20	MAR	0	.50	.50	.50	.50	.50	.50	.50
20	MAR	6	.50	.50	.50	.50	.50	.50	.50
20	MAR	12	.50	.50	.50	.50	.50	.50	.50
20	MAR	18	.50	.50	.50	.50	.50	.50	.50
21	MAR	0	.50	.50	.50	.50	.50	.50	.50
21	MAR	6	.50	.50	.50	.50	.50	.50	.50
21	MAR	12	.50	.50	.50	.50	.50	.50	.50
21	MAR	18	.50	.50	.50	.50	.50	.50	.50
22	MAR	0	.50	.50	.50	.50	.50	.50	.50
22	MAR	6	.50	.50	.50	.50	.50	.50	.50
22	MAR	12	.50	.50	.50	.50	.50	.50	.50
22	MAR	18	.50	.50	.50	.50	.50	.50	.50
23	MAR	0	.50	.50	.50	.50	.50	.50	.50
23	MAR	6	.50	.50	.50	.50	.50	.50	.50
23	MAR	12	.50	.50	.50	.50	.50	.50	.50
23	MAR	18	.50	.50	.50	.50	.50	.50	.50
TOTAL			552.20	526.20	552.20	625.30	701.50	750.50	729.30

Table C-7 (b)

PMP INFLOW HYDROGRAPHS (m3/s)
CENTER : BURNT POND EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL- PAEG	GRAN- ITE	BURNT POND	VIC- TORIA
15	MAR	0	0.	0.	0.	0.	0.	0.	0.
15	MAR	6	11.	57.	31.	83.	49.	22.	27.
15	MAR	12	57.	197.	110.	276.	159.	99.	128.
15	MAR	18	147.	342.	200.	464.	265.	218.	289.
16	MAR	0	257.	453.	278.	599.	341.	331.	449.
16	MAR	6	367.	597.	379.	779.	443.	443.	609.
16	MAR	12	499.	828.	533.	1089.	622.	605.	835.
16	MAR	18	672.	1067.	703.	1412.	814.	826.	1143.
17	MAR	0	862.	1247.	851.	1642.	950.	1044.	1456.
17	MAR	6	1023.	1337.	954.	1747.	1015.	1206.	1699.
17	MAR	12	1132.	1379.	1031.	1795.	1050.	1312.	1866.
17	MAR	18	1202.	1425.	1106.	1855.	1091.	1394.	1999.
18	MAR	0	1255.	1462.	1172.	1900.	1121.	1468.	2118.
18	MAR	6	1289.	1425.	1195.	1853.	1102.	1512.	2195.
18	MAR	12	1283.	1329.	1181.	1737.	1046.	1507.	2206.
18	MAR	18	1216.	1131.	1096.	1448.	877.	1419.	2103.
19	MAR	0	1077.	855.	952.	1034.	627.	1212.	1841.
19	MAR	6	888.	644.	824.	736.	446.	963.	1508.
19	MAR	12	701.	485.	714.	523.	317.	757.	1220.
19	MAR	18	550.	365.	618.	371.	225.	595.	987.
20	MAR	0	432.	275.	535.	263.	160.	468.	799.
20	MAR	6	339.	207.	464.	186.	113.	368.	646.
20	MAR	12	266.	155.	402.	131.	79.	289.	523.
20	MAR	18	209.	116.	348.	91.	55.	227.	423.
21	MAR	0	164.	87.	301.	62.	38.	179.	342.
21	MAR	6	128.	64.	261.	42.	26.	140.	277.
21	MAR	12	100.	46.	226.	28.	17.	110.	224.
21	MAR	18	78.	33.	196.	18.	11.	85.	181.
22	MAR	0	60.	23.	170.	10.	6.	66.	146.
22	MAR	6	46.	16.	147.	5.	3.	51.	117.
22	MAR	12	35.	10.	127.	2.	1.	39.	94.
22	MAR	18	25.	6.	110.	0.	0.	29.	75.
23	MAR	0	18.	3.	95.	0.	0.	21.	59.
23	MAR	6	13.	1.	83.	0.	0.	15.	46.
23	MAR	12	9.	0.	72.	0.	0.	10.	34.
23	MAR	18	5.	0.	62.	0.	0.	6.	26.
TOTAL Mm3			355.	382.	379.	479.	282.	411.	620.

Table C-7 (c)

ROUTED OUTFLOW HYDROGRAPHS (m3/s)
CENTER : BURNT POND EVENT : WINTER

DayMthHr	Bay dEspr Plant	Salmon Splwy	Salmon River @ RdPd	North Salmon Splwy	Ebbe Cntrl Gate	Granite Canal	Granite Splwy	Burnt SH Canal	White Bear Splwy	Victoria Ctrl.	Victoria Splwy
15 MAR 0	174.	0.	121.	1307.	0.	147.	0.	142.	0.	0.	0.
15 MAR 6	174.	0.	184.	789.	186.	147.	0.	133.	0.	0.	27.
15 MAR 12	174.	175.	324.	296.	186.	148.	0.	127.	0.	0.	68.
15 MAR 18	174.	388.	415.	386.	186.	151.	0.	130.	0.	0.	68.
16 MAR 0	174.	576.	493.	464.	186.	154.	0.	138.	0.	0.	69.
16 MAR 6	174.	797.	604.	566.	187.	160.	0.	143.	85.	0.	72.
16 MAR 12	174.	1077.	752.	721.	188.	166.	82.	138.	462.	0.	75.
16 MAR 18	174.	1428.	930.	892.	189.	173.	239.	122.	688.	0.	79.
17 MAR 0	174.	1761.	1183.	1041.	190.	180.	430.	107.	889.	0.	85.
17 MAR 6	174.	1765.	1485.	1146.	192.	184.	627.	99.	894.	0.	93.
17 MAR 12	174.	1786.	1783.	1225.	194.	186.	754.	100.	919.	0.	102.
17 MAR 18	174.	1822.	2062.	1244.	138.	188.	847.	106.	953.	0.	111.
18 MAR 0	174.	1870.	2279.	1172.	0.	189.	919.	115.	993.	0.	122.
18 MAR 6	174.	1927.	2409.	1195.	0.	190.	973.	149.	1035.	0.	132.
18 MAR 12	174.	1987.	2461.	1181.	0.	191.	995.	146.	1070.	0.	143.
18 MAR 18	174.	2049.	2443.	1096.	0.	190.	961.	146.	1101.	0.	154.
19 MAR 0	174.	2106.	2329.	952.	0.	188.	859.	153.	1117.	0.	163.
19 MAR 6	174.	2147.	2129.	824.	0.	186.	718.	169.	1113.	0.	172.
19 MAR 12	174.	2172.	1887.	714.	0.	183.	577.	177.	1079.	0.	178.
19 MAR 18	174.	2180.	1664.	618.	0.	180.	435.	136.	1026.	0.	185.
TOTAL Mm3	75.	605.	603.	385.	44.	75.	203.	58.	290.	0.	45.

Table C-7 (d)

RESERVOIR TRAJECTORIES (m)
CENTER : BURNT POND EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	180.28	184.97	241.71	266.34	311.20	313.84	323.40
15	MAR	6	180.29	185.53	241.60	266.34	311.21	313.76	323.40
15	MAR	12	180.29	185.85	241.60	266.36	311.26	313.74	323.41
15	MAR	18	180.29	185.96	241.60	266.39	311.35	313.80	323.44
16	MAR	0	180.29	186.13	241.60	266.43	311.46	313.94	323.50
16	MAR	6	180.29	186.35	241.60	266.49	311.61	314.09	323.58
16	MAR	12	180.29	186.64	241.60	266.56	311.79	314.10	323.70
16	MAR	18	180.29	187.01	241.60	266.66	311.98	314.11	323.85
17	MAR	0	180.30	187.42	241.60	266.77	312.13	314.14	324.05
17	MAR	6	180.37	187.80	241.60	266.88	312.23	314.29	324.27
17	MAR	12	180.48	188.12	241.60	267.01	312.29	314.50	324.51
17	MAR	18	180.63	188.38	241.60	267.13	312.34	314.73	324.78
18	MAR	0	180.80	188.56	241.60	267.28	312.37	314.98	325.05
18	MAR	6	180.99	188.64	241.60	267.41	312.40	315.20	325.34
18	MAR	12	181.17	188.67	241.60	267.54	312.40	315.40	325.61
18	MAR	18	181.34	188.61	241.60	267.65	312.36	315.51	325.86
19	MAR	0	181.46	188.45	241.60	267.74	312.29	315.48	326.07
19	MAR	6	181.53	188.22	241.60	267.80	312.20	315.26	326.24
19	MAR	12	181.56	187.97	241.60	267.85	312.12	314.92	326.38
19	MAR	18	181.54	187.72	241.60	267.88	312.03	314.53	326.48
AVG			180.72	187.35	241.61	267.03	311.95	314.52	324.65

Note: Victoria Control Structure and Godaleich Generating Station closed throughout simulation.

Table C-8 (c)

ROUTED OUTFLOW HYDROGRAPHS (m3/s)
CENTER : BURNT POND EVENT : WINTER

DayMthHr	Bay dEspr Plant	Salmon Splwy	Salmon River @ RdPd	North Salmon Splwy	Ebbe Cntrl Gate	Gran-ite Canal	Gran-ite Splwy	Burnt SH Canal	White Bear Splwy	Vic-toria Ctrl.	Vic-toria Splwy
15 MAR 0	174.	0.	121.	1307.	0.	147.	0.	142.	0.	0.	0.
15 MAR 6	174.	0.	184.	789.	186.	147.	0.	134.	0.	27.	0.
15 MAR 12	174.	175.	324.	296.	186.	148.	0.	134.	0.	128.	0.
15 MAR 18	174.	388.	415.	386.	186.	151.	0.	146.	0.	165.	68.
16 MAR 0	174.	576.	493.	464.	186.	155.	0.	156.	240.	165.	68.
16 MAR 6	174.	797.	604.	566.	187.	160.	1.	149.	453.	166.	69.
16 MAR 12	174.	1077.	752.	721.	188.	167.	93.	136.	622.	166.	71.
16 MAR 18	174.	1428.	930.	892.	189.	174.	247.	121.	857.	168.	75.
17 MAR 0	174.	1761.	1183.	1041.	190.	180.	439.	106.	901.	0.	80.
17 MAR 6	174.	1765.	1485.	1146.	192.	184.	632.	98.	905.	0.	88.
17 MAR 12	174.	1786.	1783.	1225.	194.	186.	756.	99.	929.	0.	97.
17 MAR 18	174.	1822.	2062.	1244.	138.	188.	848.	104.	963.	0.	106.
18 MAR 0	174.	1870.	2279.	1172.	0.	189.	919.	113.	1002.	0.	117.
18 MAR 6	174.	1927.	2409.	1195.	0.	190.	971.	144.	1044.	0.	128.
18 MAR 12	174.	1987.	2461.	1181.	0.	190.	993.	147.	1079.	0.	139.
18 MAR 18	174.	2049.	2443.	1096.	0.	190.	961.	146.	1109.	0.	150.
19 MAR 0	174.	2106.	2329.	952.	0.	188.	858.	153.	1127.	0.	159.
19 MAR 6	174.	2147.	2129.	824.	0.	186.	718.	169.	1120.	0.	167.
19 MAR 12	174.	2172.	1887.	714.	0.	183.	574.	168.	1085.	0.	174.
19 MAR 18	174.	2180.	1664.	618.	0.	180.	431.	132.	1030.	0.	180.
TOTAL Mm3	75.	605.	603.	385.	44.	75.	204.	58.	312.	21.	42.

Table C-8 (d)

RESERVOIR TRAJECTORIES (m)
CENTER : BURNT POND EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	180.28	184.97	241.71	266.34	311.20	313.84	323.40
15	MAR	6	180.29	185.53	241.60	266.34	311.21	313.78	323.40
15	MAR	12	180.29	185.85	241.60	266.36	311.26	313.84	323.40
15	MAR	18	180.29	185.96	241.60	266.39	311.35	314.01	323.41
16	MAR	0	180.29	186.13	241.60	266.43	311.47	314.08	323.44
16	MAR	6	180.29	186.35	241.60	266.49	311.63	314.09	323.50
16	MAR	12	180.29	186.64	241.60	266.56	311.80	314.10	323.59
16	MAR	18	180.29	187.01	241.60	266.66	311.98	314.11	323.72
17	MAR	0	180.30	187.42	241.60	266.77	312.14	314.13	323.92
17	MAR	6	180.37	187.80	241.60	266.88	312.23	314.28	324.15
17	MAR	12	180.48	188.12	241.60	267.01	312.29	314.47	324.39
17	MAR	18	180.63	188.38	241.60	267.13	312.34	314.70	324.66
18	MAR	0	180.80	188.56	241.60	267.28	312.37	314.95	324.93
18	MAR	6	180.99	188.64	241.60	267.41	312.40	315.17	325.22
18	MAR	12	181.17	188.67	241.60	267.54	312.40	315.36	325.50
18	MAR	18	181.34	188.61	241.60	267.65	312.36	315.47	325.75
19	MAR	0	181.46	188.45	241.60	267.74	312.29	315.42	325.96
19	MAR	6	181.53	188.22	241.60	267.80	312.20	315.20	326.14
19	MAR	12	181.56	187.97	241.60	267.85	312.11	314.87	326.27
19	MAR	18	181.54	187.72	241.60	267.88	312.02	314.47	326.38
AVG			180.72	187.35	241.61	267.03	311.95	314.52	324.56

Note: Victoria Control Structure OPEN and Godaleich Generating Station CLOSED throughout simulation.

Table C-9 (a)

PMP (RAIN + SNOW) IN MM
CENTER : VICTORIA EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	.00	.00	.00	.00	.00	.00	.00
15	MAR	6	24.10	24.90	25.40	28.50	29.40	28.50	30.90
15	MAR	12	24.10	24.90	25.40	28.50	29.40	28.50	30.90
15	MAR	18	24.10	24.90	25.40	28.50	29.40	28.50	30.90
16	MAR	0	24.10	24.90	25.40	28.50	29.40	28.50	30.90
16	MAR	6	37.20	38.50	39.30	44.10	45.50	44.10	47.80
16	MAR	12	49.60	51.90	53.40	62.40	65.00	62.40	69.30
16	MAR	18	50.20	52.50	54.10	63.30	65.90	63.30	70.40
17	MAR	0	49.30	51.50	53.00	62.00	64.50	62.00	68.80
17	MAR	6	40.70	42.90	44.30	53.10	55.60	53.10	59.70
17	MAR	12	44.00	46.50	48.10	58.00	60.80	58.00	65.50
17	MAR	18	44.00	46.50	48.10	58.00	60.80	58.00	65.50
18	MAR	0	44.30	46.80	48.50	58.50	61.30	58.50	66.00
18	MAR	6	30.30	32.80	34.50	44.50	47.30	44.50	52.00
18	MAR	12	30.30	32.80	34.50	44.50	47.30	44.50	52.00
18	MAR	18	.20	.20	.20	.20	.20	.20	.20
19	MAR	0	.20	.20	.20	.20	.20	.20	.20
19	MAR	6	.50	.50	.50	.50	.50	.50	.50
19	MAR	12	.50	.50	.50	.50	.50	.50	.50
19	MAR	18	.50	.50	.50	.50	.50	.50	.50
20	MAR	0	.50	.50	.50	.50	.50	.50	.50
20	MAR	6	.50	.50	.50	.50	.50	.50	.50
20	MAR	12	.50	.50	.50	.50	.50	.50	.50
20	MAR	18	.50	.50	.50	.50	.50	.50	.50
21	MAR	0	.50	.50	.50	.50	.50	.50	.50
21	MAR	6	.50	.50	.50	.50	.50	.50	.50
21	MAR	12	.50	.50	.50	.50	.50	.50	.50
21	MAR	18	.50	.50	.50	.50	.50	.50	.50
22	MAR	0	.50	.50	.50	.50	.50	.50	.50
22	MAR	6	.50	.50	.50	.50	.50	.50	.50
22	MAR	12	.50	.50	.50	.50	.50	.50	.50
22	MAR	18	.50	.50	.50	.50	.50	.50	.50
23	MAR	0	.50	.50	.50	.50	.50	.50	.50
23	MAR	6	.50	.50	.50	.50	.50	.50	.50
23	MAR	12	.50	.50	.50	.50	.50	.50	.50
23	MAR	18	.50	.50	.50	.50	.50	.50	.50
TOTAL			526.20	552.20	569.30	672.30	701.50	672.30	750.50

Table C-9 (b)

PMP INFLOW HYDROGRAPHS (m3/s)
CENTER : VICTORIA EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	0.	0.	0.	0.	0.	0.	0.
15	MAR	6	10.	60.	32.	90.	49.	19.	28.
15	MAR	12	55.	206.	113.	295.	159.	89.	132.
15	MAR	18	141.	357.	205.	494.	265.	196.	297.
16	MAR	0	246.	471.	285.	636.	341.	300.	462.
16	MAR	6	353.	621.	388.	827.	443.	402.	626.
16	MAR	12	479.	864.	547.	1160.	622.	549.	858.
16	MAR	18	644.	1116.	723.	1512.	814.	746.	1174.
17	MAR	0	825.	1306.	876.	1763.	950.	938.	1497.
17	MAR	6	977.	1404.	983.	1881.	1015.	1081.	1749.
17	MAR	12	1079.	1452.	1064.	1941.	1050.	1171.	1923.
17	MAR	18	1143.	1504.	1143.	2012.	1091.	1239.	2061.
18	MAR	0	1190.	1546.	1212.	2066.	1121.	1300.	2185.
18	MAR	6	1219.	1512.	1239.	2025.	1102.	1334.	2267.
18	MAR	12	1210.	1419.	1227.	1914.	1046.	1321.	2281.
18	MAR	18	1142.	1211.	1141.	1601.	877.	1236.	2178.
19	MAR	0	1008.	916.	990.	1144.	627.	1053.	1907.
19	MAR	6	830.	690.	857.	814.	446.	836.	1563.
19	MAR	12	656.	520.	743.	578.	317.	657.	1265.
19	MAR	18	515.	391.	643.	410.	225.	517.	1023.
20	MAR	0	404.	295.	557.	291.	160.	406.	828.
20	MAR	6	317.	222.	482.	206.	113.	319.	670.
20	MAR	12	249.	166.	418.	145.	79.	251.	542.
20	MAR	18	195.	124.	362.	100.	55.	197.	438.
21	MAR	0	153.	93.	313.	69.	38.	155.	355.
21	MAR	6	120.	69.	271.	46.	26.	122.	287.
21	MAR	12	93.	50.	235.	31.	17.	95.	232.
21	MAR	18	73.	36.	204.	20.	11.	74.	188.
22	MAR	0	56.	25.	176.	12.	6.	58.	151.
22	MAR	6	43.	17.	153.	6.	3.	44.	121.
22	MAR	12	32.	11.	132.	2.	1.	33.	97.
22	MAR	18	24.	7.	115.	0.	0.	25.	78.
23	MAR	0	17.	3.	99.	0.	0.	18.	61.
23	MAR	6	12.	1.	86.	0.	0.	13.	47.
23	MAR	12	8.	0.	74.	0.	0.	9.	36.
23	MAR	18	5.	0.	64.	0.	0.	6.	27.
TOTAL Mm3			335.	404.	392.	520.	282.	363.	640.

Table C-9 (c)

ROUTED OUTFLOW HYDROGRAPHS (m3/s)
CENTER : VICTORIA EVENT : WINTER

DayMthHr	Bay dEspr Plant	Salmon Splwy	Salmon River @ RdPd	North Salmon Splwy	Ebbe Cntrl Gate	Granite Canal	Granite Splwy	Burnt SH Canal	White Bear Splwy	Victoria Ctrl.	Victoria Splwy
15 MAR 0	174.	0.	121.	1307.	0.	147.	0.	142.	0.	0.	0.
15 MAR 6	174.	0.	184.	790.	186.	147.	0.	132.	0.	0.	28.
15 MAR 12	174.	174.	325.	299.	186.	148.	0.	127.	0.	0.	68.
15 MAR 18	174.	387.	420.	391.	186.	151.	0.	128.	0.	0.	68.
16 MAR 0	174.	574.	501.	471.	186.	154.	0.	134.	0.	0.	69.
16 MAR 6	174.	796.	617.	575.	187.	160.	0.	141.	0.	0.	72.
16 MAR 12	174.	1074.	769.	735.	188.	166.	80.	138.	392.	0.	75.
16 MAR 18	174.	1425.	955.	912.	189.	173.	237.	123.	608.	0.	80.
17 MAR 0	174.	1761.	1226.	1067.	191.	180.	428.	105.	889.	0.	86.
17 MAR 6	174.	1765.	1547.	1176.	193.	184.	624.	92.	882.	0.	94.
17 MAR 12	174.	1787.	1864.	1244.	180.	186.	749.	90.	895.	0.	103.
17 MAR 18	174.	1824.	2154.	1244.	101.	188.	839.	92.	916.	0.	113.
18 MAR 0	174.	1873.	2371.	1212.	0.	189.	907.	96.	943.	0.	123.
18 MAR 6	174.	1931.	2506.	1239.	0.	190.	952.	102.	974.	0.	134.
18 MAR 12	174.	1992.	2570.	1227.	0.	190.	966.	109.	1005.	0.	146.
18 MAR 18	174.	2055.	2560.	1141.	0.	189.	932.	119.	1029.	0.	156.
19 MAR 0	174.	2113.	2445.	990.	0.	188.	830.	122.	1038.	0.	166.
19 MAR 6	174.	2155.	2237.	857.	0.	185.	685.	122.	1027.	0.	175.
19 MAR 12	174.	2182.	1984.	743.	0.	182.	532.	116.	990.	0.	183.
19 MAR 18	174.	2192.	1737.	643.	0.	179.	396.	106.	809.	0.	189.
20 MAR 0	174.	2188.	1522.	557.	0.	176.	301.	103.	387.	0.	194.
20 MAR 6	174.	2172.	1328.	482.	0.	173.	238.	106.	256.	0.	197.
20 MAR 12	174.	2147.	1163.	418.	0.	171.	184.	110.	157.	0.	200.
20 MAR 18	174.	2115.	1017.	362.	0.	169.	139.	115.	81.	0.	202.
21 MAR 0	174.	2072.	906.	313.	0.	167.	101.	119.	24.	0.	203.
21 MAR 6	174.	2025.	805.	271.	0.	166.	71.	123.	0.	0.	204.
21 MAR 12	174.	1976.	704.	274.	39.	165.	48.	125.	0.	0.	205.
21 MAR 18	174.	1925.	611.	413.	209.	164.	28.	124.	0.	0.	205.
22 MAR 0	174.	1871.	555.	385.	209.	163.	13.	122.	0.	0.	205.
22 MAR 6	174.	1817.	522.	362.	209.	162.	1.	119.	0.	0.	204.
22 MAR 12	174.	414.	490.	341.	209.	162.	0.	115.	0.	0.	204.
22 MAR 18	174.	309.	459.	324.	209.	161.	0.	111.	0.	0.	203.
TOTAL Mm3	120.	1060.	846.	492.	66.	118.	222.	81.	287.	0.	98.

Table C-9 (d)

RESERVOIR TRAJECTORIES (m)
CENTER : VICTORIA EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	180.28	184.97	241.71	266.34	311.20	313.84	323.40
15	MAR	6	180.29	185.54	241.60	266.34	311.21	313.75	323.40
15	MAR	12	180.29	185.86	241.60	266.36	311.26	313.73	323.41
15	MAR	18	180.29	185.97	241.60	266.40	311.34	313.78	323.44
16	MAR	0	180.29	186.15	241.60	266.44	311.46	313.90	323.50
16	MAR	6	180.29	186.38	241.60	266.50	311.61	314.08	323.59
16	MAR	12	180.29	186.68	241.60	266.58	311.79	314.10	323.71
16	MAR	18	180.29	187.06	241.60	266.68	311.97	314.11	323.87
17	MAR	0	180.30	187.49	241.60	266.80	312.13	314.07	324.06
17	MAR	6	180.37	187.89	241.60	266.92	312.22	314.14	324.29
17	MAR	12	180.49	188.21	241.60	267.05	312.28	314.27	324.55
17	MAR	18	180.64	188.47	241.60	267.20	312.33	314.44	324.82
18	MAR	0	180.81	188.65	241.60	267.35	312.37	314.62	325.10
18	MAR	6	181.00	188.74	241.60	267.50	312.39	314.80	325.40
18	MAR	12	181.19	188.78	241.60	267.64	312.38	314.94	325.67
18	MAR	18	181.36	188.73	241.60	267.76	312.35	315.01	325.93
19	MAR	0	181.48	188.56	241.60	267.85	312.27	314.93	326.16
19	MAR	6	181.56	188.32	241.60	267.92	312.18	314.71	326.33
19	MAR	12	181.59	188.06	241.60	267.97	312.09	314.40	326.47
19	MAR	18	181.58	187.80	241.60	268.01	312.00	314.12	326.58
20	MAR	0	181.53	187.55	241.60	268.04	311.92	314.06	326.66
20	MAR	6	181.46	187.32	241.60	268.07	311.86	314.03	326.72
20	MAR	12	181.36	187.09	241.60	268.09	311.80	314.02	326.77
20	MAR	18	181.24	186.89	241.60	268.11	311.75	314.02	326.80
21	MAR	0	181.10	186.70	241.60	268.12	311.71	314.03	326.82
21	MAR	6	180.95	186.51	241.60	268.13	311.68	314.03	326.83
21	MAR	12	180.79	186.33	241.60	268.14	311.65	314.01	326.83
21	MAR	18	180.63	186.19	241.60	268.14	311.63	313.97	326.83
22	MAR	0	180.46	186.13	241.60	268.14	311.62	313.92	326.82
22	MAR	6	180.30	186.07	241.60	268.14	311.60	313.87	326.81
22	MAR	12	180.29	186.02	241.60	268.13	311.59	313.81	326.80
22	MAR	18	180.29	185.96	241.60	268.13	311.57	313.75	326.78
AVG			180.78	187.10	241.60	267.47	311.85	314.16	325.47

Note: Victoria Control Structure and Godaleich Generating Station closed throughout simulation.

Table C-10 (c)

ROUTED OUTFLOW HYDROGRAPHS (m3/s)
CENTER : VICTORIA EVENT : WINTER

DayMthHr	Bay dEspr Plant	Salmon Splwy	Salmon River @ RdPd	North Salmon Splwy	Ebbe Cntrl Gate	Gran-ite Canal	Gran-ite Splwy	Burnt SH Canal	White Bear Splwy	Vic-toria Ctrl.	Vic-toria Splwy
15 MAR 0	174.	0.	121.	1307.	0.	147.	0.	142.	0.	0.	0.
15 MAR 6	174.	0.	184.	790.	186.	147.	0.	133.	0.	28.	0.
15 MAR 12	174.	174.	325.	299.	186.	148.	0.	134.	0.	132.	0.
15 MAR 18	174.	387.	420.	391.	186.	151.	0.	145.	0.	165.	68.
16 MAR 0	174.	574.	501.	471.	186.	155.	0.	155.	181.	165.	68.
16 MAR 6	174.	796.	617.	575.	187.	160.	1.	149.	413.	166.	69.
16 MAR 12	174.	1074.	769.	735.	188.	167.	93.	136.	566.	166.	72.
16 MAR 18	174.	1425.	955.	912.	189.	174.	247.	122.	777.	168.	75.
17 MAR 0	174.	1761.	1226.	1067.	191.	180.	438.	104.	901.	0.	81.
17 MAR 6	174.	1765.	1547.	1176.	193.	184.	629.	91.	893.	0.	89.
17 MAR 12	174.	1787.	1864.	1244.	180.	186.	752.	88.	905.	0.	98.
17 MAR 18	174.	1824.	2154.	1244.	101.	188.	840.	90.	925.	0.	108.
18 MAR 0	174.	1873.	2371.	1212.	0.	189.	908.	94.	952.	0.	118.
18 MAR 6	174.	1931.	2506.	1239.	0.	190.	952.	100.	982.	0.	130.
18 MAR 12	174.	1992.	2570.	1227.	0.	190.	965.	107.	1012.	0.	141.
18 MAR 18	174.	2055.	2560.	1141.	0.	189.	929.	113.	1037.	0.	152.
19 MAR 0	174.	2113.	2445.	990.	0.	187.	826.	118.	1046.	0.	162.
19 MAR 6	174.	2155.	2237.	857.	0.	185.	682.	120.	1034.	0.	171.
19 MAR 12	174.	2182.	1984.	743.	0.	182.	528.	113.	995.	0.	178.
19 MAR 18	174.	2192.	1737.	643.	0.	179.	394.	105.	934.	193.	184.
20 MAR 0	174.	2188.	1522.	557.	0.	176.	300.	103.	580.	194.	188.
20 MAR 6	174.	2172.	1328.	482.	0.	173.	237.	106.	450.	194.	190.
20 MAR 12	174.	2147.	1163.	418.	0.	171.	183.	111.	351.	194.	192.
20 MAR 18	174.	2115.	1017.	362.	0.	169.	138.	115.	275.	194.	193.
21 MAR 0	174.	2072.	906.	313.	0.	167.	101.	120.	186.	194.	193.
21 MAR 6	174.	2025.	805.	271.	0.	166.	72.	128.	112.	194.	193.
21 MAR 12	174.	1976.	704.	274.	39.	165.	50.	132.	162.	194.	192.
21 MAR 18	174.	1925.	611.	413.	209.	164.	32.	134.	136.	194.	191.
22 MAR 0	174.	1871.	555.	385.	209.	163.	19.	136.	118.	194.	190.
22 MAR 6	174.	1817.	522.	362.	209.	163.	8.	137.	102.	194.	189.
22 MAR 12	174.	414.	490.	341.	209.	162.	1.	138.	90.	193.	187.
22 MAR 18	174.	309.	459.	324.	209.	162.	0.	139.	80.	193.	186.
TOTAL Mm3	120.	1060.	846.	492.	66.	118.	223.	83.	350.	76.	92.

Table C-10 (d)

RESERVOIR TRAJECTORIES (m)
CENTER : VICTORIA   EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	180.28	184.97	241.71	266.34	311.20	313.84	323.40
15	MAR	6	180.29	185.54	241.60	266.34	311.21	313.77	323.40
15	MAR	12	180.29	185.86	241.60	266.36	311.26	313.84	323.40
15	MAR	18	180.29	185.97	241.60	266.40	311.35	313.99	323.41
16	MAR	0	180.29	186.15	241.60	266.44	311.47	314.09	323.44
16	MAR	6	180.29	186.38	241.60	266.50	311.63	314.09	323.50
16	MAR	12	180.29	186.68	241.60	266.58	311.80	314.10	323.60
16	MAR	18	180.29	187.06	241.60	266.68	311.98	314.11	323.74
17	MAR	0	180.30	187.49	241.60	266.80	312.14	314.06	323.94
17	MAR	6	180.37	187.89	241.60	266.92	312.23	314.13	324.17
17	MAR	12	180.49	188.21	241.60	267.05	312.29	314.25	324.43
17	MAR	18	180.64	188.47	241.60	267.20	312.33	314.41	324.70
18	MAR	0	180.81	188.65	241.60	267.35	312.37	314.59	324.98
18	MAR	6	181.00	188.74	241.60	267.50	312.38	314.76	325.28
18	MAR	12	181.19	188.78	241.60	267.64	312.38	314.91	325.56
18	MAR	18	181.36	188.73	241.60	267.76	312.35	314.97	325.82
19	MAR	0	181.48	188.56	241.60	267.85	312.27	314.89	326.05
19	MAR	6	181.56	188.32	241.60	267.92	312.18	314.67	326.23
19	MAR	12	181.59	188.06	241.60	267.97	312.08	314.35	326.37
19	MAR	18	181.58	187.80	241.60	268.01	312.00	314.12	326.45
20	MAR	0	181.53	187.55	241.60	268.04	311.92	314.06	326.51
20	MAR	6	181.46	187.32	241.60	268.07	311.86	314.03	326.54
20	MAR	12	181.36	187.09	241.60	268.09	311.80	314.02	326.56
20	MAR	18	181.24	186.89	241.60	268.11	311.75	314.02	326.57
21	MAR	0	181.10	186.70	241.60	268.12	311.71	314.05	326.57
21	MAR	6	180.95	186.51	241.60	268.13	311.68	314.10	326.55
21	MAR	12	180.79	186.33	241.60	268.14	311.66	314.10	326.53
21	MAR	18	180.63	186.19	241.60	268.14	311.64	314.10	326.51
22	MAR	0	180.46	186.13	241.60	268.14	311.63	314.10	326.48
22	MAR	6	180.30	186.07	241.60	268.14	311.61	314.10	326.44
22	MAR	12	180.29	186.02	241.60	268.13	311.61	314.10	326.41
22	MAR	18	180.29	185.96	241.60	268.13	311.60	314.10	326.37
AVG			180.78	187.10	241.60	267.47	311.86	314.21	325.31

Note: Victoria Control Structure OPEN and Godaleich Generating Station CLOSED throughout simulation.

Table C-11 (c)

ROUTED OUTFLOW HYDROGRAPHS (m3/s)
CENTER : VICTORIA EVENT : WINTER

DayMthHr	Bay dEspr Plant	Salmon Splwy	Salmon River @ RdPd	North Salmon Splwy	Ebbe Cntrl Gate	Gran-ite Canal	Gran-ite Splwy	Burnt SH Canal	White Bear Splwy	Vic-toria Ctrl.	Vic-toria Splwy
15 MAR 0	174.	0.	121.	1307.	0.	147.	0.	142.	0.	0.	0.
15 MAR 6	174.	0.	184.	790.	186.	147.	0.	132.	0.	0.	28.
15 MAR 12	174.	174.	325.	299.	186.	148.	0.	127.	0.	0.	95.
15 MAR 18	174.	387.	420.	391.	186.	151.	0.	128.	0.	0.	95.
16 MAR 0	174.	574.	501.	471.	186.	154.	0.	134.	0.	0.	96.
16 MAR 6	174.	796.	617.	575.	187.	160.	0.	141.	0.	0.	98.
16 MAR 12	174.	1074.	769.	735.	188.	166.	80.	138.	392.	0.	101.
16 MAR 18	174.	1425.	955.	912.	189.	173.	237.	123.	608.	0.	105.
17 MAR 0	174.	1761.	1226.	1067.	191.	180.	428.	105.	901.	0.	111.
17 MAR 6	174.	1765.	1547.	1176.	193.	184.	623.	91.	893.	0.	119.
17 MAR 12	174.	1787.	1864.	1244.	180.	186.	748.	89.	904.	0.	128.
17 MAR 18	174.	1824.	2154.	1244.	101.	188.	838.	90.	925.	0.	137.
18 MAR 0	174.	1873.	2371.	1212.	0.	189.	906.	94.	952.	0.	147.
18 MAR 6	174.	1931.	2506.	1239.	0.	190.	951.	100.	982.	0.	157.
18 MAR 12	174.	1992.	2570.	1227.	0.	190.	965.	107.	1012.	0.	168.
18 MAR 18	174.	2055.	2560.	1141.	0.	189.	929.	113.	1037.	0.	179.
19 MAR 0	174.	2113.	2445.	990.	0.	187.	826.	118.	1046.	0.	190.
19 MAR 6	174.	2155.	2237.	857.	0.	185.	682.	120.	1034.	0.	200.
19 MAR 12	174.	2182.	1984.	743.	0.	182.	528.	113.	995.	0.	207.
19 MAR 18	174.	2192.	1737.	643.	0.	179.	394.	105.	740.	0.	212.
20 MAR 0	174.	2188.	1522.	557.	0.	176.	300.	103.	387.	0.	216.
20 MAR 6	174.	2172.	1328.	482.	0.	173.	237.	106.	256.	0.	219.
20 MAR 12	174.	2147.	1163.	418.	0.	171.	183.	110.	157.	0.	222.
20 MAR 18	174.	2115.	1017.	362.	0.	169.	138.	115.	81.	0.	223.
21 MAR 0	174.	2072.	906.	313.	0.	167.	101.	119.	24.	0.	224.
21 MAR 6	174.	2025.	805.	271.	0.	166.	71.	123.	0.	0.	225.
21 MAR 12	174.	1976.	704.	274.	39.	165.	48.	125.	0.	0.	225.
21 MAR 18	174.	1925.	611.	413.	209.	164.	28.	124.	0.	0.	225.
22 MAR 0	174.	1871.	555.	385.	209.	163.	13.	122.	0.	0.	225.
22 MAR 6	174.	1817.	522.	362.	209.	162.	1.	119.	0.	0.	225.
22 MAR 12	174.	414.	490.	341.	209.	162.	0.	115.	0.	0.	224.
22 MAR 18	174.	309.	459.	324.	209.	161.	0.	111.	0.	0.	224.
TOTAL Mm3	120.	1060.	846.	492.	66.	118.	222.	80.	288.	0.	113.

Table C-11 (d)

RESERVOIR TRAJECTORIES (m)
CENTER : VICTORIA   EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	180.28	184.97	241.71	266.34	311.20	313.84	324.10
15	MAR	6	180.29	185.54	241.60	266.34	311.21	313.75	324.10
15	MAR	12	180.29	185.86	241.60	266.36	311.26	313.73	324.11
15	MAR	18	180.29	185.97	241.60	266.40	311.34	313.78	324.13
16	MAR	0	180.29	186.15	241.60	266.44	311.46	313.90	324.18
16	MAR	6	180.29	186.38	241.60	266.50	311.61	314.08	324.26
16	MAR	12	180.29	186.68	241.60	266.58	311.79	314.10	324.36
16	MAR	18	180.29	187.06	241.60	266.68	311.97	314.11	324.51
17	MAR	0	180.30	187.49	241.60	266.80	312.13	314.06	324.70
17	MAR	6	180.37	187.89	241.60	266.92	312.22	314.13	324.93
17	MAR	12	180.49	188.21	241.60	267.05	312.28	314.25	325.18
17	MAR	18	180.64	188.47	241.60	267.20	312.33	314.41	325.44
18	MAR	0	180.81	188.65	241.60	267.35	312.37	314.59	325.70
18	MAR	6	181.00	188.74	241.60	267.50	312.38	314.76	325.97
18	MAR	12	181.19	188.78	241.60	267.64	312.38	314.90	326.24
18	MAR	18	181.36	188.73	241.60	267.76	312.35	314.96	326.50
19	MAR	0	181.48	188.56	241.60	267.85	312.27	314.89	326.72
19	MAR	6	181.56	188.32	241.60	267.92	312.18	314.67	326.90
19	MAR	12	181.59	188.06	241.60	267.97	312.08	314.35	327.03
19	MAR	18	181.58	187.80	241.60	268.01	312.00	314.12	327.14
20	MAR	0	181.53	187.55	241.60	268.04	311.92	314.06	327.22
20	MAR	6	181.46	187.32	241.60	268.07	311.86	314.03	327.27
20	MAR	12	181.36	187.09	241.60	268.09	311.80	314.02	327.31
20	MAR	18	181.24	186.89	241.60	268.11	311.75	314.02	327.34
21	MAR	0	181.10	186.70	241.60	268.12	311.71	314.03	327.36
21	MAR	6	180.95	186.51	241.60	268.13	311.68	314.03	327.36
21	MAR	12	180.79	186.33	241.60	268.14	311.65	314.01	327.36
21	MAR	18	180.63	186.19	241.60	268.14	311.63	313.97	327.36
22	MAR	0	180.46	186.13	241.60	268.14	311.62	313.92	327.35
22	MAR	6	180.30	186.07	241.60	268.14	311.60	313.87	327.34
22	MAR	12	180.29	186.02	241.60	268.13	311.59	313.81	327.32
22	MAR	18	180.29	185.96	241.60	268.13	311.57	313.75	327.31
	AVG		180.78	187.10	241.60	267.47	311.85	314.15	326.07

Note: Victoria Control Structure and Godaleich Generating Station closed throughout simulation.

Table C-12 (c)

ROUTED OUTFLOW HYDROGRAPHS (m3/s)
CENTER : VICTORIA EVENT : WINTER

DayMthHr	Bay dEspr Plant	Salmon Splwy	Salmon River @ RdPd	North Salmon Splwy	Ebbe Cntrl Gate	Gran-ite Canal	Gran-ite Splwy	Burnt SH Canal	White Bear Splwy	Vic-toria Ctrl.	Vic-toria Splwy
15 MAR 0	174.	0.	121.	1307.	0.	147.	0.	142.	0.	0.	0.
15 MAR 6	174.	0.	184.	790.	186.	147.	0.	133.	0.	28.	0.
15 MAR 12	174.	174.	325.	299.	186.	148.	0.	134.	0.	132.	0.
15 MAR 18	174.	387.	420.	391.	186.	151.	0.	145.	0.	177.	107.
16 MAR 0	174.	574.	501.	471.	186.	155.	0.	155.	204.	177.	107.
16 MAR 6	174.	796.	617.	575.	187.	160.	1.	149.	424.	177.	108.
16 MAR 12	174.	1074.	769.	735.	188.	167.	93.	136.	577.	177.	110.
16 MAR 18	174.	1425.	955.	912.	189.	174.	247.	121.	788.	178.	113.
17 MAR 0	174.	1761.	1226.	1067.	191.	180.	438.	104.	901.	0.	118.
17 MAR 6	174.	1765.	1547.	1176.	193.	184.	629.	91.	893.	0.	125.
17 MAR 12	174.	1787.	1864.	1244.	180.	186.	752.	88.	905.	0.	134.
17 MAR 18	174.	1824.	2154.	1244.	101.	188.	840.	90.	925.	0.	144.
18 MAR 0	174.	1873.	2371.	1212.	0.	189.	908.	94.	952.	0.	153.
18 MAR 6	174.	1931.	2506.	1239.	0.	190.	952.	100.	982.	0.	163.
18 MAR 12	174.	1992.	2570.	1227.	0.	190.	965.	107.	1012.	0.	173.
18 MAR 18	174.	2055.	2560.	1141.	0.	189.	929.	113.	1037.	0.	185.
19 MAR 0	174.	2113.	2445.	990.	0.	187.	826.	118.	1046.	0.	197.
19 MAR 6	174.	2155.	2237.	857.	0.	185.	682.	120.	1034.	0.	206.
19 MAR 12	174.	2182.	1984.	743.	0.	182.	528.	113.	995.	0.	213.
19 MAR 18	174.	2192.	1737.	643.	0.	179.	394.	105.	940.	199.	218.
20 MAR 0	174.	2188.	1522.	557.	0.	176.	300.	103.	586.	199.	221.
20 MAR 6	174.	2172.	1328.	482.	0.	173.	237.	106.	455.	200.	223.
20 MAR 12	174.	2147.	1163.	418.	0.	171.	183.	111.	356.	200.	224.
20 MAR 18	174.	2115.	1017.	362.	0.	169.	138.	115.	281.	200.	225.
21 MAR 0	174.	2072.	906.	313.	0.	167.	101.	122.	155.	200.	225.
21 MAR 6	174.	2025.	805.	271.	0.	166.	72.	129.	154.	200.	224.
21 MAR 12	174.	1976.	704.	274.	39.	165.	50.	132.	166.	200.	224.
21 MAR 18	174.	1925.	611.	413.	209.	164.	33.	134.	141.	200.	223.
TOTAL Mm3	105.	965.	802.	461.	48.	104.	222.	72.	344.	61.	94.

Table C-12 (d)

RESERVOIR TRAJECTORIES (m)
CENTER : VICTORIA EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	180.28	184.97	241.71	266.34	311.20	313.84	324.40
15	MAR	6	180.29	185.54	241.60	266.34	311.21	313.77	324.40
15	MAR	12	180.29	185.86	241.60	266.36	311.26	313.84	324.40
15	MAR	18	180.29	185.97	241.60	266.40	311.35	314.00	324.40
16	MAR	0	180.29	186.15	241.60	266.44	311.47	314.08	324.43
16	MAR	6	180.29	186.38	241.60	266.50	311.63	314.09	324.47
16	MAR	12	180.29	186.68	241.60	266.58	311.80	314.10	324.55
16	MAR	18	180.29	187.06	241.60	266.68	311.98	314.11	324.68
17	MAR	0	180.30	187.49	241.60	266.80	312.14	314.06	324.87
17	MAR	6	180.37	187.89	241.60	266.92	312.23	314.13	325.09
17	MAR	12	180.49	188.21	241.60	267.05	312.29	314.25	325.34
17	MAR	18	180.64	188.47	241.60	267.20	312.33	314.41	325.59
18	MAR	0	180.81	188.65	241.60	267.35	312.37	314.59	325.85
18	MAR	6	181.00	188.74	241.60	267.50	312.38	314.76	326.12
18	MAR	12	181.19	188.78	241.60	267.64	312.38	314.91	326.39
18	MAR	18	181.36	188.73	241.60	267.76	312.35	314.97	326.65
19	MAR	0	181.48	188.56	241.60	267.85	312.27	314.89	326.87
19	MAR	6	181.56	188.32	241.60	267.92	312.18	314.67	327.04
19	MAR	12	181.59	188.06	241.60	267.97	312.08	314.35	327.18
19	MAR	18	181.58	187.80	241.60	268.01	312.00	314.12	327.26
20	MAR	0	181.53	187.55	241.60	268.04	311.92	314.06	327.31
20	MAR	6	181.46	187.32	241.60	268.07	311.86	314.03	327.34
20	MAR	12	181.36	187.09	241.60	268.09	311.80	314.02	327.35
20	MAR	18	181.24	186.89	241.60	268.11	311.75	314.02	327.35
21	MAR	0	181.10	186.70	241.60	268.12	311.71	314.08	327.34
21	MAR	6	180.95	186.51	241.60	268.13	311.68	314.10	327.33
21	MAR	12	180.79	186.33	241.60	268.14	311.66	314.10	327.31
21	MAR	18	180.63	186.19	241.60	268.14	311.64	314.10	327.28
	AVG		180.85	187.25	241.60	267.37	311.89	314.23	326.02

Note: Victoria Control Structure OPEN and Godaleich Generating Station CLOSED throughout simulation.

Table C-13 (c)

ROUTED OUTFLOW HYDROGRAPHS (m3/s)
CENTER : VICTORIA   EVENT : WINTER

DayMthHr	Bay dEspr Plant	Salmon Splwy	Salmon River @ RdPd	North Salmon Splwy	Ebbe Cntrl Gate	Gran- ite Canal	Gran- ite Splwy	Burnt SH Canal	White Bear Splwy	Vic- toria Ctrl.	Vic- toria Splwy
15 MAR 0	174.	0.	121.	1307.	0.	147.	0.	142.	0.	0.	0.
15 MAR 6	174.	0.	184.	790.	186.	147.	0.	133.	0.	28.	0.
15 MAR 12	174.	174.	325.	299.	186.	148.	0.	134.	0.	132.	0.
15 MAR 18	174.	387.	420.	391.	186.	151.	0.	145.	0.	153.	77.
16 MAR 0	174.	574.	501.	471.	186.	155.	0.	155.	158.	153.	77.
16 MAR 6	174.	796.	617.	575.	187.	160.	1.	149.	401.	154.	77.
16 MAR 12	174.	1074.	769.	735.	188.	167.	93.	136.	554.	155.	77.
16 MAR 18	174.	1425.	955.	912.	189.	174.	246.	122.	765.	156.	77.
17 MAR 0	174.	1761.	1226.	1067.	191.	180.	437.	104.	901.	0.	77.
17 MAR 6	174.	1765.	1547.	1176.	193.	184.	629.	91.	893.	0.	80.
17 MAR 12	174.	1787.	1864.	1244.	180.	186.	751.	88.	905.	0.	95.
17 MAR 18	174.	1824.	2154.	1244.	101.	188.	840.	90.	925.	0.	110.
18 MAR 0	174.	1873.	2371.	1212.	0.	189.	908.	94.	952.	0.	127.
18 MAR 6	174.	1931.	2506.	1239.	0.	190.	952.	100.	982.	0.	143.
18 MAR 12	174.	1992.	2570.	1227.	0.	190.	965.	107.	1012.	0.	160.
18 MAR 18	174.	2055.	2560.	1141.	0.	189.	929.	113.	1037.	0.	178.
19 MAR 0	174.	2113.	2445.	990.	0.	187.	826.	118.	1046.	0.	193.
19 MAR 6	174.	2155.	2237.	857.	0.	185.	682.	120.	1034.	0.	204.
19 MAR 12	174.	2182.	1984.	743.	0.	182.	528.	113.	995.	0.	211.
19 MAR 18	174.	2192.	1737.	643.	0.	179.	394.	105.	928.	187.	217.
20 MAR 0	174.	2188.	1522.	557.	0.	176.	300.	103.	574.	188.	221.
20 MAR 6	174.	2172.	1328.	482.	0.	173.	237.	106.	444.	188.	223.
20 MAR 12	174.	2147.	1163.	418.	0.	171.	183.	111.	345.	189.	224.
20 MAR 18	174.	2115.	1017.	362.	0.	169.	138.	115.	270.	189.	225.
21 MAR 0	174.	2072.	906.	313.	0.	167.	101.	121.	154.	189.	225.
21 MAR 6	174.	2025.	805.	271.	0.	166.	72.	128.	133.	189.	225.
21 MAR 12	174.	1976.	704.	274.	39.	165.	50.	132.	155.	189.	224.
21 MAR 18	174.	1925.	611.	413.	209.	164.	33.	134.	130.	188.	223.
TOTAL Mm3	105.	965.	802.	461.	48.	104.	222.	71.	339.	57.	86.

Table C-13 (d)

RESERVOIR TRAJECTORIES (m)
CENTER : VICTORIA   EVENT : WINTER

DAY	MTH	HR	LONG POND	ROUND POND	UPPER SALMON	MEEL-PAEG	GRAN-ITE	BURNT POND	VIC-TORIA
15	MAR	0	180.28	184.97	241.71	266.34	311.20	313.84	322.50
15	MAR	6	180.29	185.54	241.60	266.34	311.21	313.77	322.50
15	MAR	12	180.29	185.86	241.60	266.36	311.26	313.84	322.50
15	MAR	18	180.29	185.97	241.60	266.40	311.35	313.99	322.51
16	MAR	0	180.29	186.15	241.60	266.44	311.47	314.09	322.55
16	MAR	6	180.29	186.38	241.60	266.50	311.63	314.09	322.60
16	MAR	12	180.29	186.68	241.60	266.58	311.80	314.10	322.70
16	MAR	18	180.29	187.06	241.60	266.68	311.98	314.11	322.84
17	MAR	0	180.30	187.49	241.60	266.80	312.14	314.06	323.06
17	MAR	6	180.37	187.89	241.60	266.92	312.23	314.13	323.31
17	MAR	12	180.49	188.21	241.60	267.05	312.29	314.25	323.59
17	MAR	18	180.64	188.47	241.60	267.20	312.33	314.41	323.88
18	MAR	0	180.81	188.65	241.60	267.35	312.37	314.59	324.16
18	MAR	6	181.00	188.74	241.60	267.50	312.38	314.76	324.46
18	MAR	12	181.19	188.78	241.60	267.64	312.38	314.91	324.75
18	MAR	18	181.36	188.73	241.60	267.76	312.35	314.97	325.03
19	MAR	0	181.48	188.56	241.60	267.85	312.27	314.89	325.27
19	MAR	6	181.56	188.32	241.60	267.92	312.18	314.67	325.45
19	MAR	12	181.59	188.06	241.60	267.97	312.08	314.35	325.58
19	MAR	18	181.58	187.80	241.60	268.01	312.00	314.12	325.66
20	MAR	0	181.53	187.55	241.60	268.04	311.92	314.06	325.72
20	MAR	6	181.46	187.32	241.60	268.07	311.86	314.03	325.75
20	MAR	12	181.36	187.09	241.60	268.09	311.80	314.02	325.77
20	MAR	18	181.24	186.89	241.60	268.11	311.75	314.02	325.77
21	MAR	0	181.10	186.70	241.60	268.12	311.71	314.07	325.76
21	MAR	6	180.95	186.51	241.60	268.13	311.68	314.10	325.75
21	MAR	12	180.79	186.33	241.60	268.14	311.66	314.10	325.72
21	MAR	18	180.63	186.19	241.60	268.14	311.64	314.10	325.69
AVG			180.85	187.25	241.60	267.37	311.89	314.23	324.32

Note: Victoria Control Structure and Godaleich Generating Station closed throughout simulation.

FREEBOARD STUDY

ACRES INTERNATIONAL LIMITED
44 TORBAY ROAD
ST. JOHN'S, NEWFOUNDLAND
A1A 2G4

FOR

NEWFOUNDLAND AND LABRADOR HYDRO
P.O. BOX 9100, PHILIP PLACE
ST. JOHN'S, NEWFOUNDLAND
A1A 2X8

DECEMBER 1985

BAY D'ESPOIR FREEBOARD STUDY IN PMF CONDITIONS: LONG POND, BURNT POND AND VICTORIA

TABLE OF CONTENTS

SUMMARY

This study assessed the available freeboard for the Long Pond, Burnt Pond and Victoria earth structures above maximum flood levels (MFL), and the geotechnical implications should such freeboard be insufficient to prevent wave overtopping. A potential damage rating against overtopping was assessed for all earth structures. In addition all major concrete structures were briefly analyzed for stability under MFL conditions.

MFL for each reservoir is the lowest top of core of any structure around a reservoir, as defined in the 1985 flood handling study.

The results are presented in Table S.1 below.

The design criterion used in this study was that no waves should overtop a structure when the reservoir is at maximum flood level during the probable maximum flood in a test wind of just under 40 km/h. The test wind was chosen to represent a typical wind condition and is about 1.8 times the mean annual wind speed. Two other wind speeds were examined to provide information on the sensitivity of each structure to lower and higher winds.

The test wind is a design wind only appropriate to an extremely rare event such as the probable maximum flood. This study shows that if the design wind speed is increased, for example to maximum historic, the rated potential damage to the earth embankments can be high. This result emphasizes the fact that although freeboard is adequate when reservoirs are at maximum levels during a PMF event, such high levels are not acceptable for normal operation.

Table S.1

Summary of Results of Freeboard Study Under PMF Conditions

Basin	Structure	Assumed MFL (m)	Required Freeboard Increase	Action Recommended
Long Pond	Salmon Dam	182.73	None	None
	South Cut off Dams	182.73	None	None
	North West Cut off Dam	182.73	None	None
	Power Canal Embankment	182.73	None	None
Burnt Pond	Burnt Dam	315.47	None	None
	Burnt Canal Dyke u/s of bridge	315.47	0.9 m	1) check freeboard under normal operating conditions 2) raise crest
	Burnt Canal Dyke d/s of bridge	varies	cannot be determined	Hydraulic analysis to determine water levels in PMF conditions
Victoria	Victoria Dam	327.36 (proposed)	None	None
	Victoria Dykes near control structure	327.36	0.2 m	Set MFL lower or add riprap

Freeboard requirements at other reservoir levels and for conditions other than the PMF were not considered in this study.

The stability of the concrete structures was assessed and preliminary analyses indicate that acceptable factors of safety are met for the various loading conditions. One exception is the Burnt Canal bridge deck which is considered vulnerable under ice loading in conjunction with MFL. The consequences of failure of the bridge were not examined, but are not expected to be severe for such an extreme event.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations arising from this study are listed below. The first two require immediate attention.

1. The available freeboard at Burnt Canal dyke upstream of the bridge is inadequate under the conditions examined, and probably under normal operating conditions as well. The required freeboard should be determined for both normal and PMF conditions and action taken to upgrade the dyke in this area. Soundings should be taken over the fetch (to the northeast).

2. The hydraulics of Burnt Sidehill Canal should be assessed by backwater analysis at high water levels. Freeboard should be checked when canal water levels have been determined. The assumption that the area to the east of Burnt bridge is sound, and will not wash out, should be checked. If it may wash out, the implications for the canal dyke should be assessed.

The remaining findings of the study do not require immediate action, but are brought forward because they may have implications for future work.

3. Riprap must be added to the tops of the Victoria dykes if storage up to MFL (top of core) is to be used for flood handling. At present, the MFL is set at the elevation of a lower area near the control structure, and a small closure dyke is required before a top of core MFL can be used. An alternative to adding riprap is to set the MFL slightly lower than the top of the core (0.2 m) to ensure adequate freeboard.

4. One section of the Power Canal Embankment at Long Pond has been identified as the most vulnerable of all the structures examined (except Burnt and Victoria dykes, noted above). The results of this study indicate that no damage will occur to the power canal embankment in the recommended design conditions; however, because of its importance, and because of the lack of downstream slope protection, a more detailed examination should be considered.

5. Hoist capacities of all gates should be checked under the increased head due to MFL's.

6. Burnt Canal Bridge was found to be vulnerable to ice loading under PMF conditions. The implications of failure of Burnt Canal Bridge should be assessed, and the feasibility of strengthening it should be reviewed.

This study only addresses the first condition, a probable maximum flood (PMF) event in combination with a test wind of just under 40 km/h (1.8 times average annual wind speed).

In general, there is no need to check the FSL and high wind combination, since surcharges are large under PMF conditions. It is assumed in this study that the freeboard requirements as determined in the original design studies for reservoirs at normal operating levels have not changed. If new operating levels are being considered (for example, different rule curves through the year) a freeboard check to determine maximum normal operating levels would be advisable. The actual design values chosen depend on the acceptable level of risk for the structures.

There are clearly many combinations of wind speed and reservoir level between these 2 limiting conditions. The design assumption behind choosing these 2 is that the same level of risk should be maintained throughout. For example, suppose condition 1 is a 1:10000 year flood with an average wind speed. Condition 2 could then be an average water level and an 1:10000 year wind. In between would be various combinations of wind speed and water level, all having approximately the same level of risk. Normally return periods for these intermediate conditions are not determined, although there may be particular cases where a check is desirable.

This report discusses the approach taken to assess available freeboard under PMF conditions, including the selection of design wind speeds, and the evaluation of the available freeboard at all the earth structures at Long Pond, Burnt Pond and Victoria. The geotechnical implications of wave overtopping are discussed, and the results of the stability checks of the concrete structures in the reservoirs concerned are presented.

1 - INTRODUCTION

The purpose of the freeboard study was to assess whether there is sufficient freeboard above the maximum flood levels (MFL) (defined as elevation minimum top of core) to protect the earth structures at Long Pond, Burnt Pond and Victoria. In addition, the concrete structures were briefly checked to identify any structures which might be endangered if reservoirs are at MFL.

Schematic location maps for all structures examined are shown in Appendix E.

Granite Lake was not examined because the flood analysis indicated levels will not rise to the top of the structure cores. The MFL is well below the top of the core at Meelpaeg, also, being governed by the low saddle. Upper Salmon was not examined because the MFL was not changed, although some of the flood handling alternatives may require such a change.

The need for this freeboard analysis arose because MFL's used in the Bay d'Espoir Flood Handling Analysis and Alternatives Study were considerably higher than those used in the original design of flood handling facilities. They are defined as the lowest top of core of dry structure around a reservoir. Because these MFL's do not change through the year and because all season data is used in the wind analysis, the results apply to the PMF in any season.

Freeboard requirements are usually determined for two limiting conditions,

1) Very high water levels arising from an extremely rare event combined with a relatively low wind speed
2) Normal water levels (e.g. full supply), with very high wind speeds.

2 - APPROACH

The most important consideration in determining whether freeboard is adequate for an earth structure is the number of waves expected to overtop it. A structure well-protected with riprap on the downstream slope might be able to withstand a fairly large number of waves; on the other hand, a structure with a steep, unprotected downstream slope might fail after just a few overtopping waves.

The approach taken in this study was to estimate the number of waves expected to overtop each structure in a test wind condition. If overtopping was shown to occur, the potential damage to the structure was assessed. In addition, higher winds and resulting damage were examined, in order to provide Newfoundland and Labrador Hydro with information on the vulnerability of their structures in more severe conditions.

It is important to note that the numbers are order-of-magnitude only; they cannot be exact, for several reasons. First, the results can be sensitive to water levels, within a few centimetres. Neither the flood analysis results nor the field placement of riprap are accurate within that tolerance. Even conversion from Imperial to metric units and rounding can produce differences of that order. Second, in most cases, the calculated number of waves likely to overtop is based on an assessment of the extreme end of an assumed distribution of irregular waves. With thousands of waves arriving at a given point each hour, it is impossible to predict the exact number that will overtop. Third, the method of estimating wave heights and wave run up requires extrapolation from other data, often small-scale experiments. Adjustments must be made to account not only for changes in scale, but also for changes in slope and type of material. In one case, for example, a change in one of these factors from 0.81 to 0.82 changed the number of waves overtopping from 11 to 3. From the point of view of assessing the potential for structural damage however, the level of accuracy obtained is sufficient.

The method used to obtain the number of waves overtopping for each structure was as follows. The technique used is that described in the most recent edition of the Shore Protection Manual (Ref 1) unless otherwise indicated.

1. Evaluate fetch length and direction.
2. Select design wind speed for longest fetch.
3. Adjust wind speed for factors such as stability (air/sea temperature difference) and location (overland/overwater).
4. Convert wind speed to wind stress.
5. Estimate average depth of fetch and depth of structure at the intersection of the dam slope and the natural slope. Determine whether wave is depth-limited.
6. Calculate significant wave height (Hs), period and minimum wind duration to fully develop the significant wave height.
7. Calculate runup for given wave on a smooth impermeable slope.
8. Adjust for actual slope and roughness.
9. Calculate wind setup (Ref. 2).
10. Calculate available freeboard (difference between top of riprap and MFL less wind setup).

11. Estimate required height of wave to produce runup exceeding available freeboard.

12. Calculate the probability that a wave of that height or greater will occur in an irregular wave train having an H_s as calculated in step 6.

13. Calculate the number of waves of this height or greater by multiplying the probability by the estimated total number of waves per hour.

14. Calculate the required additional freeboard for no overtopping at a probability level of 0.0001 in the maximum historic hourly wind speed. (This freeboard can be provided either by raising the crest, or setting the MFL at a lower elevation.)

15. Rate the damage potential for each structure in the range of wind conditions, and specify the remedial measures necessary for the moist severe case.

Details of the results of steps 1-14 are provided in the tables in Appendix C, and of step 15 in Table 5.1.

3 - SELECTION OF DESIGN WINDS

3.1 - General

The wind speed selected to assess freeboard must represent a typical value expected during and following a major storm, in order to maintain the same level of risk as the PMF event itself, as discussed in Section 1. A higher design wind speed will make the total event more improbable; a lower design wind speed makes it a more probable event.

For this study, a test wind of just under 40 km/h was chosen as the design wind speed. It represents a condition considerably higher than the average (1.8 times annual average wind speed), yet is not so high as to make the total event unreasonably improbable. Two other wind speeds were examined, however, to provide information about overtopping at both higher and lower wind speeds. These two other wind speeds were

1) the maximum of all the mean monthly wind speeds, and
2) the maximum hourly wind speed from the period of record.

Both of these take account of direction.

Information is also required on the persistence of the wind from a given direction, because the total number of waves overtopping a structure depends on the length of time the wind blows from the critical direction. Short-term (11 day) records were used to estimate persistence.

Section 3.2 describes the data, and Sections 3.3 and 3.4 discuss the wind speed and persistence values used.

3.2 - Analysis of Historic Wind Data

Two types of historic wind data were used.

1) AES longterm from Buchans A meteorological station, supplemented by Burgeo data.

2) AES short term (hourly) data for 3 storms,

   - February 2-12, 1973 (Burgeo)
   - January 13-23, 1978 (St. Alban's)
   - January 11-21, 1983 (St. Alban's)

The first set of data was used to obtain a range of design wind speeds, as discussed below in Section 3.3. The second set was used to determine whether a set pattern of wind direction could be assumed during a storm event, and to determine the length of time the wind can typically be expected to blow from each direction during and following a storm event.

3.2.1 - Longterm Data

Buchans is located about 70 km northeast of Victoria, and over 100 km northwest of Long Pond. The period of record is 1953-1965 (13 years); in 1965 the anemometer was removed. The anemometer was located in generally flat country in the immediate area with Buchans Lake just to the west. The plateau conditions are similar to those in the reservoir areas and the elevation of about 280 m is comparable to the elevations of the reservoirs. The mean annual wind speed at Buchans is 21.4 km/h.

The Burgeo data was also examined. Burgeo is located on the south coast of Newfoundland, about 70 km south of the Burnt Pond and Victoria Lake area and over 100 km southwest of Long Pond. Although the distances from the project sites are about the same as Buchans, the coastal setting is quite different. The anemometer is located on a small hill on an island off the coast and the cliffs rise very steeply. Because of the exposed coastal location, the average wind speed at Burgeo is 23.5 km/h, compared with 21.4 at Buchans. The Burgeo record was used to obtain a conservatively high test wind, as described below in Section 3.3, and to provide direction/duration information during a severe storm in 1973.

Some data is also available from St. Alban's, but because the anemometer is in a sheltered location, wind speeds are not representative of those on the plateau. The records of wind direction are more representative of those in the reservoir areas, although only 8 points are recorded. St. Alban's data was only used for direction/duration information during storms in 1978 and 1983.

Two types of wind data from Buchans were used, monthly mean wind speeds and maximum hourly recorded wind speeds for each year. Both sets of data were sorted by wind direction (16 points).

Summaries of the records for Buchans and Burgeo are reproduced in Appendix A.

3.2.2 - Short-term Storm Records

Hourly wind direction, wind speed and precipitation data were examined for 3 large storms. Plots of these records are presented in Appendix B. These records were examined for two reasons; first, to determine whether a set pattern of wind direction could be assumed during and following a major storm, and second, to select a typical duration for winds from each direction during and following a storm. (As discussed in Section 3.2.1, these storm records can not be used to estimate representative wind speeds on the plateau, since they are from Burgeo and St. Alban's. The location of the Burgeo anemometer results in unusually high local winds from the northeast and east and the St. Alban's anemometer is sheltered in winds from all directions.)

The records of the 11 days during and following each of three storms suggest that no set pattern of wind direction and duration can safely be assumed. The winds experienced at any particular location depend on such factors as the track of the storm and its age, size, and type.

The February 1973 storm recorded at Burgeo showed a fairly typical pattern; winds preceding the rain were easterly and southeasterly just before the storm and during the heaviest rain. They shifted to southerly and southwesterly in the last hours of the rain, continuing the next day. The two following days brought westerly and northwesterly winds. Northeasterly winds returned 4 days after the first storm, but brought no precipitation.

The storm record at St. Alban's for January 1978 by contrast shows southwesterlies during the rain. Light to moderate southwesterlies continued to prevail until moderate westerlies filled in 2 days after the first storm. Winds were generally from the quadrant SW to NW except for about 12 hours of light southeasterlies 3 days after the major rainfall. No precipitation occurred in these southeasterlies.

The January 1983 storm records from St. Alban's also show southwesterly winds during the rain somewhat stronger than in 1978. After the rain ended, the winds shifted to light northwesterly and northerly for a day, then to northwesterly for a day, and northeasterly to southeasterly for another day, finally coming around again to light southwesterlies 5 days after the first rainfall. No further precipitation was recorded in this period.

These three storm records show sufficient variability in direction to make it necessary to assume that the wind could come from any direction while a reservoir is at MFL. This finding is supported by the meteorology of storms in Newfoundland; heavy precipitation can occur when winds are from any direction from southwest through southeast to east, depending on the type of storm. Westerly, northwesterly, and northeasterly winds following storms can persist for many hours.

The records are useful in providing information on how long the wind may be expected to blow continuously from a given direction. The average lengths of time in hours are as follows.

N	NE	E	SE	S	SW	W	NW
9	24	3	22	3	44	18	19

These figures give only a general indication of duration by direction, and are sufficient to indicate how long winds might be expected to blow from a given sector of interest during a PMF event. No conclusions can be drawn about wind speed however, because the wind speeds on the plateau are probably lower than those at Burgeo and higher than those at St. Alban's. Better estimates of duration, direction and wind speed could be obtained by more rigorous meteorological techniques, such as a persistence analysis of hourly station records over the period of record, or detailed examination by a meteorologist of 6 hour surface weather maps for a number of events. Since the results for the structures examined in this study are not particularly sensitive to duration, it was considered that the extra effort for these detailed analyses was not warranted.

3.3 - Wind Speed and Direction

Because of the interdependency of wind speed, direction and duration, the approach taken was to examine 3 different wind speeds, representing a range. Since the event covers a number of days, and the highest water levels occur after the storm, it is appropriate to obtain these values from the long-term records rather than from storm events.

The wind speeds examined were

1) Test wind (38.8 km/h)
2) Mean hourly wind speed
3) Maximum recorded hourly wind speed

1) Test wind: A wind speed of 38.8 km/h is the highest mean wind speed from any direction recorded at Burgeo in any month. (Table A.1, Burgeo, January, ESE). It is 1.65 times the mean wind speed at Burgeo, and 1.81 times the mean wind speed at Buchans. It was arbitrarily chosen as a reasonably high representative wind speed to be used for all structures to provide a common basis for comparison.

2) Mean Wind Speed: The mean wind speed used in the analysis is the highest mean wind speed recorded at Buchans in any month from the sector of interest. The sector of interest is defined by the fan of radials drawn out from the structure to calculate fetch length. If a structure is most exposed from the northeast, for example, then the record was scanned for the highest mean wind speed from the sector NNE-NE-ENE. Scanning from all 3 directions in a sector results in more conservative results than selecting a mean wind speed from the principal direction only.

The mean values were chosen to represent the lower end of the range of design wind speeds. It might be appropriate to use the average wind speed for design, if the wind blew steadily at this mean wind speed, but since the wind will often blow from the same direction for a number of hours or even days, overtopping might occur in an hour when the wind was slightly above average. The mean wind speed is thus not considered adequate for design.

(3) Maximum recorded wind speed: The AES computer records were scanned to select the maximum recorded hourly wind speed in each year of record from each of 16 directions. As in (2) above, the maximum of any of the 3 directions in the sector of interest for each structure was used. These maximum hourly values were chosen to indicate the upper end of the range of design wind speeds.

Generally, they have return periods for maximum wind speed from a single direction of the order of 1:10 to 1:50 years, so they are quite conservative. One recorded hourly wind speed of 105 km/hr from the SSE is particularly high; it has a return period probably closer to 1:200 years. The probability of any of these maximum hourly values continuing for a number of hours in succession is even more remote, and if used as the single design wind speed during the PMF, they would have the effect of making the total event unreasonably improbable. They are useful for indicating what happens at higher wind speeds, however, since for many structures, no waves overtop in the two lower conditions.

3.4 - Duration and Persistence

Two durations must be determined. The first is the minimum duration necessary for the waves to become fully developed; this duration will determine whether adjustment of the wind data from the records is required and the second is the persistence of the wind from a given direction.

In general, most of the reservoirs have a minimum duration of the order of 1/2 to 2 hours before the waves become fully developed for the given fetch. The hourly wind data provided by AES is thus appropriate, and no adjustments were made for duration.

The second duration required is also called persistence; it is the length of time the wind might be expected to blow from the critical direction for each structure. The runup calculations based on wind speed result in the number of waves expected to overtop the reservoir per hour. To determine total number of waves overtopping in an event, the number of hours the wind is likely to blow from a given direction must be estimated. The results of the storm records described in Section 3.2.2 were used for this analysis.

The length of time that the reservoir is at MFL must also be considered. For the three reservoirs considered, the wind duration generally governed, because the flood handling analysis showed that reservoirs can stay near their peak levels for several days.

For any erodible material, such as sand, gravel or glacial till, continual overtopping will lower the crest, causing more overtopping. No account was taken of possibly diminished crest elevations due to erosion during the period of wave overtopping.

4 - EARTH STRUCTURES: RESULTS OF FREEBOARD ANALYSIS

The results of the freeboard analysis are summarized below for each structure. Locations of structures are shown in Figure 4.1. Detailed summary sheets are provided in Appendix C.

Freeboard is required to protect structures against wave runup, wave set up, and wind setup. Wave set up is included in runup calculations. Wind setup is small, but was taken into account by reducing available freeboard by that amount in the calculation.

4.1 - Long Pond

4.1.1 - Northwest Cutoff

The Northwest Cutoff Dam is a homogeneous earth fill structure located across Northwest Brook, north of the powerhouse. It is about 40 m high with a crest length of about 760 m. The top 15 m of the upstream slope is protected with riprap. The downstream slope suffered precipitation erosion in the January 1983 flood, and was subsequently repaired. The Northwest Cutoff Dam is most exposed to winds from the north. Relevant data are summarized as follows:

Assumed Elevation of Top of Riprap	185.31 m*
MFL	182.73 m
Available Freeboard (before wind setup)	2.58 m

	TEST WIND	MEAN WIND	1-HR MAXIMUM RECORDED
Wind speed (km/hr)	38.8	29	77
Runup resulting from H_s (m)	0.89	0.72	1.46
Number of waves overtopping per hour	0	0	0
Estimated duration 9 hrs (wind or reservoir level)			
Total # of waves overtopping at given wind speed	0	0	2

*Conservative value. Drawings show 186.0 m (610'), i.e. 1.6 m riprap above crest. Normally structures have only 0.91 m (3') additional riprap, so the elevation of the top of riprap was taken as 184.4 + 0.91 = 185.31 (m).

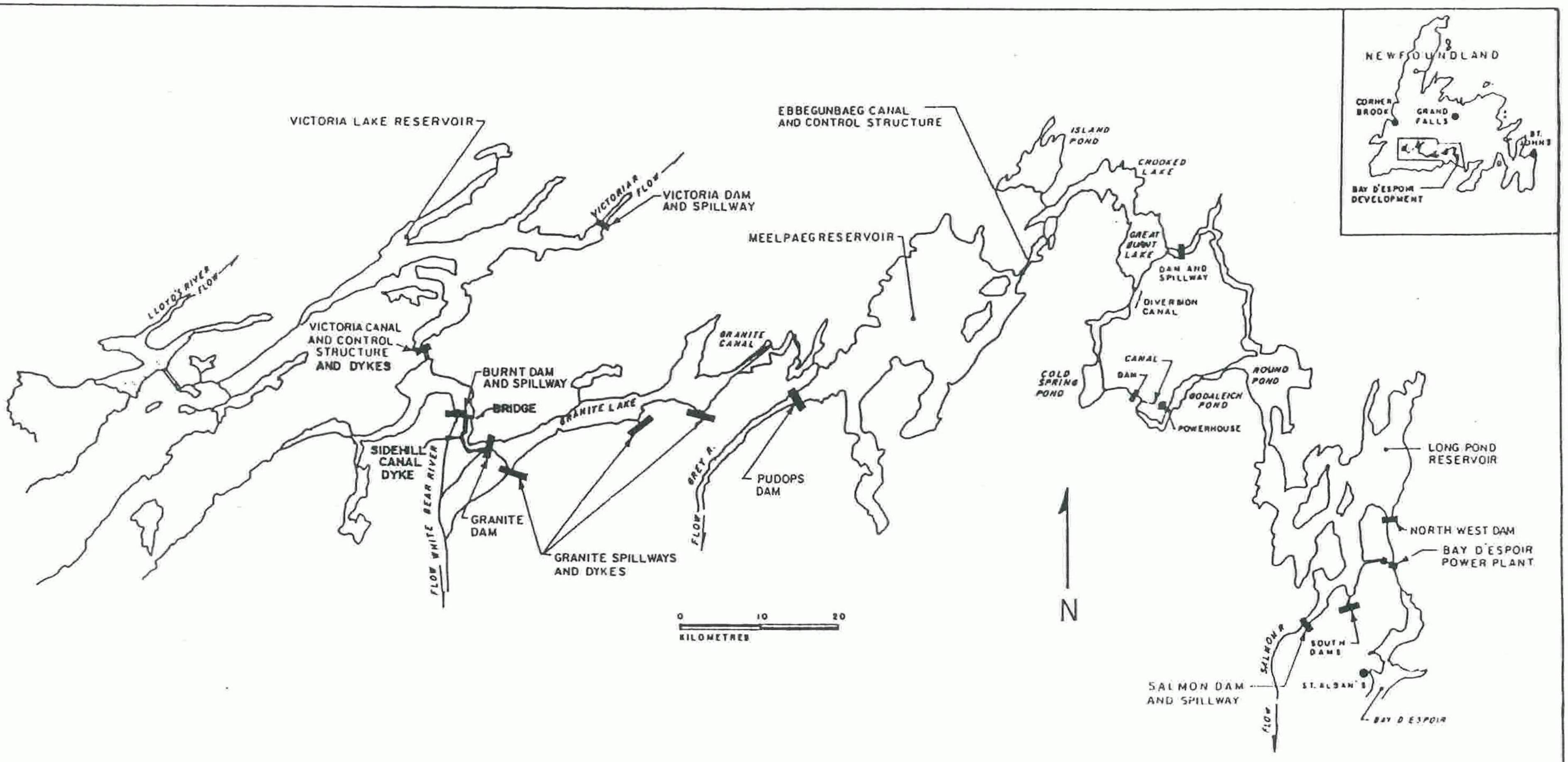

FIG. 4.1

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FREEBOARD STUDY
STRUCTURE LOCATION MAP

ACRES

Conclusion:

The Northwest Cutoff Dam is expected to be safe from wave overtopping during a PMF event. Typical wind conditions would not likely include the maximum hourly wind of record especially for 9 hours, and even so, only a few waves would overtop the structure.

4.1.2 - South Cutoff Dam, West Section

The small southwest section of the South Cutoff Dams plugs a low area at the south end of Long Pond. It is a homogeneous structure with a maximum height of just over 5 m. The entire upstream face is covered with riprap. The most south Cutoff Dam is exposed to winds from the north.

Relevant data are as follows:

Assumed Elevation of Top of Riprap	185.31 m
MFL	182.73 m
Available Freeboard (before wind setup)	2.58 m

	TEST WIND	**MEAN WIND**	**1-HR MAXIMUM RECORDED**
Wind speed (km/hr)	38.8	29	77
Runup resulting from H_s (m)	0.69	0.54	1.17
Number of waves overtopping per hour	0	0	0
Estimated duration 9 hrs (wind or reservoir level)			
Total # of waves overtopping at given wind speed	0	0	0

Conclusion:

The freeboard available at the southwest portion of the South Cutoff Dams is sufficient during the PMF event.

4.1.3 - South Cutoff Dam, East Section

The east section of the South Cutoff Dams plugs another low saddle area at the southern end of Long Pond. Like the west section, it is built of homogeneous material and the upstream face is entirely protected with riprap. Maximum structure height is about 7 - 10 m. Relevant data are as follows:

Assumed Elevation of Top of Riprap	185.31 m
MFL	182.73 m
Available Freeboard (before wind setup)	2.58 m

	TEST WIND	**MEAN WIND**	**1-HR MAXIMUM RECORDED**
Wind speed (km/hr)	38.8	29	7
Runup resulting from H_S (m)	0.98	0.79	1.66
Number of waves overtopping per hour	0	0	4
Estimated duration 9 hrs (wind or reservoir level)			
Total # of waves overtopping at given wind speed	0	0	32

Conclusion:

The freeboard available at the east section of the south cut off dams is adequate for the PMF event. As with the North Cutoff dam, it is unlikely that the maximum recorded wind would continue for 9 hours in combination with a PMF event. The fact that the structure is small and most exposed to the north, where winds tend to be less frequent, also suggests that freeboard is sufficient.

4.1.4 - Power Canal Embankment

The power canal is located at the south east corner of Long Pond. An earth embankment about 1100 m long was built of homogeneous impervious fill with a maximum height of about 25m. The elevation of the top of the core, 182.73 m, establishes the MFL in Long Pond. About 1/2 m of gravel covers the impervious material, bringing the crest to 183.2 m with riprap above to an elevation of 184.1 m. The riprap protects the top 10 m of the upstream slope.

The most exposed part of the embankment is towards the upstream end, where a curve in the dyke exposes it to westerly winds.

Relevant data are as follows:

Assumed Elevation of Top of Riprap	184.1 m
MFL	182.73 m
Available Freeboard (before wind setup)	1.37 m

	TEST WIND	**MEAN WIND**	**1-HR MAXIMUM RECORDED**
Wind speed (km/hr)	38.8	32	97
Runup resulting from H_s (m)	0.54	0.45	1.08
Number of waves overtopping per hour	0	0	45 (5)*
Estimated duration 18 hrs (wind or reservoir level)			
Total # of waves overtopping at given wind speed	0	0	820 (100)

*Values in parentheses assume losses in wave energy due to refraction.

Conclusions:

The freeboard along the power canal is just adequate for a PMF event. The calculations show that no waves overtop in the test wind, and that the height of the wave required to overtop the structure in the maximum historic wind is more than 1.2 times the significant wave height H_S (Table C-4 (a)). (H_S is the significant wave height, often used for design.)

Nevertheless, the Power Canal Embankment has less of a margin of safety than the other Long Pond structures. The section of concern, as shown in the location map in Appendix E, is exposed to westerly winds, which tend to be stronger and more frequent than winds from other directions (Table A-1). During the 18 hour estimated duration, the wind might exceed the test wind in some hours, although it is unlikely to reach the 97 km/h maximum historic wind speed. Some overtopping might occur. At 50 km/h, for example, no waves overtop, but at 60 km/h, about 2 waves per hour could overtop. If the total number of waves overtopping were 45 (the same number that would overtop in 1 hour of the maximum hourly wind), the geotechnical analysis indicates that severe erosion would likely occur, although the structure would not be expected to fail. More erosion would be expected at the power canal embankment than at other structures, because the downstream slope has no riprap protection.

It should be noted that the number of waves overtopping cannot be accurately estimated by any of the usual approximate methods, because they cannot account for refraction along the fetch. The values in parentheses indicate the numbers of waves expected to overtop if losses have the effect of reducing the fetch length by about 25%. Numerical modelling is required to accurately estimate refraction effects.

Because of the importance of the power canal embankment, and the considerations discussed above, a more detailed analysis might be warranted. A suggested approach would include a persistence analysis of westerly winds, and numerical modelling to better estimate the rate of overtopping.

4.1.5 - Salmon Dam

The Salmon Dam, across the Salmon River in the southwest corner of Long Pond, is built of rockfill with an impervious core. The top 13 m of the upstream face is protected with riprap. Maximum height is about 40 m. The dam is most exposed to northeasterly winds. Relevant data are as follows:

Assumed Elevation of Top of Riprap	184.70 m
MFL	182.73 m
Available Freeboard (before wind setup)	1.97 m

	TEST WIND	**MEAN WIND**	**1-HR MAXIMUM RECORDED**
Wind speed (km/hr)	38.8	29	80
Runup resulting from H_s (m)	0.68	0.55	1.29
Number of waves overtopping per hour	0	0	11
Estimated duration 24 hrs (wind or reservoir level)			
Total # of waves overtopping at given wind speed	0	0	270

Conclusions:

Freeboard at Salmon Dam is adequate in the PMF event, although a few waves will probably overtop the dam, due to the length of time winds can persist from the northeast. The wave analysis for this location is very approximate because Salmon Dam is located at the end of a long narrow reach. Losses of wave energy by refraction cannot properly be estimated except by numerical modelling. The results presented here make an approximate adjustment for refraction effects by reducing the fetch length.

4.2 - Burnt Pond

Burnt Pond is located on the western side of the Bay d'Espoir basin, as shown in Figure 4.1. Burnt Dam was built across Burnt River, one of the headwaters of the White Bear River. Burnt Sidehill Canal conducts the waters from Burnt Pond watershed and from the Victoria diversion down to Granite Lake.

Burnt Dam and Burnt Canal Dyke are contiguous. The dam extends to the canal entrance, curving just around the northwest corner of the canal entrance, where it converges with the sidehill canal dyke. A bridge crosses the canal about 150 m downstream of the entrance.

4.2.1 - Burnt Dam

Burnt Dam is over 1100 m long, with a maximum height of just over 20 m. Like Salmon Dam, it is rockfill with a central impervious core. The upstream face is protected by riprap. It is most exposed to northeasterly winds.

Relevant data are as follows:

Assumed Elevation of Top of Riprap	317.30 m
MFL	315.47 m
Available Freeboard (before wind setup)	1.83 m

	TEST WIND	MEAN WIND	1-HR MAXIMUM RECORDED
Wind speed (km/hr)	38.8	29	80
Runup resulting from H_s (m)	0.58	0.45	1.10
Number of waves overtopping per hour	0	0	5
Estimated duration 24 hrs (wind or reservoir level)			
Total # of waves overtopping at given wind speed	0	0	130

Conclusion:

Burnt Dam has adequate freeboard under PMF conditions.

4.2.2 - Burnt Sidehill Canal Dyke

The Sidehill Canal dyke is constructed of homogeneous impervious fill, with washed till on the upstream face. A gravel road runs along the crest. No riprap protection is provided.

The Sidehill Canal dyke was investigated at 2 locations,

1) upstream of the bridge, exposed to northerly and north-easterly winds across Burnt Pond.
2) about 3 km downstream of the bridge, at a location where ponding provides exposure to a southeasterly fetch of about 500 m.

Relevant data for the 2 locations are as follows:

1. Burnt Dyke, Upstream of Bridge

Assumed Elevation of Top of Structure	315.50 m
MFL	315.47 m
Available Freeboard (before wind setup)	0.03 m

	TEST WIND	**MEAN WIND**	**1-HR MAXIMUM RECORDED**
Wind speed (km/hr)	38.8	29	80
Runup resulting from H_s (m)	0.60	0.48	1.06
Number of waves overtopping per hour	1570	1700	1270
Estimated duration 24 hrs (wind or reservoir level)			
Total # of waves overtopping at given wind speed	37700	40800	all

Conclusion:

Burnt Sidehill Canal Dyke is very vulnerable upstream of the bridge. The smooth surface (till instead of riprap) leads to higher runup for the same incoming wave height, and the low crest provides very little freeboard. The wind set up alone in the case of maximum historic hourly wind exceeds the available freeboard, and all waves overtop.

If the vulnerable portion upstream of the bridge were upgraded to the same standard as the dam, i.e. riprap to an elevation of 317.30 m, no waves would overtop even in the maximum hourly recorded wind.

Because of the lack of freeboard in this area, a quick check was made assuming the reservoir to be at FSL. Even then 5 waves per hour would overtop in the maximum historic hourly wind. Normally, structures should have adequate freeboard to avoid overtopping at high winds when at FSL.

The average depths over the fetch should be confirmed by soundings. If depths are lower than those assumed in this study (5 1/2 m at FSL, 7 m at MFL), wave heights may be depth-limited, especially in high wind conditions. Wind set up would increase.

2. Road Embankment East of Bridge

Waves will overtop the road embankment to the east of the bridge. This study assumed that the foundations are sound and that the whole area will not wash out. This assumption should be checked and the effect of a washout on the canal hydraulics should be assessed.

3. Burnt Dyke, Downstream of Bridge.

When Burnt Pond is at MFL, the water will be up to the bridge deck, and in fact will probably be washing over the road on the eastern side of the bridge. This area to the east of the bridge should be checked; it has been assumed here that the entire area is sound and will not wash out.

The canal discharge hydraulics will be affected by the bridge, although the rising levels in Granite Lake at the downstream end may still control the discharge.

Two cases were examined for the purpose of the freeboard study. In both it was assumed that crest of the sidehill canal dyke slopes uniformly and linearly down to Granite Lake. In the first case, the water surface was assumed to slope linearly from the water level at Burnt to the water level at Granite Lake. The location chosen is about 3 km downstream of the canal entrance, i.e. about 3/8 of the length of the canal. The crest is therefore estimated to be at about elevation 315.28, and the maximum water level is about 314.30. (The flood analysis is showed that Granite Lake is at elevation 312.36 when Burnt Pond is at its peak, a difference of 3.11 m in water levels.) In the second case, the water surface was assumed to slope at the same rate as the crest, so that the freeboard remains constant. The results of the calculations are dramatically different.

Relevant data for Case 1 are as follows:

Assumed Elevation of Top of Structure	315.28 m	(no riprap)
MFL	314.30 m	
Available Freeboard (before wind setup)	0.98 m	

	TEST WIND	MEAN WIND	1-HR MAXIMUM RECORDED
Wind speed (km/hr)	38.8	23	105
Runup resulting from H_s (m)	0.23	0.11	0.52
Number of waves overtopping per hour	0	0	
Estimated duration 22 hrs (wind or reservoir level)			
Total # of waves overtopping at given wind speed	0	0	27

Relevant data for Case 2 are as follows:

Assumed Elevation of Top of Structure	315.28 m	(no riprap)
MFL	315.25 m	
Available Freeboard (before wind setup)	0.03 m	

	TEST WIND	MEAN WIND	1-HR MAXIMUM RECORDED
Wind speed (km/hr)	38.8	23	105
Runup resulting from H_s (m)	0.23	0.11	0.52
Number of waves overtopping per hour	2630	3180	1950
Estimated duration 22 hrs (wind or reservoir level)			
Total # of waves overtopping at given wind speed	58000	7000	42900*

Note that these are small but frequent waves; heights are of the order of 10 - 50 cm.

*Note that fewer waves overtop in the maximum wind because wave periods are longer.

Conclusion:

The sidehill canal dyke cannot be assumed to be safe during the PMF event until a detailed examination of the canal hydraulics establishes the water levels to be used in the freeboard assessment.

4.3 - Victoria

4.3.1 - Victoria Control Structure Dykes

A small earth structure was required on the south side of Victoria Lake to plug a low area, as well as earth embankments adjacent to the control structure. Under normal operating conditions the structures are high and dry, but since maximum water levels are about 3 m above FSL, much of the surrounding country would be flooded during the PMF event.

During the course of the study, a low area to the east of the dykes was identified from recent mapping. Water would flow from Victoria Lake into Burnt Pond. For the purpose of this study, it was assumed that a rockfill dyke (about 150 m long) would plug this low area. Other alternatives should be examined, however, such as setting the maximum allowable flood level at a lower elevation, and drawing the reservoir down if necessary.

The small dykes east of the control structures are of homogeneous earthfill construction with maximum heights of 3 - 5 m. Although their orientation is SW-NE, the most exposed location is the southwestern side of the dyke to the west of the control structure, which is exposed to winds from the NNE when the surrounding land is flooded. The embankment just to the northeast of the control structure is quite sheltered by surrounding land and islands. The small dyke on the other side of the hill is exposed to the northwest, but the exact fetch length could not be determined because of lack of topographic information of islands in the lake. Results are expected to be similar to those for the western embankment.

Riprap protects the upstream face of the dykes, but does not extend above the crest.

Assumed Elevation of Top of Structure	327.96 m
MFL	327.36 m
Available Freeboard (before wind setup)	0.60 m

	TEST WIND	**MEAN WIND**	**1-HR MAXIMUM RECORDED**
Wind speed (km/hr)	38.8	29	80
Runup resulting from H_s (m)	0.42	0.34	0.66
Number of waves overtopping per hour	16	1	280
Estimated duration 9 hrs (wind or reservoir level)			
Total # of waves overtopping at given wind speed	150	7	2500
Additional freeboard required for no overtopping (m)	0.20	0.05	0.70

Conclusion:

Victoria Control dykes do not have adequate freeboard when the reservoir is at the top of core MFL. If riprap were added above the crest, the structures would be safe in the PMF event. The table above shows 20 cm of additional freeboard is required in the test wind. The MFL could be set 20 cm lower, and the reservoir drawn down if necessary to ensure that this MFL would not be exceeded.

4.3.2 - Victoria Dam

Victoria Dam is located in a narrow section of the Victoria River valley in the northeastern corner of Victoria Lake. It is a high dam, with a maximum height of nearly 60 m, built of zoned rolled earthfill with a central impervious core. The top 13 m of the upstream slope is protected by riprap. The most exposed section is the northeastern end, which faces southwest.

Relevant data are as follows:

Assumed Elevation of Top of Riprap	328.88 m
MFL	327.36 m
Available Freeboard (before wind setup)	1.52 m

	TEST WIND	**MEAN WIND**	**1-HR MAXIMUM RECORDED**
Wind speed (km/hr)	38.8	25	97
Runup resulting from H_S (m)	0.45	0.31	0.96
Number of waves overtopping per hour	0	0	2
Estimated duration 44 hrs (wind or reservoir level)			
Total # of waves overtopping at given wind speed	0	0	100

Conclusions:

Victoria Dam should have adequate freeboard in a PMF event. Even in the 1 hr maximum recorded wind speed, only 2 waves/hr. are expected to overtop.

5 - GEOTECHNICAL IMPLICATIONS

Geotechnical implications as a result of embankment overtopping were considered by means of a qualitative assessment on the basis of anticipated potential damage and remedial measures required to reduce the impact of overtopping. Consideration was given to the number of waves per hour which would overtop the embankment, the duration of wave overtopping, and the zoning and nature of the fill material, particularly on the downstream slope of the embankment.

Remedial measures to either reduce the potential damage by overtopping or to prevent overtopping of the embankments are suggested. Such measures include protection of the downstream slopes by seeding or rockfill or raising the dam crest or upstream riprap protection respectively.

Table 5.1 gives a summary of the geotechnical assessment for potential damage to the embankments as a result of overtopping in a variety of wind conditions, and the suggested preventative measures. Only Burnt Dyke requires immediate attention. Each embankment is rated as having either a low, medium or high potential for damage for each of the three wind conditions. For the purpose of this report the above damage ratings are defined as follows.

- Low Potential Damage
  Erosion of the crest and downstream slope requiring general repair and is equivalent to what may be expected from severe rainfall damage.

- Medium Potential Damage
  Severe erosion of the crest and downstream slope requiring immediate repair and which may result in washing out of the downstream toe or portions of the dam crest.

- High Potential Damage
  Damage that affects the structural integrity of the embankment and which may result in failure of the embankment and loss of containment.

Two main assumptions have been made for the purpose of this assessment which have a direct bearing on the potential damage rating given in Table 5.1. The first is that overtopping is limited to wave runup and not by waves breaking over the crest, and the second is that there are no cumulative effects of crest erosion as a result of wave action for the duration of the wind.

TABLE 5.1: DAMAGE POTENTIAL, EARTH STRUCTURES

The number of waves overtopping in a range of wind conditions, and the resulting damage potential, are tabulated below. The design conditions are the PMF event and reservoirs at MFL's set at the elevation of the lowest top of core of any structure around the reservoir. The design wind in these conditions is the test wind. Damage potential for 2 scenarios in the maximum historic wind is rated, to provide information on structure vulnerability in more severe wind conditions.

Dam	Type	Existing Downstream Slope Protection	Emin(1) (m)	Duration of Wind (h)	Total No. of Waves/ Damage Potential		Maximum Hist. Wind(2)	Geotechnical Remedial Measures for No Damage Up To Maximum Hist. (not required unless noted)	
					Test Wind	Average Wind			
Salmon Dam	Central core rock-fill shells	Rock fill	0.77	24	0/-	0/-	273/med. 11/low	Raise Crest(3)	—
Northwest cutoff	Homogeneous impervious fill	None on slopes Protection on erosion control berms	0.22	9	0/-	0/-	0/- 2/low	None required	—
South cutoff west section	Homogeneous impervious fill	0.5-m thick gravel and fine rock fill	0	9	0/-	0/-	0/-	None	—
South cutoff east section	Homogeneous impervious fill	0.5-m thick gravel and fine rock fill	0.74	9	0/-	0/-	4/low 32/med	Raise Crest(3)	A secondary but less effective option may include rock-fill slope protection seeding of the downstream slope.
Power canal embankment	Homogeneous impervious fill	0.5-m thick gravel and fine rock fill	0.83	18	0/-	0/-	45/med 819/high	Raise Crest(3)	Most vulnerable structure at Long Pond because lacking d/s slope protection.

Notes:

1) Emin = minimum freeboard above existing crest level required to prevent overtopping in maximum historic wind for MFL's as defined above.
2) Damage potential is rated for 2 scenarios
   a) maximum historic hourly wind blowing for 1 hour
   b) maximum historic hourly wind blowing constantly for the estimated total length of time.
3) Only the crest requires raising, not core.

TABLE 5.1 (continued)

DAMAGE POTENTIAL

EARTH STRUCTURES

Dam	Type	Existing Downstream Slope Protection	Emin (m)	Duration of Wind (h)	Total No. of Waves/ Damage Potential Test Wind	Average Wind	Maximum Hist. Wind	Remedial Measures For No Damage up to Max. Hist.	
Burnt Dam	Central core rock-fill shells	Rock fill	0.50	24	0/-	0/-	5/low 126/med	Raise Crest(3)	
Burnt Canal Dyke upstream of bridge	Homogeneous impervious fill	None	1.84	24	37670/ high	40760/ high	all/ high	Raise Crest(3)	ACTION REQUIRED: **HIGH DAMAGE IN ALL WIND CONDITIONS**
Burnt Canal Dyke downstream of bridge	Homogeneous impervious fill	None	—	-	-	-	-	-	See Section 4 for Burnt Pond canal dyke downstream of bridge. Potential damage assessment dependent on water level assumptions.
Victoria Dam	Central core sand and gravel	Sand and gravel or fine rock	0.18	44	2/low 0/-	0/-	100/med.	Raise Crest(3)	A secondary but less effective option may include rock-fill slope protection or seeding of the downstream slope.
Victoria Dykes	Homegeneous impervious fill	sand and gravel 0.5 m	0.70	24	145/high	7/low	278/high 2510/high	Raise Crest(3)	**SOME DAMAGE IN ALL WIND CONDITIONS**

Notes:

1) Emin = minimum freeboard above existing crest level required to prevent overtopping in maximum historic wind for MFL's as defined above.
2) Damage potential is rated for 2 scenarios
   a) maximum historic hourly wind blowing for 1 hour
   b) maximum historic hourly wind blowing constantly for the estimated total length of time.
3) Only the crest requires raising, not core.

6 - STABILITY OF CONCRETE STRUCTURES

A brief assessment was made of the stability of selected concrete structures under extreme loading due to maximum probable flood levels (MFL). The structures analyzed and reference data are as follows.

Location	Structure	MFL	Reference Drawing No.* (m)
Long Pond	Salmon River Spillway	182.73	F-103-C-8 Rev 8
	Salmon River Intake	182.73	F-105-C-1 Rev 5 F-105-C-2 Rev 7
Burnt Pond	Burnt Spillway	315.47	F-2135-C-7 Rev 1 -C-8 Rev 0
	Burnt Canal Bridge	315.47	F-243-C-6 Rev 3 -C-8 Rev 1 -C-12 Rev 3
Victoria Reservoir	Victoria Spillway	327.36	F-2143-C-2 Rev 1
	Victoria Control Structure	327.36	F-2142-C-13 Rev 1 -C-14 Rev 3

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*Drawings by Shawmont Engineering Newfoundland Limited

The structures were analyzed for the following load cases with maximum flood levels.

- Dead load + hydrostatic
- Dead load + hydrostatic + ice
- Dead load + hydrostatic + seismic

Criteria adopted for the analyses of the concrete structures are summarized in Appendix D.

Based on the results of the stability analyses the structures appear to be stable with acceptable factors of safety for the extreme load cases considered. However, the Burnt Canal bridge deck would be vulnerable to damage in the event of ice loading in conjunction with the MFL. It is emphasized that the analyses conducted are very preliminary and subject to verification by a more rigorous assessment of stability at each structure.

6.1 - Gates

The implications of maximum flood levels on the gates was briefly examined.

a) Long Pond Intake: These are low level gates, and no problems due to increased head are expected. Hoist capacities should be checked.

b) Salmon Spillway: The flood analysis indicates that these gates will be opened early and left open until reservoir levels subside, so no overtopping is expected. Hoist capacities under increased head should be checked.

c) Burnt Spillway Gates: These gates are expected to be opened early in the flood and left open until levels subside. No problems are expected, but hoist capacities under increased head should be checked.

d) Victoria Canal Structure: These are low level gates and no problems are expected. Hoist capacities under the increased head should be checked.

e) Victoria Spillway: The flood analysis assumes these gates will be opened only slightly if at all. Consequently, they will be overtopped, by nearly 2 m if left completely closed. The increased pressure would not be expected to damage the gates, but hoist capacities should be checked.

Although overflow for short periods could likely be tolerated, nevertheless, it is recommended that gates be operated so that overtopping does not occur, or that flashboards be added.

GLOSSARY

A. Symbols Used in Summary Tables

U - Wind velocity
- adjusted from meteorologic records to account for air/water temperature difference and overland/overwater deviations.

U_A - Wind Stress Factor
- accounts for non-linear relation between wind velocity and surface stress.

$$U_A = 0.71(U)^{1.23}$$

F - Fetch length; the horizontal distance in the direction of the wind over which the wind blows, calculated by averaging the length of 9 radials at 3° intervals.

D - Estimated average depth over the fetch.

Ds - Depth at base of the structure.

MFL - Maximum Flood Level, set at minimum top of core of any structure around the reservoir.

PSH - Peak Structure Height (measured to the top of the riprap).

Dfb - Freeboard Distance (available freeboard =PSH-MFL).

H_o - Incident wave height to structure, equal to H_s in this analysis.

Hrms - Root mean square wave height. A characteristic value of an irregular wave train, equal to the square root of the average of the sum of the squares of all wave heights. (Hs/1.416).

T - Period of the incident wave; also period at which spectual energy in a wave train is concentrated. Generally comparable to average period.

t min - minimum duration of the wind to produce a wave with height Ho and period T.

t - typical duration of wind from sector of interest (hours).

Ho/gT^2 - Dimensionless parameter used in wave runup calculations.

Ds/Ho - Dimensionless parameter used in wave runup calculations.

R/Ho - Ratio of runup to wave height.

H_{cr} - Critical Wave Height, i.e. wave height which will runup to the maximum allowable level on the structure (produces Rcr i.e. approaches overtopping).

R - Runup height in meters; vertical height above the stillwater level to which water from Ho will runup the face of a structure.

Rcr - Critical Runup
- Equal to Dfb (available freeboard) minus wind setup.

$P\ (R>Rcr)$ - probability of getting a wave that will overtop the structure.

N - Number of waves overtopping in waves/hour.

E_{min} - Increase required to raise structure to an elevation which would result in no waves overtopping with a probability less than 0.0001 (1:10000).

W_{set} - Wind Setup; increase in elevation of water level due to wind.

$$= \frac{U^2_A F}{62800D}$$

where

U - km/h
F - km
D - m

B. - Other

AES	-	Atmospheric Environment Service of Environment Canada.
FSL	-	Full supply level of reservoir.
H_S	-	Significant wave height; average height of the highest 1/3 of all waves.
PMF	-	Probable maximum flood.

REFERENCES

1. Shore Protection Manual, US Dept. of the Army, Waterways Experiment Station, Corps of Engineers, Coastal Engineering Research Center, Vicksburg, Mississippi Fourth Edition, 2 Vols, 1984.

2. Saville, Thorndike et al, "Freeboard Allowances for Waves in Inland Reservoirs", Journal of the Waterways and Harbours Division, ASCE Proceedings, May, 1962, p. 93-125.

APPENDICES - FREEBOARD STUDY

APPENDIX A
METEOROLOGICAL DATA

Table A-1 - AES Wind Data for Burgeo and Buchans

BURGEO NFLD.

PERIOD 1966-80 PERIODE

Lat. 47°37′N Long. 057°37′W

Elevation 12 m Altitude

PERCENTAGE FREQUENCY / **FRÈQUENCE EN %**

	JAN JANV	FEB FEV	MAR MARS	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEP SEPT	OCT OCT	NOV NOV	DEC DEC	YEAR ANNUEL	
N	4.8	5.3	4.3	5.1	3.2	2.0	1.2	2.1	2.6	3.6	3.7	5.1	3.6	N
NNE	3.4	3.8	4.4	3.4	2.7	1.3	0.6	1.9	2.2	3.2	3.5	4.6	2.9	NNE
NE	6.1	6.9	8.6	5.5	4.5	2.1	1.5	2.2	4.4	4.0	6.0	5.9	4.8	NE
ENE	4.8	6.1	7.1	7.9	5.7	4.2	4.2	5.3	5.6	5.0	5.9	6.3	5.7	ENE
E	6.4	6.5	9.8	13.9	19.1	24.6	24.4	15.9	11.4	9.8	10.7	8.1	13.4	E
ESE	3.2	4.6	5.1	8.4	10.9	13.7	11.8	6.4	5.3	4.0	4.2	4.3	6.8	ESE
SE	2.3	2.4	2.6	3.4	3.7	5.1	5.2	3.3	2.6	2.8	2.4	2.9	3.2	SE
SSE	1.9	1.5	2.0	2.4	2.6	2.9	3.7	2.9	2.7	2.5	2.6	2.2	2.5	SSE
S	2.4	2.2	3.2	2.0	2.1	2.3	3.1	3.8	4.5	3.4	3.9	3.4	3.0	S
SSW	3.0	2.2	3.3	2.8	2.1	2.6	2.5	4.0	3.6	3.8	3.3	2.6	3.0	SSW
SW	4.6	4.3	5.0	4.1	5.4	6.1	5.9	6.9	5.8	5.4	4.3	3.4	5.1	SW
WSW	4.0	3.5	5.1	4.6	5.7	5.4	6.8	7.7	7.1	6.5	4.7	4.4	5.5	WSW
W	14.2	14.0	13.2	13.1	12.3	10.2	10.4	13.5	15.4	17.7	16.5	14.5	13.8	W
WNW	18.2	15.4	9.5	6.7	4.5	3.9	3.6	5.7	8.8	9.4	12.8	14.8	9.4	WNW
NW	10.1	10.6	6.2	5.6	4.0	2.9	2.0	3.5	5.8	6.8	7.1	8.5	6.1	NW
NNW	7.5	6.4	5.6	5.0	4.2	2.2	1.5	2.7	3.5	5.7	4.6	6.3	4.6	NNW
Calm	3.1	4.3	5.0	6.1	7.3	8.5	11.6	12.2	8.7	6.4	3.8	2.7	6.6	Calme

MEAN WIND SPEED IN KILOMETRES PER HOUR
VITESSE MOYENNE DES VENTS EN KILOMÈTRES PAR HEURE

	JAN JANV	FEB FEV	MAR MARS	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEP SEPT	OCT OCT	NOV NOV	DEC DEC	YEAR ANNUEL	
N	18.5	19.0	21.2	23.5	22.6	22.7	18.6	18.7	17.1	19.4	19.3	19.0	20.0	N
NNE	27.6	27.1	30.1	27.4	29.0	22.8	20.2	25.0	22.0	26.2	28.8	27.8	26.2	NNE
NE	28.0	27.9	30.8	28.9	27.7	21.4	16.5	18.6	21.3	24.8	29.8	26.0	25.1	NE
ENE	29.2	31.4	30.9	29.9	25.8	20.1	15.1	17.6	21.4	24.4	29.7	31.0	25.5	ENE
E	34.8	35.9	33.0	30.7	25.5	22.0	19.5	19.9	23.8	27.0	32.4	37.9	28.5	E
ESE	38.8	37.0	30.4	28.6	24.8	20.2	17.5	19.5	25.1	29.6	34.8	41.6	29.0	ESE
SE	32.3	30.5	21.0	20.3	17.0	15.6	15.0	16.7	20.9	25.8	31.8	36.2	23.6	SE
SSE	33.4	28.1	23.7	18.3	16.3	15.9	16.0	19.5	20.8	25.0	31.5	32.2	23.4	SSE
S	30.5	27.6	28.1	20.6	15.5	17.7	17.6	21.0	24.3	25.4	29.0	31.2	24.0	S
SSW	31.8	30.0	28.6	21.9	15.5	14.2	13.4	21.1	23.8	26.1	30.6	31.9	24.1	SSW
SW	33.1	33.1	27.5	20.0	17.4	15.8	15.0	18.1	20.1	25.0	32.7	35.0	24.4	SW
WSW	33.5	32.8	28.4	25.4	22.3	19.2	18.1	20.4	21.9	25.1	32.4	36.3	26.3	WSW
W	36.5	36.0	31.0	26.2	24.4	21.6	20.3	21.7	24.1	27.1	31.3	34.3	27.9	W
WNW	32.4	31.4	29.4	23.2	20.0	19.2	16.4	18.5	20.6	23.0	25.7	28.5	24.0	WNW
NW	22.9	23.4	25.9	22.1	24.8	21.2	16.5	18.4	18.6	20.0	20.0	20.9	21.2	NW
NNW	18.3	20.0	25.5	23.5	24.5	24.3	16.6	18.4	18.0	21.2	19.5	18.5	20.7	NNW
All Directions / Toutes directions	29.1	28.5	27.5	24.3	21.6	18.3	15.7	17.3	20.1	23.3	27.6	29.2	23.5	
Maximum Hourly Speed / Vitesse horaire maximale	129 SW	113 NNE	101 W	80 SVL	76 E	89 ENE	69 E	74 NNE	74 NE	97 S	105 NNE	97 E	129 SW	
Maximum Gust Speed / Vitesse maximale des rafales	161 SW	148 SVL	153 NNE	137 NE	116 NNE	137 ENE	96 SW	126 NNE	111 NE	142 SSW	161 NNE	134 E	161 SVL	

Height of anemometer 10.1 m hauteur de l'anémomètre

STATION INFORMATION

Well exposed on a small hill which is 12 m above station level. The site is located on one of the many islands clinging to the rugged south coast. The hilly terrain along the south coast causes super gradient winds between the coast and a point 20-30 km out to sea. This would probably be most pronounced with a southeasterly gradient.

DONNÉES RELATIVES À LA STATION

L'anémomtre jouit d'une excellente exposition, sur une petite colline qui domine de 12 m la station. Ils se trouve dans l'une des nombreuses petites îles bordant la côte sud, trs découpée. Le terrain vallonné de cette côte engendre de grands vents de gradient entre le littoral et un point situé à 20-30 km en mer. Le plus prononcé est probablement un vent gradiental sud-est.

BUCHANS A NFLD.

PERIOD 1955-80 PERIODE

Lat. 48°51′N Long. 056°50′W

Elevation 276 m Altitude

PERCENTAGE FREQUENCY / **FREQUENCE EN %**

	JAN JANV	FEB FEV	MAR MARS	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEP SEPT	OCT OCT	NOV NOV	DEC DEC	YEAR ANNUEL	
N	3.3	2.4	4.7	5.0	4.1	2.0	1.8	1.8	2.0	3.6	2.0	2.4	2.9	N
NNE	5.4	4.5	9.4	8.2	5.5	3.7	1.8	2.1	2.9	3.5	2.9	2.6	4.4	NNE
NE	7.8	7.0	9.3	7.7	7.3	7.3	3.8	4.0	4.3	4.5	4.9	3.5	6.0	NE
ENE	5.1	6.6	6.9	4.4	4.3	5.6	4.4	3.3	3.2	3.2	4.9	3.8	4.6	ENE
E	5.0	3.7	3.3	3.4	2.8	4.2	3.5	3.4	3.2	2.8	4.2	3.4	3.6	E
ESE	2.9	3.9	2.9	2.6	3.6	2.3	3.0	2.3	1.9	2.4	2.2	2.3	2.7	ESE
SE	2.9	2.9	1.9	3.2	4.5	4.6	4.8	5.1	3.2	3.0	3.5	2.7	3.5	SE
SSE	2.9	3.1	2.3	3.4	5.8	6.4	7.8	7.0	3.4	4.4	5.6	3.5	4.6	SSE
S	2.6	3.1	1.9	4.2	7.1	10.3	11.4	9.7	6.7	5.5	6.1	3.8	6.0	S
SSW	3.5	3.4	2.9	4.6	5.6	8.3	11.4	9.5	8.6	7.3	5.7	5.4	6.4	SSW
SW	7.1	6.1	4.3	5.7	5.3	6.2	6.7	8.6	9.2	8.5	8.4	10.0	7.2	SW
WSW	9.6	6.6	4.3	6.8	6.2	5.7	7.7	9.3	10.6	9.6	7.4	10.2	7.8	WSW
W	13.4	10.2	9.3	7.6	9.9	7.9	8.1	10.9	12.8	11.2	12.3	14.9	10.7	W
WNW	10.3	11.8	10.2	8.5	7.8	7.8	7.5	8.9	10.3	10.7	12.7	12.5	9.9	WNW
NW	12.3	17.4	17.6	15.2	10.6	9.4	8.1	7.6	9.9	11.6	9.6	11.6	11.7	NW
NNW	2.6	3.6	5.3	4.5	4.8	2.4	2.1	2.2	3.3	4.0	3.6	4.3	3.6	NNW
Calm	3.3	3.7	3.5	5.0	4.8	5.9	6.1	4.3	4.5	4.2	4.0	3.1	4.4	Calme

MEAN WIND SPEED IN KILOMETRES PER HOUR
VITESSE MOYENNE DES VENTS EN KILOMETRES PAR HEURE

	JAN JANV	FEB FEV	MAR MARS	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEP SEPT	OCT OCT	NOV NOV	DEC DEC	YEAR ANNUEL	
N	22.0	21.1	23.6	22.8	21.8	15.0	16.2	13.9	15.5	19.6	19.0	20.3	19.2	N
NNE	26.6	24.8	29.3	27.6	21.7	19.1	15.3	17.1	17.5	22.3	18.9	20.4	21.7	NNE
NE	22.2	19.8	24.4	21.5	17.8	17.0	12.6	14.6	14.5	18.0	15.5	17.4	17.9	NE
ENE	24.7	26.8	29.2	25.2	17.1	18.4	17.3	17.4	17.6	18.8	19.0	24.1	21.3	ENE
E	17.7	21.0	20.8	17.7	13.8	15.1	12.5	15.1	13.9	13.7	15.1	17.0	16.1	E
ESE	19.2	25.0	23.6	20.5	17.8	13.9	12.5	12.7	13.3	13.6	16.0	17.8	17.2	ESE
SE	17.0	16.4	17.2	14.1	13.0	11.8	12.3	11.9	10.2	12.7	14.9	16.7	14.0	SE
SSE	22.6	20.2	20.8	16.5	16.9	15.3	14.8	15.0	13.1	18.6	21.3	20.1	17.9	SSE
S	19.6	17.5	18.5	18.6	18.7	17.1	16.5	15.3	16.5	16.2	19.7	16.9	17.6	S
SSW	23.0	23.2	25.2	23.0	21.9	20.9	21.2	20.3	21.8	21.3	21.7	23.2	22.2	SSW
SW	22.4	23.2	24.8	21.0	20.1	19.3	19.8	18.5	19.4	18.4	21.7	23.3	21.0	SW
WSW	30.5	29.9	28.5	25.9	24.0	27.4	24.4	25.7	26.1	25.6	27.1	28.8	27.0	WSW
W	29.5	27.4	27.9	22.3	22.6	25.7	22.2	24.9	24.3	26.0	26.2	27.0	25.5	W
WNW	32.1	31.9	31.7	28.2	24.3	26.5	23.4	23.9	26.2	27.1	29.9	31.8	28.1	WNW
NW	27.0	28.3	27.2	25.4	20.3	21.0	19.5	18.3	19.6	21.4	24.3	23.4	23.0	NW
NNW	25.4	25.1	26.0	26.0	22.1	18.9	18.0	18.6	21.5	22.9	24.8	23.4	22.7	NNW
All Directions / Toutes directions	24.8	24.7	25.7	22.2	19.2	18.5	17.4	18.3	19.5	20.5	21.8	23.6	21.4	
Maximum Hourly Speed / Vitesse horaire maximale	105 SSE	85 W	84 WNW	93 WNW	68 SSE	68 ENE	71 WSW	72 W	84 WSW	64 SVL	89 WNW	89 NW	105 SSE	

Height of anemometer 13.1 m hauteur de l'anemometre

STATION INFORMATION

Generally flat country in the immediate area with the large Buchan's Lake immediately west. Surrounding are hills 100-200 m higher.

DONNÉES RELATIVES A LA STATION

Dans la région immediate, le paysage est en géneral plat; le grand lac de Buchan se trouve immediatement à l'ouest. Les collines avoisinantes dominent de 100 a 200 m.

WIND DATA FOR BUCHANS
MAXIMUM HOURLY WINDS BY MONTH AND SECTOR

YR	MTH	02	05	07	09	11	14	16	18	20	23	25	27	29	32	34	36
53	1	26	26	10	35	32	45	35	45	55	35	64	80	58	45	58	27
53	2	42	48	35	29	39	35	74	58	48	51	68	74	55	42	32	45
53	3	51	48	39	32	26	35	42	35	29	51	58	45	51	64	42	42
53	4	19	42	32	32	35	29	56	55	48	29	40	42	48	42	26	34
53	5	51	48	23	48	6	23	19	32	32	26	10	55	32	48	55	48
53	6	-9	26	10	19	16	16	19	32	35	48	48	64	48	51	32	-9
53	7	-9	32	23	19	19	19	29	35	35	48	48	51	29	29	16	10
53	8	23	26	16	13	29	23	23	39	39	51	56	45	55	39	23	29
53	9	26	29	6	13	10	42	42	42	39	48	48	58	45	48	19	32
53	10	58	48	35	19	16	39	32	32	39	51	39	45	45	35	16	23
53	11	26	48	16	16	13	23	26	32	61	42	39	35	55	32	16	29
53	12	39	45	32	32	32	35	19	48	42	45	64	72	55	51	48	29
54	1	-9	56	26	45	42	48	48	35	23	42	40	72	56	56	56	40
54	2	68	80	42	26	26	26	23	32	26	39	39	64	55	61	-9	42
54	3	40	29	29	23	32	29	6	42	32	48	55	64	55	64	64	19
54	4	29	19	10	13	13	23	23	45	45	42	42	51	48	42	39	26
54	5	39	39	35	29	32	26	29	39	26	32	32	48	45	42	48	39
54	6	32	26	19	19	19	26	39	42	39	45	23	19	19	48	19	29
54	7	19	32	23	35	32	24	29	35	48	39	45	48	29	19	16	10
54	8	39	40	23	26	29	26	10	29	29	45	45	45	39	39	19	45
54	9	-9	13	6	16	13	64	23	39	55	61	42	56	45	29	32	19
54	10	39	39	35	16	19	32	35	32	42	39	51	61	64	64	39	39
54	11	45	51	39	26	29	45	45	45	55	80	64	64	55	48	39	45
54	12	45	48	45	29	35	29	45	42	45	51	45	48	39	29	32	48
55	1	51	58	35	26	42	16	29	42	51	56	56	58	58	55	39	51
55	2	39	29	26	23	48	58	51	48	39	48	61	64	64	48	39	19
55	3	42	39	42	48	48	35	61	48	58	61	56	48	64	72	32	35
55	4	45	42	35	16	26	26	19	19	19	26	32	39	48	45	39	39
55	5	39	45	42	32	39	32	35	55	42	26	39	61	58	42	42	45
55	6	32	45	35	23	23	19	32	39	42	42	39	42	39	32	26	35
55	7	35	39	26	19	13	23	19	42	42	42	71	45	48	48	29	29
55	8	32	35	42	32	6	19	23	35	35	39	48	48	42	51	29	26
55	9	48	58	35	42	23	26	39	55	48	61	84	64	64	61	48	19
55	10	48	48	29	29	19	29	29	29	35	42	48	51	48	51	56	56
55	11	19	48	56	48	16	42	29	42	42	56	56	58	48	48	23	19
55	12	58	68	51	26	6	19	32	16	35	80	48	72	64	48	48	51
56	1	55	45	35	39	29	45	32	42	42	48	42	48	58	48	39	48
56	2	39	42	42	51	35	48	42	35	48	64	55	48	61	55	45	42
56	3	48	39	42	45	10	42	51	48	48	48	61	51	72	74	48	45
56	4	64	55	26	45	26	42	42	64	32	71	29	35	51	51	42	42
56	5	48	45	32	26	35	26	32	45	35	48	45	58	64	48	29	26
56	6	39	42	35	19	16	23	35	48	42	32	58	55	48	55	48	35
56	7	19	19	19	29	29	32	39	32	39	45	51	58	55	35	29	16
56	8	29	26	23	26	29	29	32	32	42	39	58	45	39	45	26	29
56	9	23	29	32	29	29	19	32	45	39	35	64	48	45	29	23	19
56	10	29	35	16	16	16	45	45	40	39	35	64	64	51	51	45	40
56	11	42	42	42	23	16	32	42	48	45	48	42	45	45	45	45	42
56	12	45	26	13	29	35	32	32	56	72	72	56	64	56	58	45	45

57	1	45	72	64	51	16	19	23	26	48	56	61	58	77	64	72	51
57	2	48	48	72	39	39	24	35	35	40	45	40	61	77	64	35	39
57	3	48	48	64	32	42	32	13	16	35	35	40	39	39	64	55	48
57	4	32	26	48	56	45	32	26	26	32	45	51	58	93	64	39	32
57	5	48	45	35	29	26	26	32	32	29	45	64	64	48	39	39	45
57	6	32	29	29	32	32	19	39	35	39	32	35	61	51	58	40	32
57	7	23	23	26	23	19	26	32	45	55	40	42	45	42	32	32	29
57	8	10	13	16	10	16	23	32	35	51	45	71	72	45	40	16	16
57	9	40	29	26	23	26	19	19	26	56	56	51	51	51	40	48	40
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57	11	19	32	39	35	19	29	45	45	45	58	51	45	51	48	39	10
57	12	58	42	19	24	39	35	42	35	48	64	64	42	32	10	55	19
58	1	42	39	39	32	19	40	45	29	51	45	64	61	56	51	23	35
58	2	48	48	55	55	56	48	48	32	56	56	29	39	48	55	48	56
58	3	51	48	48	39	24	13	6	-9	-9	16	19	29	55	51	39	55
58	4	42	51	45	39	29	35	39	45	51	48	56	42	45	45	39	35
58	5	48	32	29	23	26	35	42	48	45	39	58	45	42	32	29	48
58	6	35	32	23	39	42	35	40	39	35	42	55	58	64	45	23	32
58	7	39	35	23	19	10	24	35	32	29	40	48	58	64	51	39	51
58	8	45	24	35	26	19	24	26	35	45	48	48	51	51	39	40	26
58	9	55	56	64	26	26	29	26	35	42	39	48	61	64	80	48	42
58	10	23	29	29	29	19	19	19	32	42	45	48	56	56	35	35	39
58	11	32	29	48	32	42	45	48	48	42	58	56	64	58	56	39	42
58	12	19	29	29	48	45	42	29	45	29	51	51	64	80	55	45	35
59	1	16	32	29	48	27	39	45	39	35	51	64	72	61	55	42	42
59	2	48	40	13	48	45	13	45	45	51	48	64	64	77	72	48	51
59	3	45	39	26	29	51	48	45	55	48	58	61	64	64	80	42	45
59	4	24	42	32	39	16	26	35	39	35	35	51	61	45	51	48	48
59	5	39	42	35	19	23	19	19	39	55	56	45	58	64	51	32	45
59	6	32	48	35	35	29	29	32	32	35	45	40	51	48	42	26	24
59	7	16	29	16	19	13	19	26	39	51	39	51	42	56	61	61	48
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59	10	26	29	23	19	35	32	40	39	42	42	51	56	56	56	29	19
59	11	42	29	40	35	39	35	39	58	61	64	64	51	48	39	39	32
59	12	32	26	16	26	26	26	32	29	35	39	56	51	61	56	40	32
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60	2	31	39	51	39	55	48	39	19	24	19	48	56	45	64	45	29
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60	4	48	35	19	32	35	23	23	42	56	64	58	61	55	56	45	40
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61	6	19	19	32	24	24	19	26	37	45	51	61	61	48	27	32	23
61	7	32	27	21	19	23	29	19	37	37	35	40	43	45	37	27	35
61	8	37	35	24	29	26	19	29	29	45	39	53	56	51	51	35	27
61	9	32	24	32	29	16	19	26	27	48	42	42	53	64	61	43	29
61	10	51	35	40	23	19	35	43	29	48	26	48	56	61	42	48	40
61	11	45	51	48	24	24	16	32	21	26	37	37	39	35	35	37	19
61	12	35	19	35	45	43	51	40	24	29	39	51	55	77	89	56	72
62	1	35	42	21	29	29	48	48	48	56	48	80	72	80	93	40	13
62	2	61	60	56	32	29	23	35	45	51	58	48	48	72	72	72	61
62	3	60	80	80	42	19	11	13	21	27	27	35	40	53	56	51	48
62	4	53	48	45	48	53	35	27	29	56	40	53	37	64	40	48	45
62	5	27	32	21	16	23	19	43	29	32	35	48	43	37	48	53	35
62	6	40	37	68	48	16	26	29	27	40	-9	53	40	61	64	48	23
62	7	23	48	51	29	32	42	39	32	42	51	53	48	29	29	26	26
62	8	23	29	40	21	32	27	29	29	48	43	61	56	53	45	27	16
62	9	29	48	32	32	32	35	37	24	29	35	45	35	51	40	35	32
62	10	56	43	48	32	35	23	53	45	48	55	64	53	56	48	40	32
62	11	43	37	35	27	35	37	55	48	84	29	64	55	51	48	39	37
62	12	29	51	56	24	27	32	27	37	53	35	45	45	74	51	48	35
63	1	64	61	72	37	51	45	105	64	60	45	72	56	61	21	60	51
63	2	51	64	77	35	27	29	35	32	61	61	77	56	64	51	48	13
63	3	37	53	56	16	37	24	32	27	42	45	51	48	84	68	56	42
63	4	43	45	61	45	51	27	32	23	40	29	51	51	64	61	53	53
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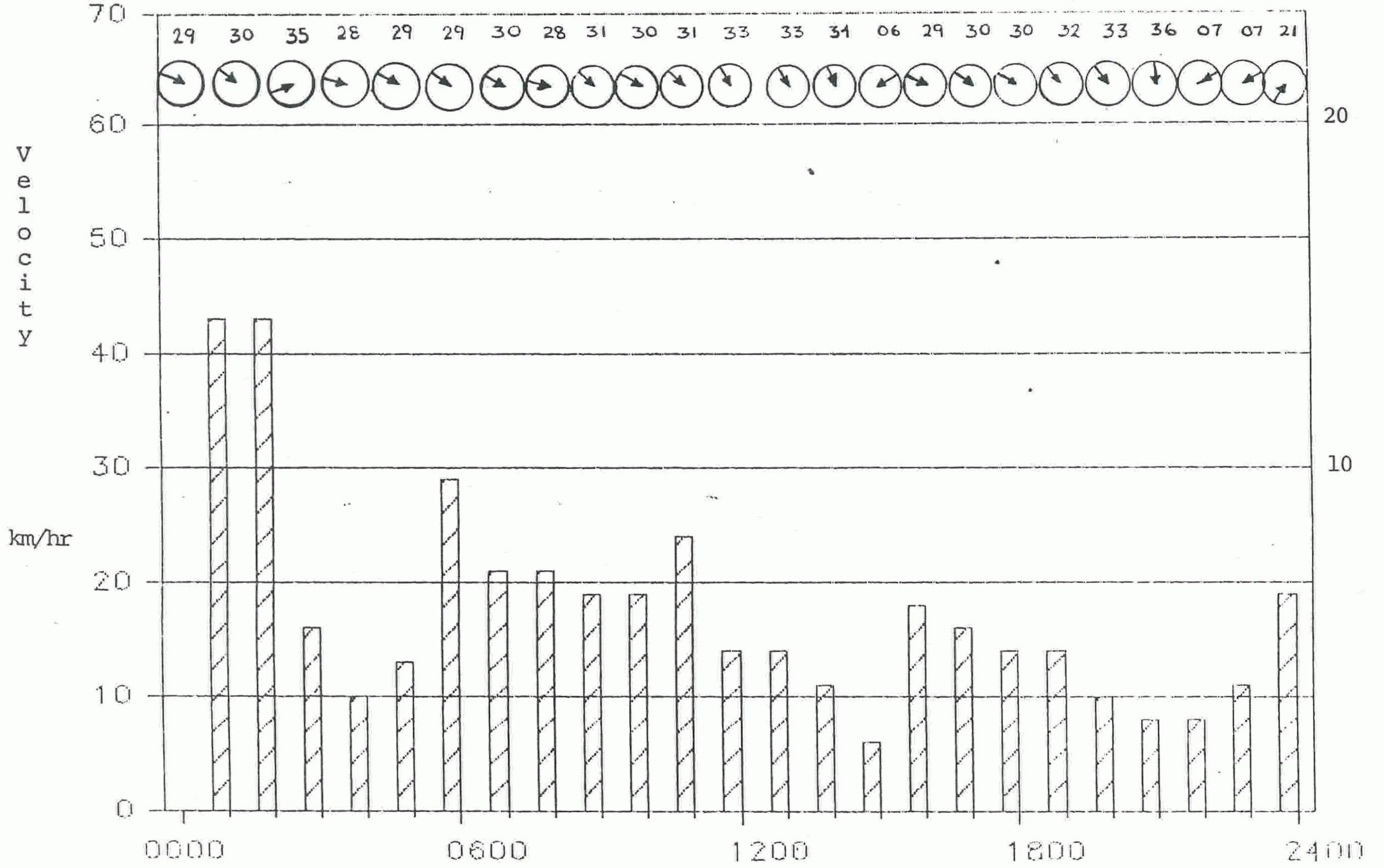
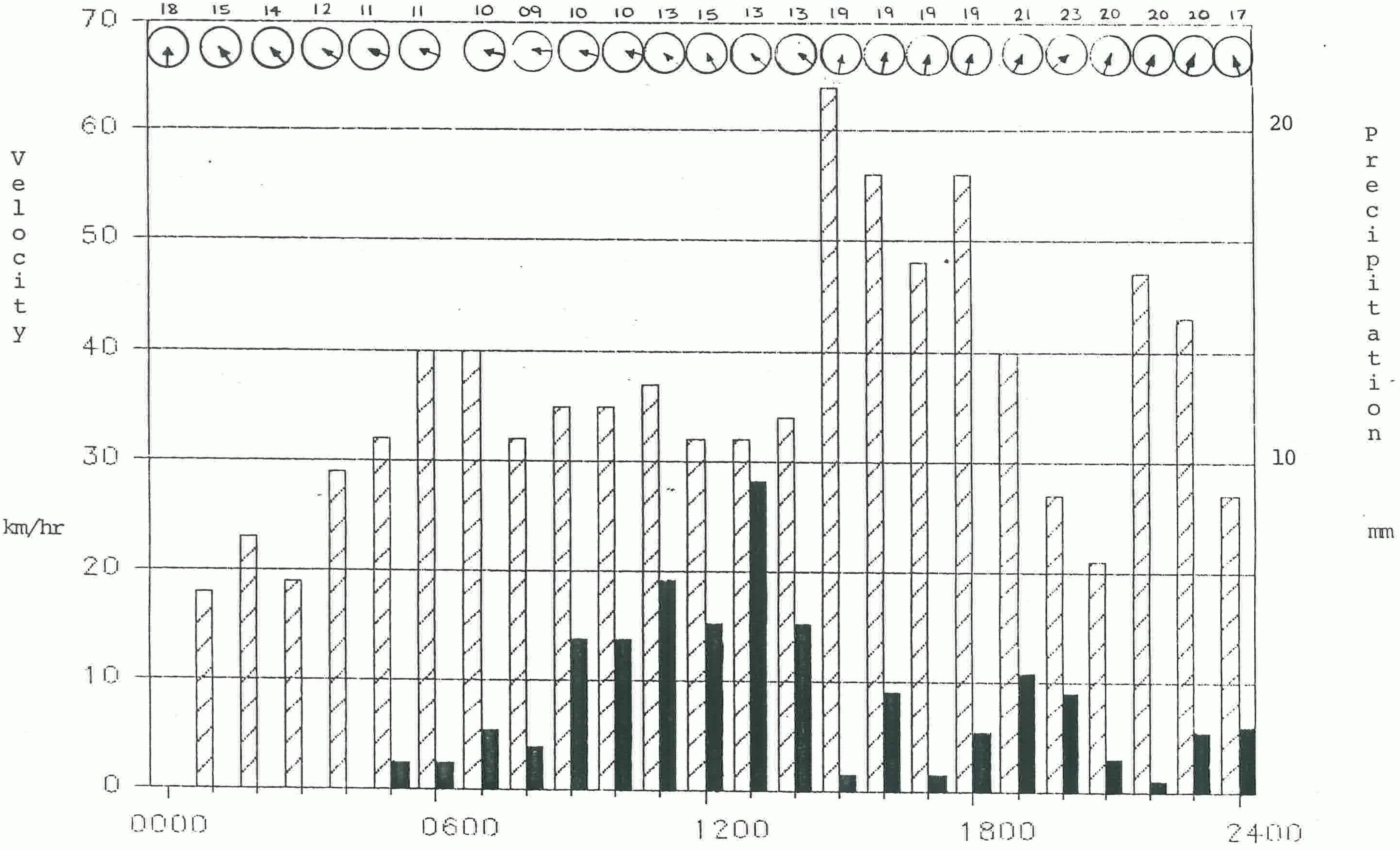
63	10	37	45	51	24	32	27	35	43	42	43	53	53	53	37	35	32
63	11	40	37	35	27	42	48	45	29	53	40	61	72	89	55	53	45
63	12	26	43	72	48	43	40	40	51	68	60	53	72	68	43	29	16
64	1	53	29	24	29	27	45	51	43	45	48	51	60	77	60	43	40
64	2	61	58	72	39	45	45	43	24	27	37	80	85	53	72	60	64
64	3	61	43	60	45	37	48	32	45	45	68	72	64	68	61	60	35
64	4	51	51	43	43	24	21	35	32	40	51	64	69	64	76	77	43
64	5	27	27	27	27	32	29	40	40	40	35	61	61	45	35	37	48
64	6	37	45	43	35	26	21	43	37	48	29	51	45	43	37	37	11
64	7	27	27	29	24	27	21	24	32	43	32	51	51	43	37	29	19
64	8	37	43	29	29	24	29	32	32	29	43	51	51	51	39	43	45
64	9	35	19	21	42	24	13	16	21	76	32	72	56	48	43	48	45
64	10	40	27	27	24	26	35	35	32	40	56	48	48	45	45	40	27
64	11	32	32	35	19	26	27	53	32	35	26	42	40	60	58	64	45
64	12	64	60	53	35	19	24	60	51	45	56	53	56	56	45	35	29
65	1	45	35	37	37	51	24	32	37	40	60	64	97	77	69	35	51
65	2	63	45	51	40	40	35	32	45	56	48	51	51	61	69	68	69
65	3	48	51	53	35	35	21	26	13	27	27	68	77	84	80	43	48
65	4	72	60	27	16	16	32	32	27	32	40	48	48	53	56	45	40
65	5	37	35	27	16	23	21	24	27	24	24	29	40	45	56	45	45
65	6	37	40	45	32	27	24	35	43	37	42	61	45	51	53	43	27
MAX		72	80	77	56	56	64	105	64	84	80	80	97	93	93	77	69

APPENDIX B
PLOTS OF STORMS

1973 STORM PERIOD
DATA RECORDED AT BURGEO
PERIOD: 73 02 02 TO 73 02 12


70
60
50
40
30
20
10
0
Velocity
km/hr
20
10
Precipitation
mm
29
30
35
28
29
29
30
28
31
30
31
33
33
34
06
29
30
30
32
33
36
07
07
21
0000
0600
1200
1800
2400

73 02 02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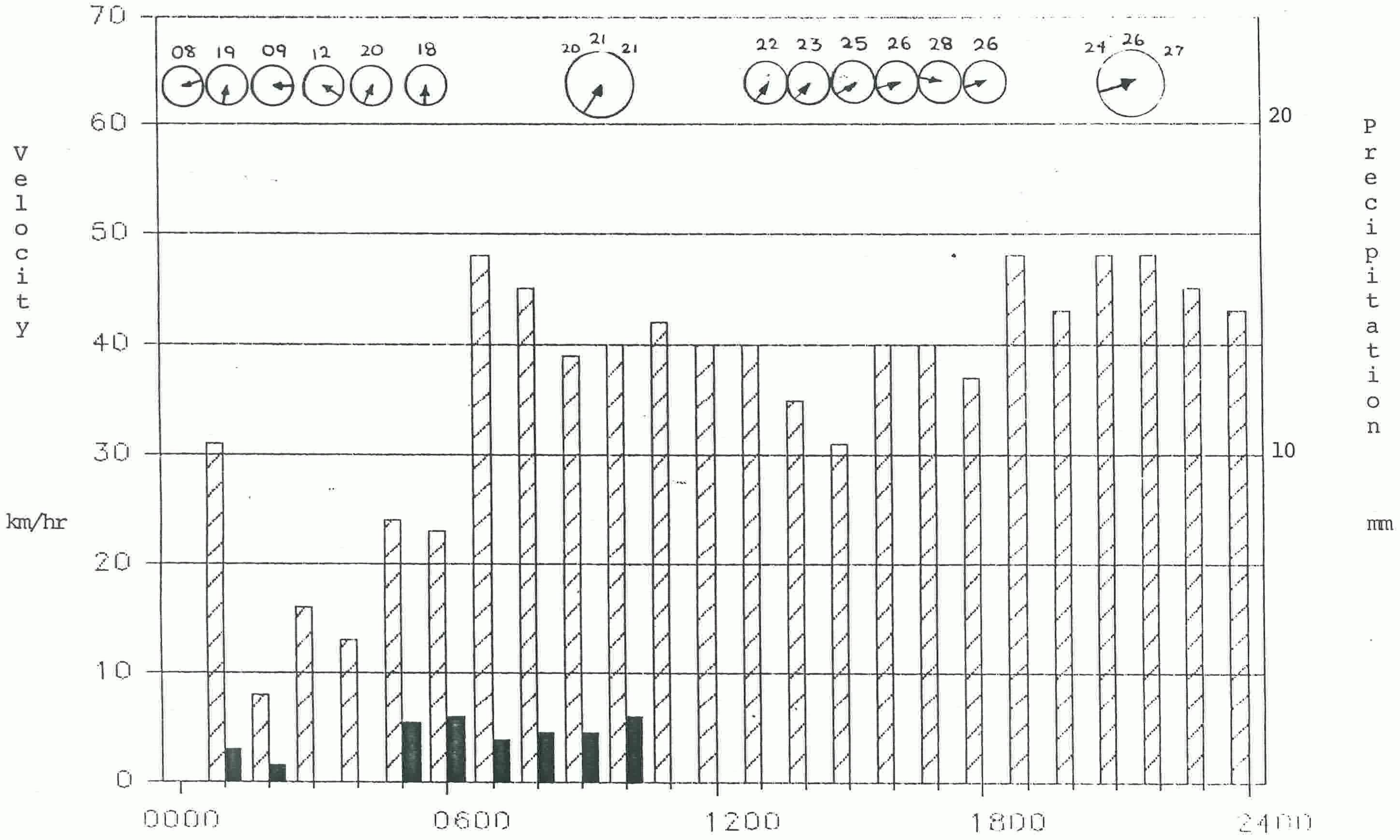
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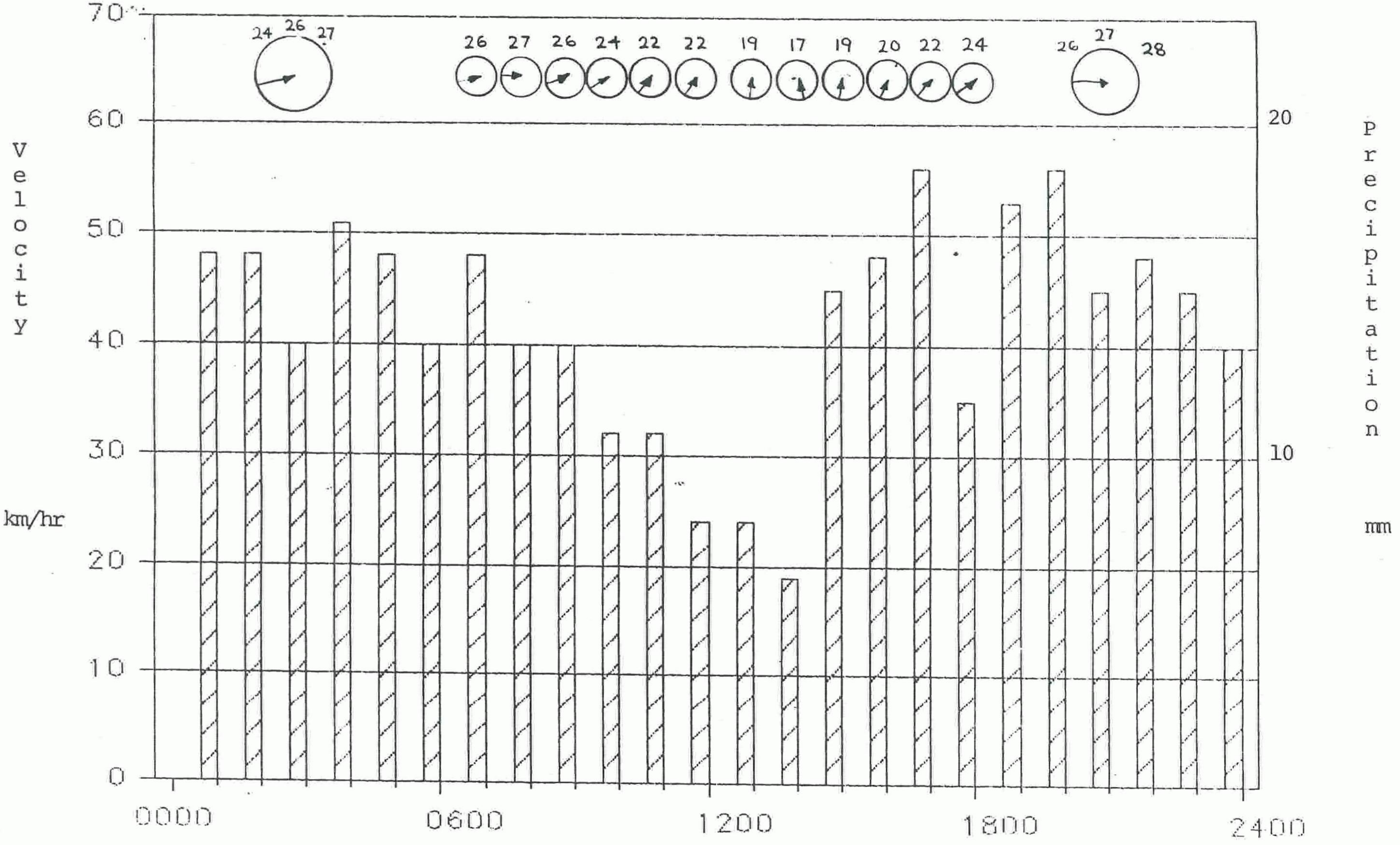
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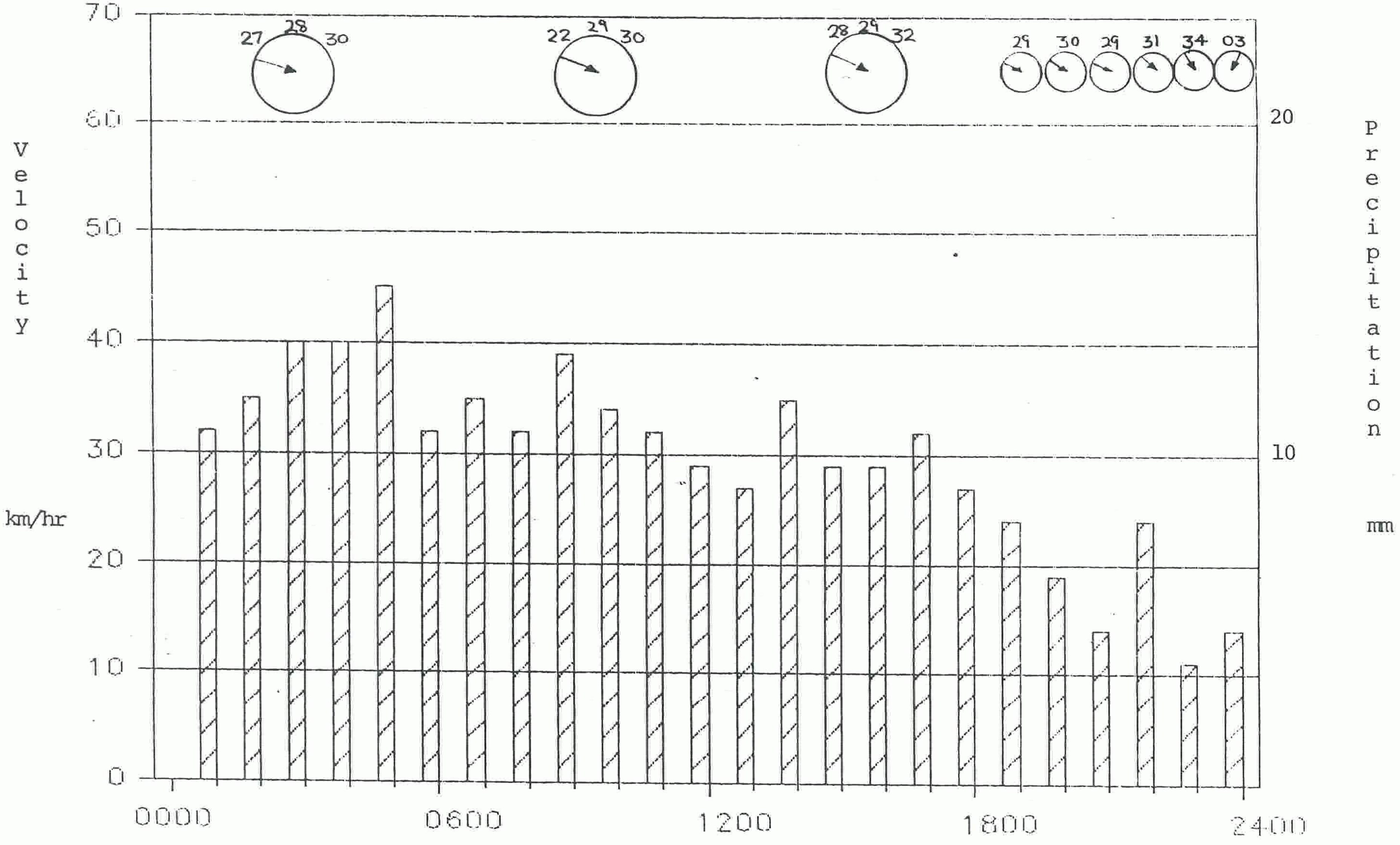
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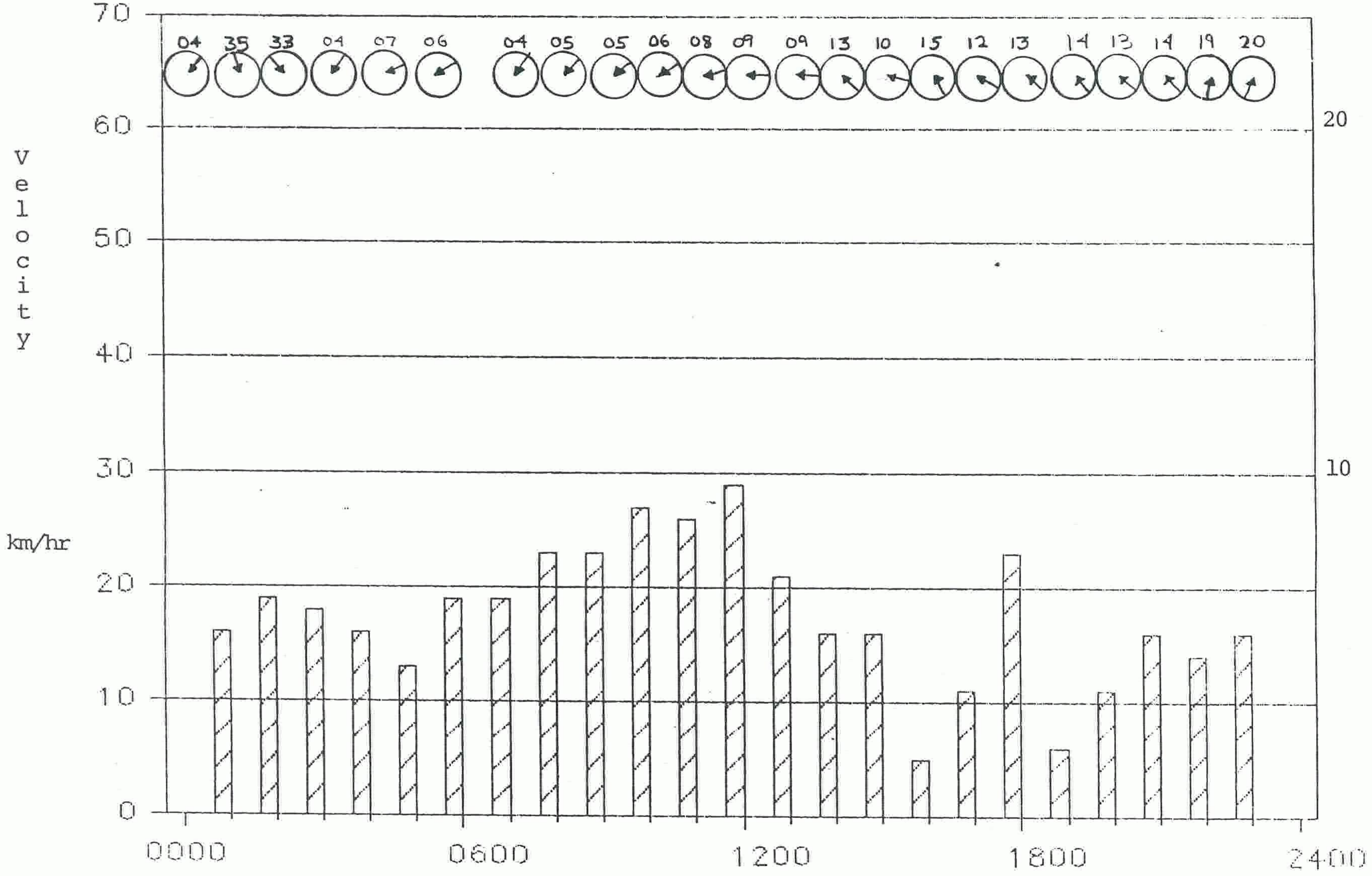
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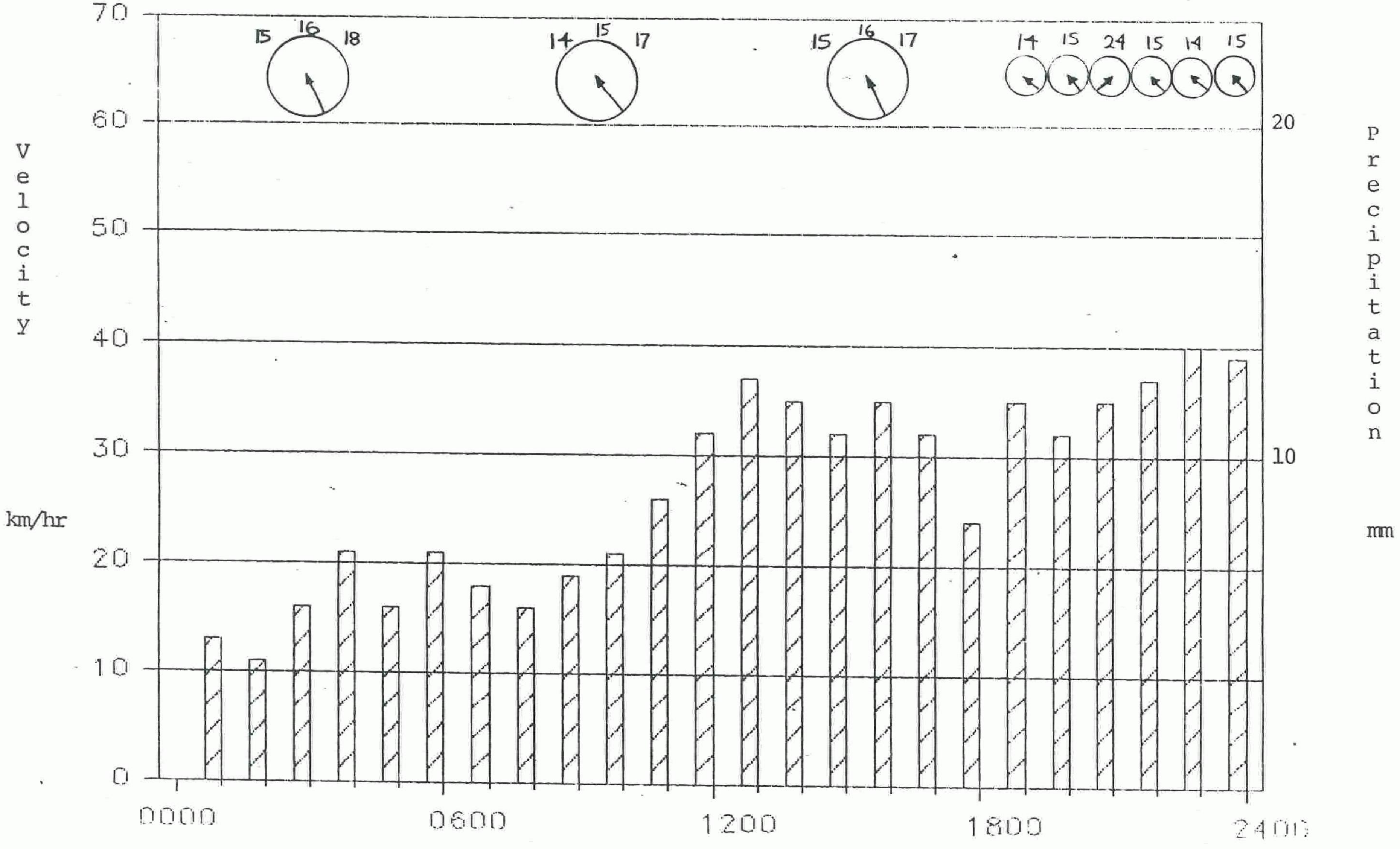
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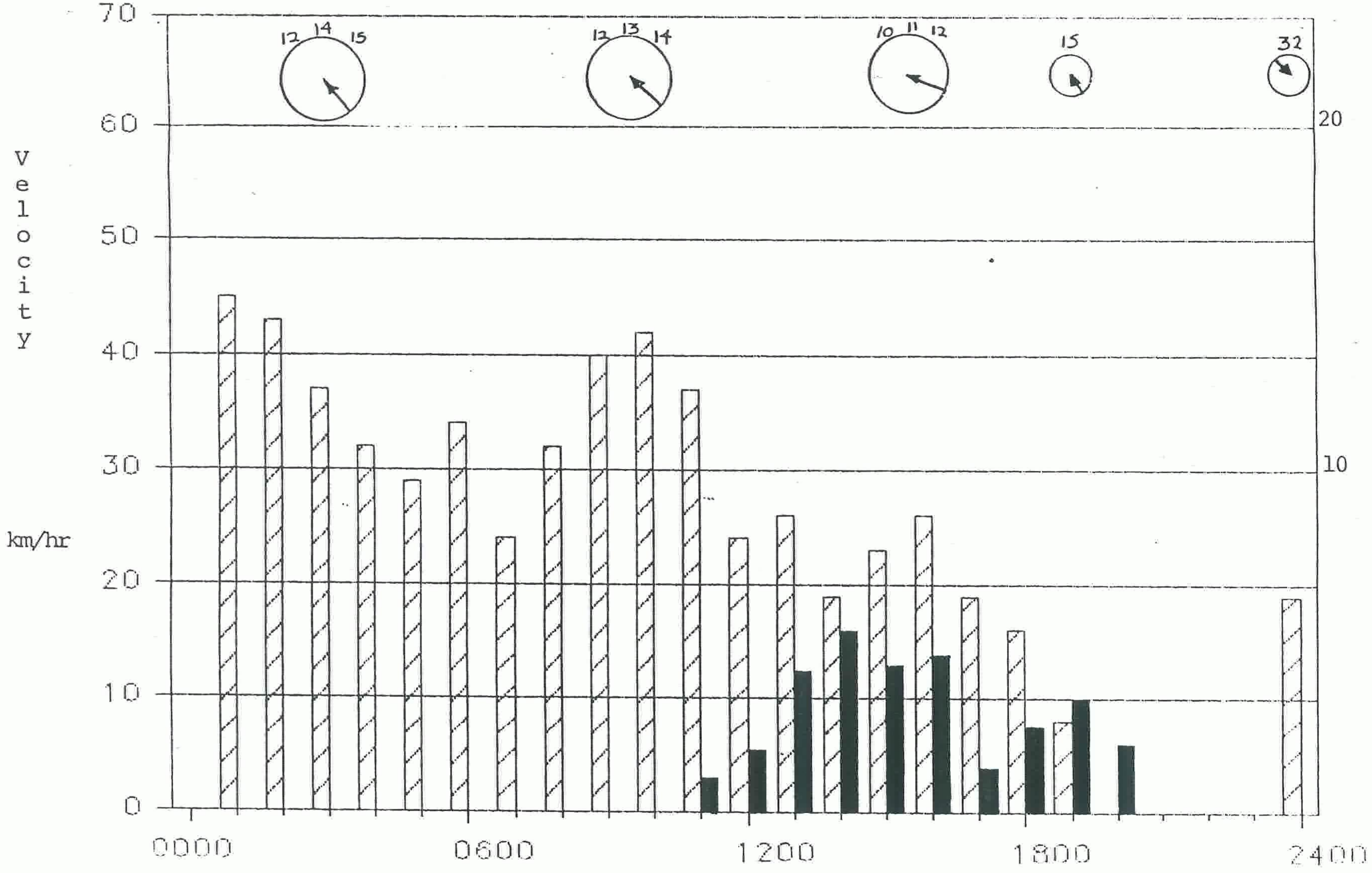
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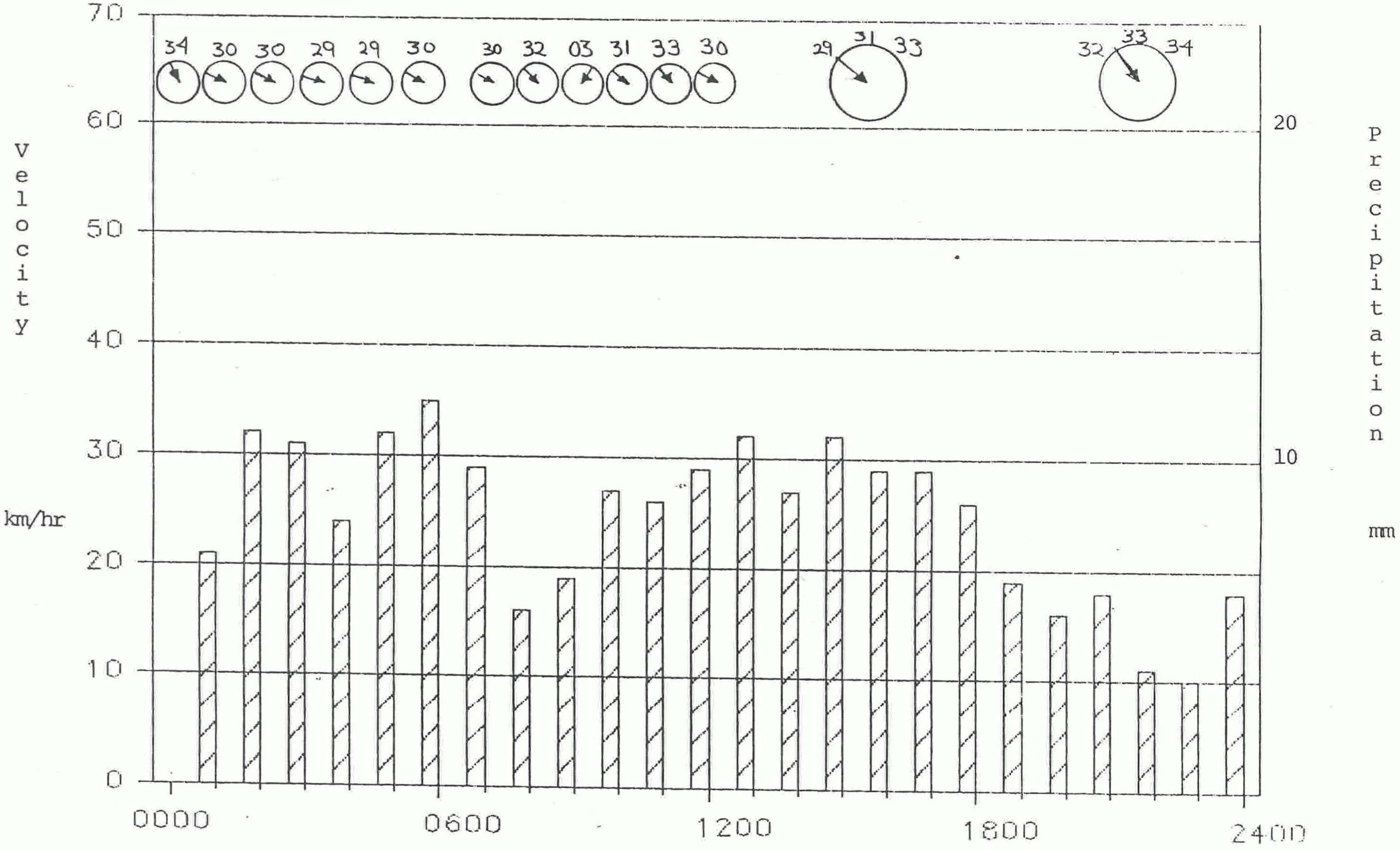
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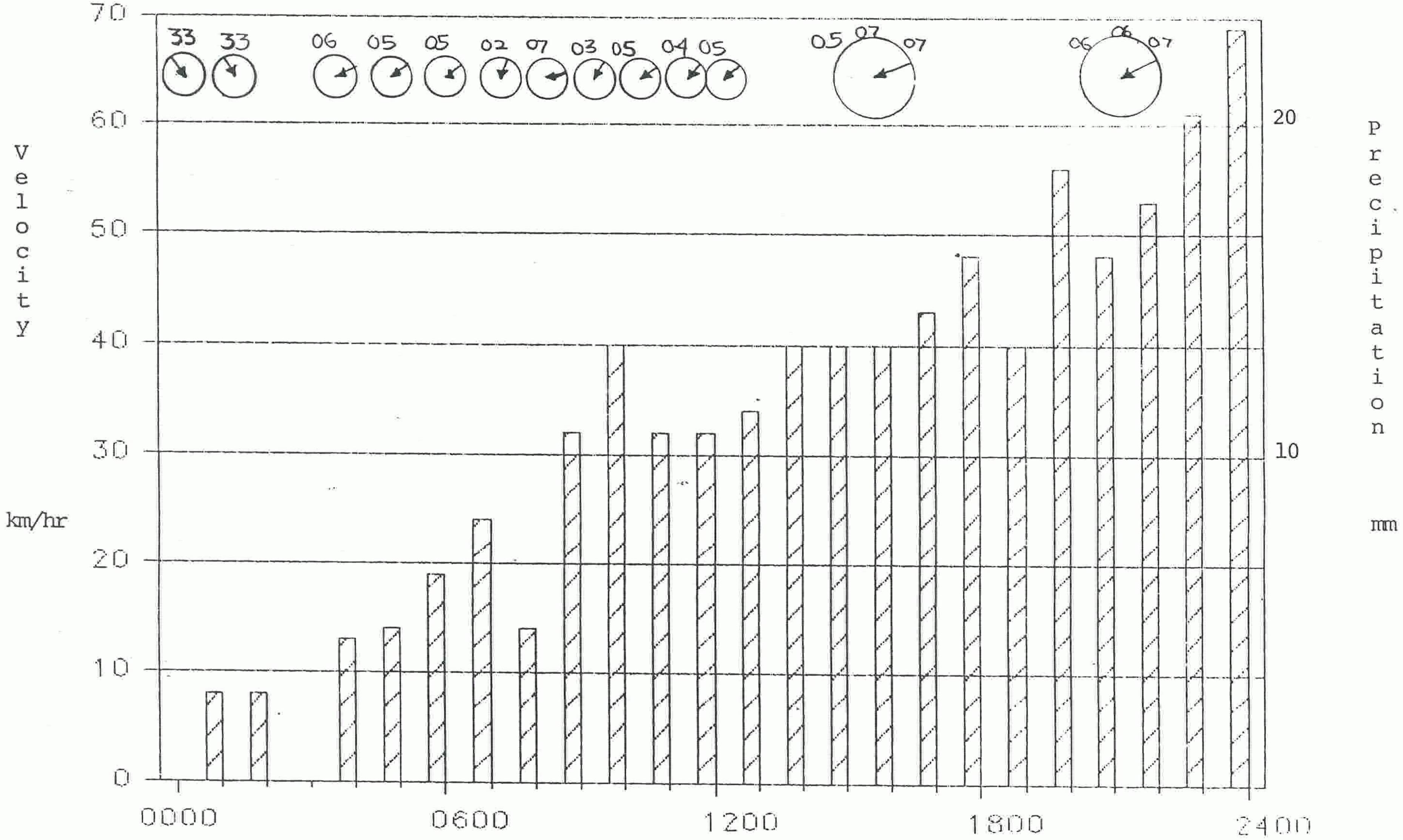
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km/hr
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Precipitation
mm
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2400

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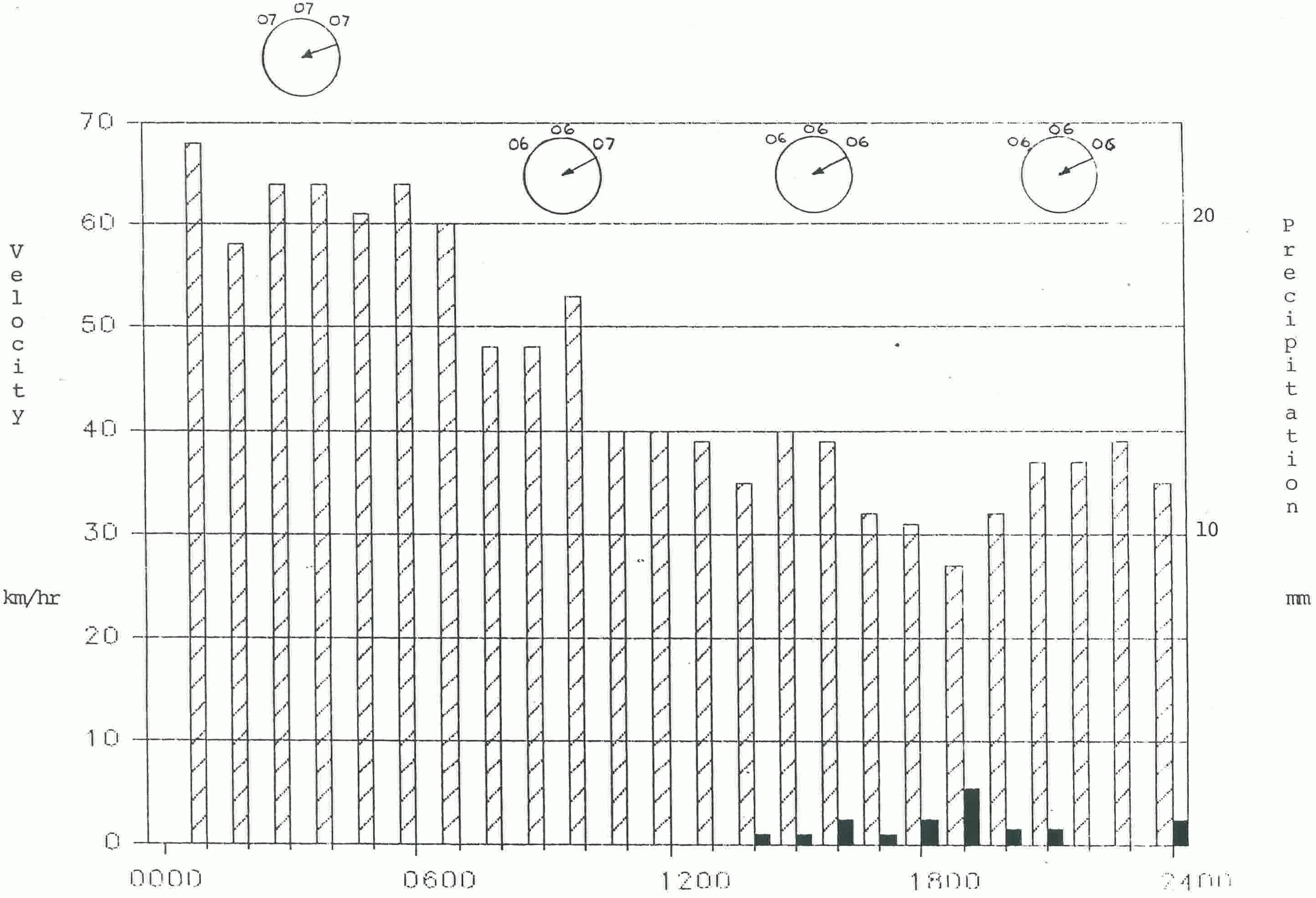
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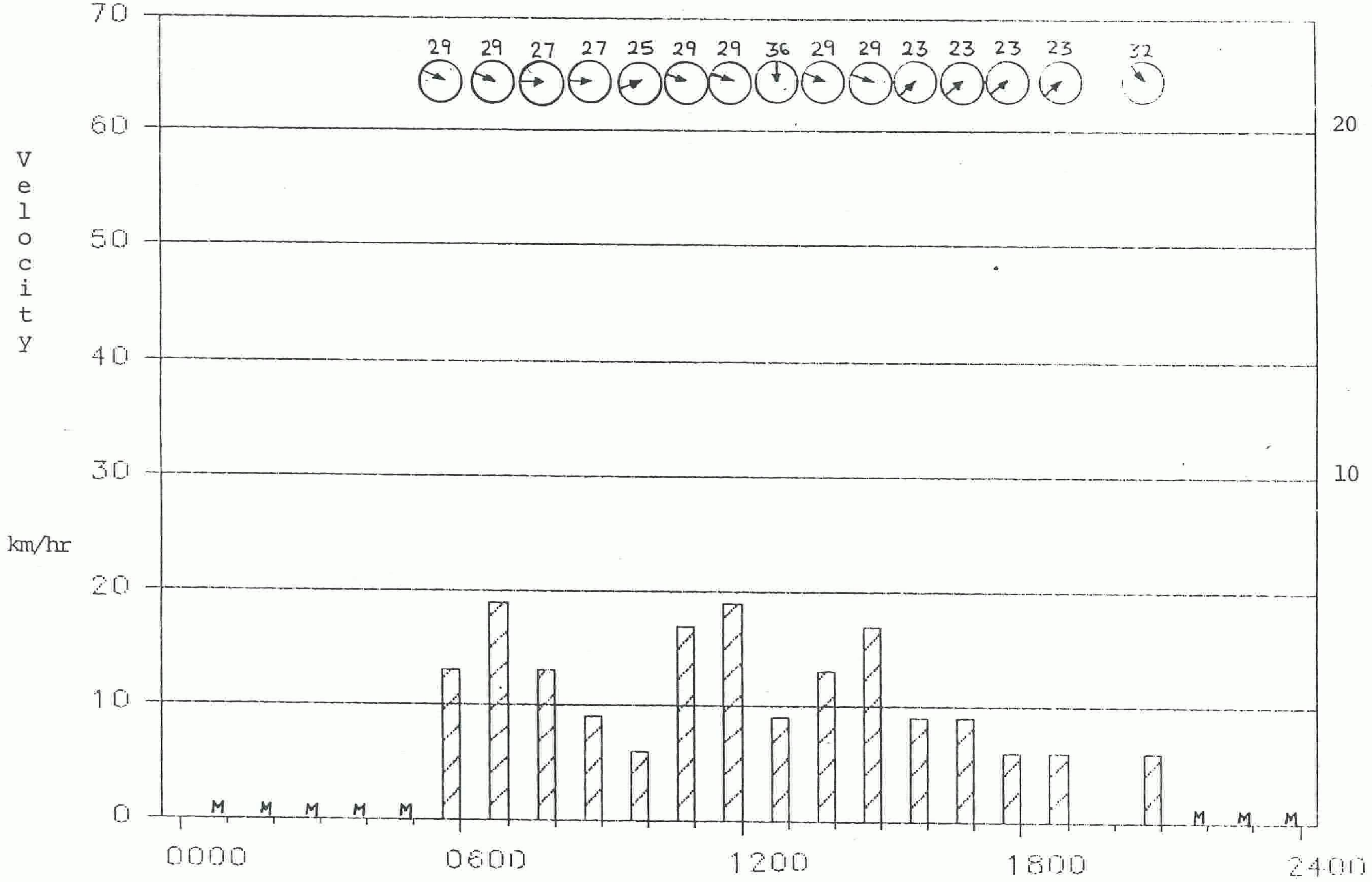
73 02 12

1978 STORM PERIOD
DATA RECORDED AT ST. ALBANS
PERIOD: 78 01 13 TO 78 01 23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Precipitation
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29
36
29
29
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1800
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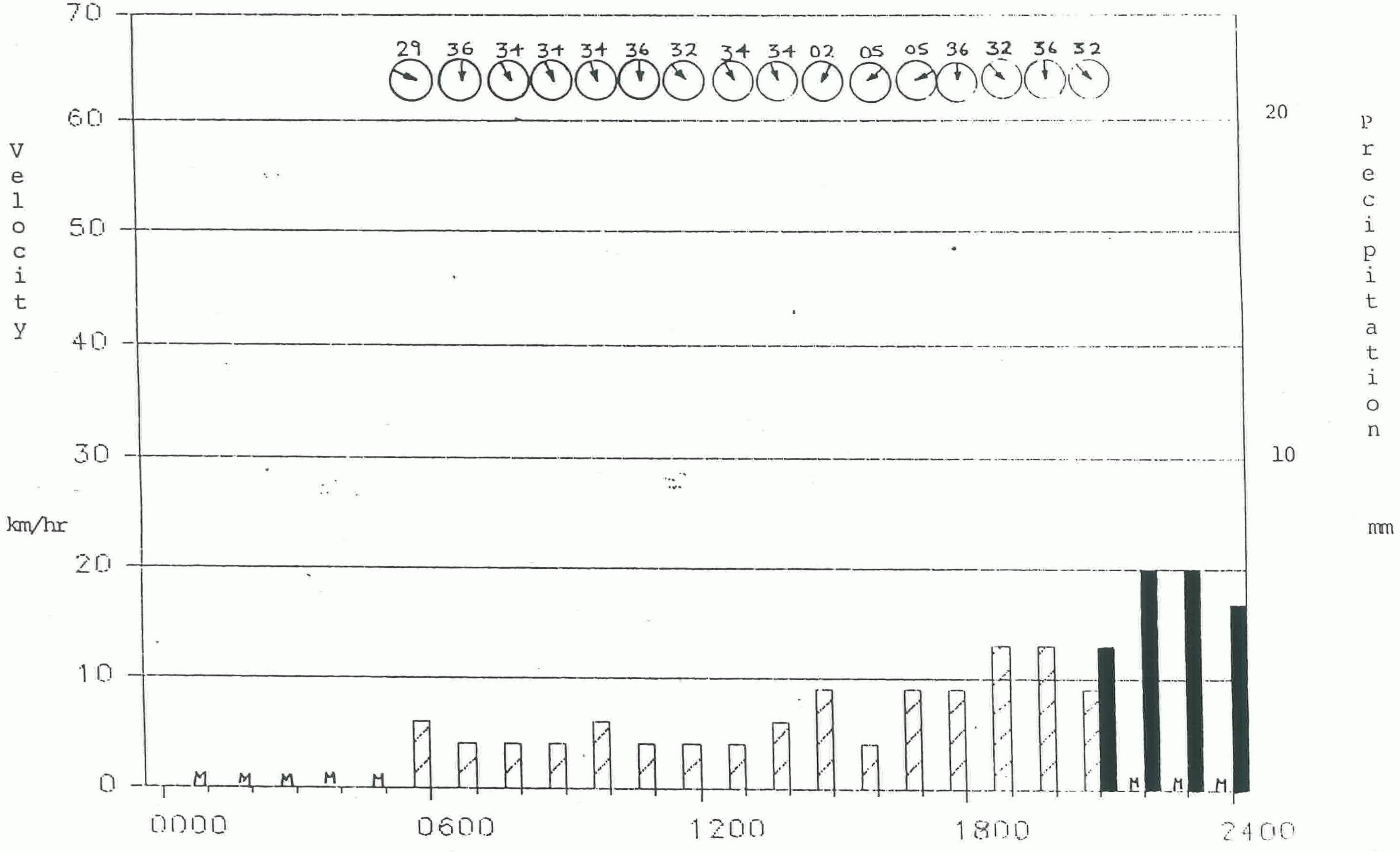
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Velocity
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40
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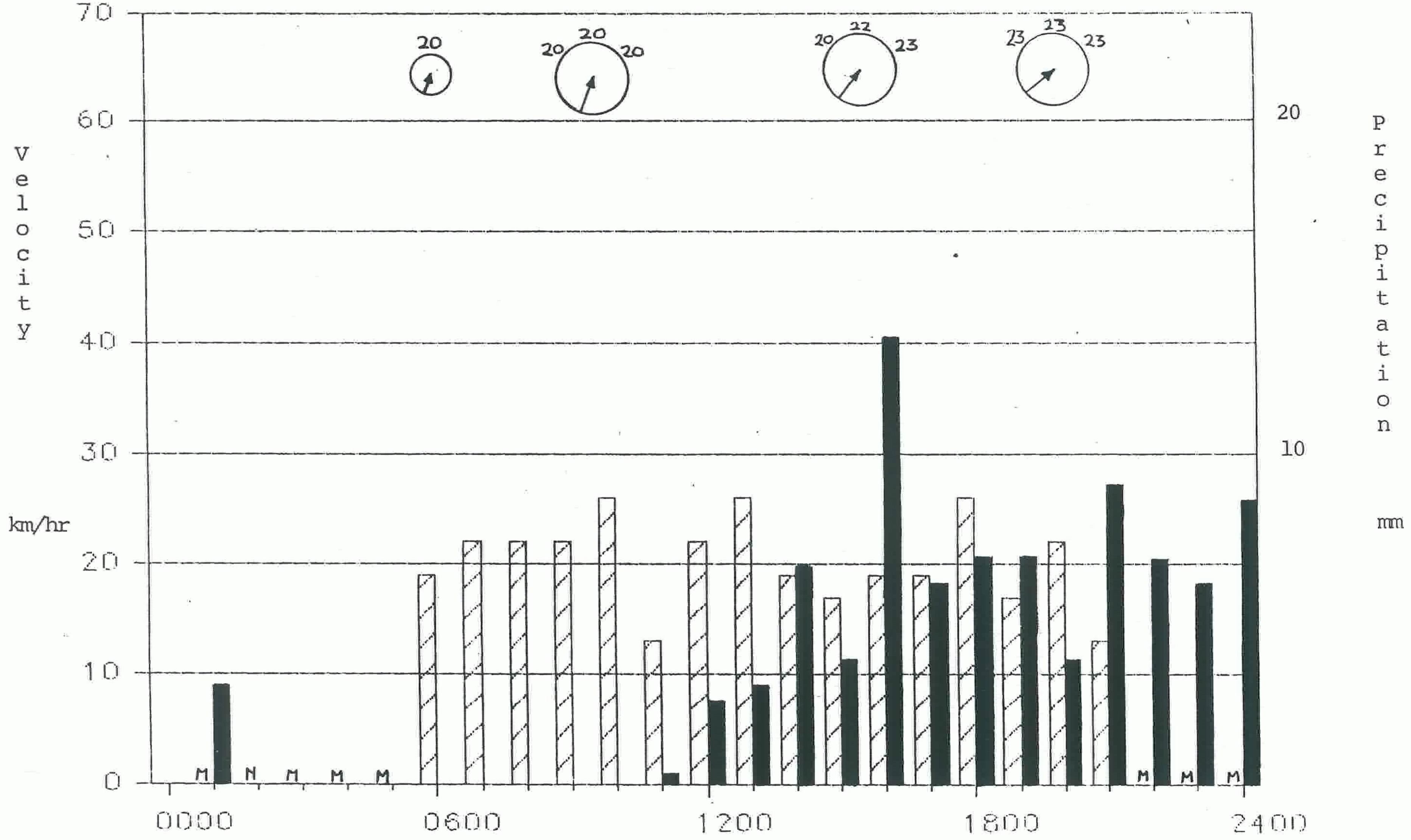
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Precipitation
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1800
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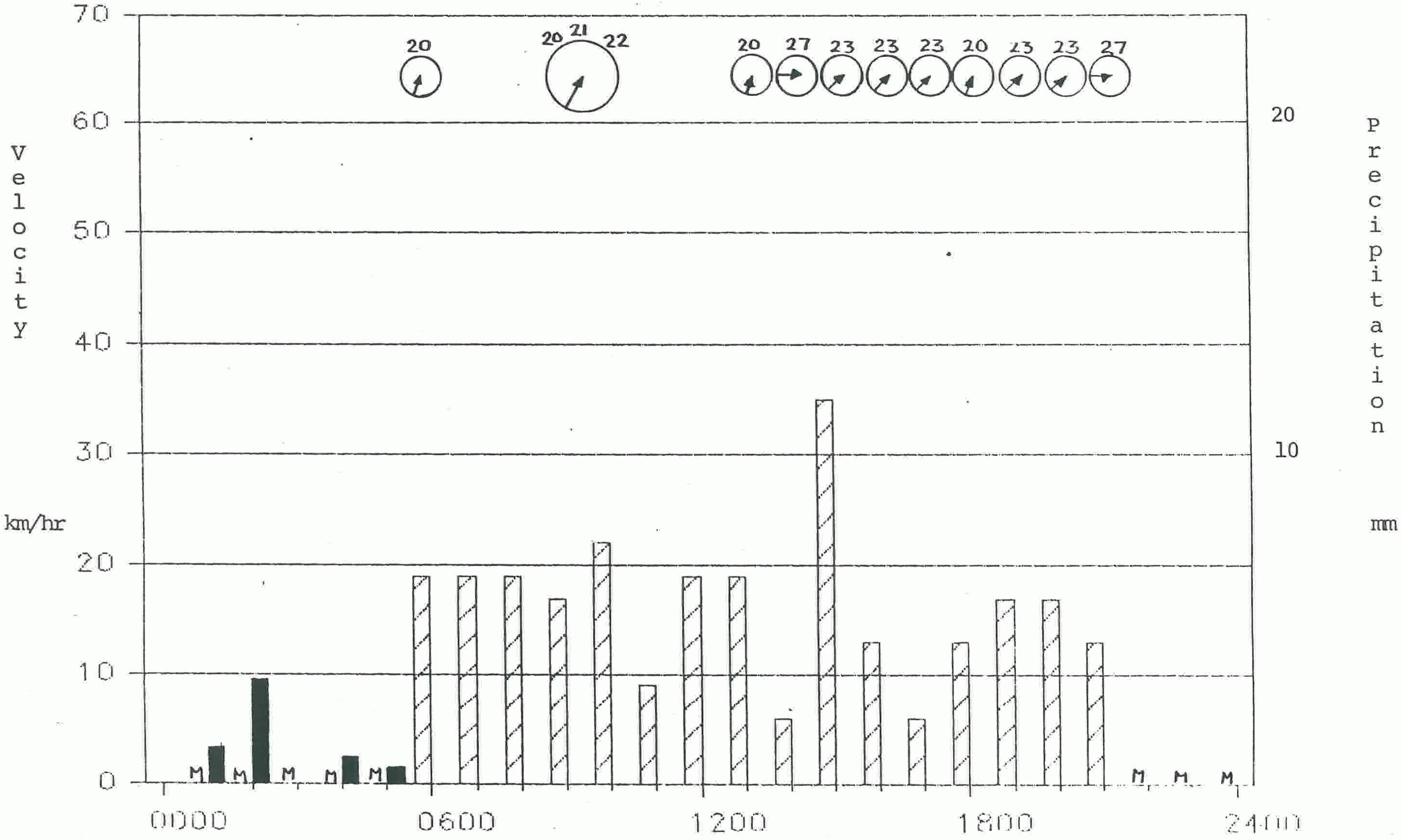
78 01 15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Precipitation
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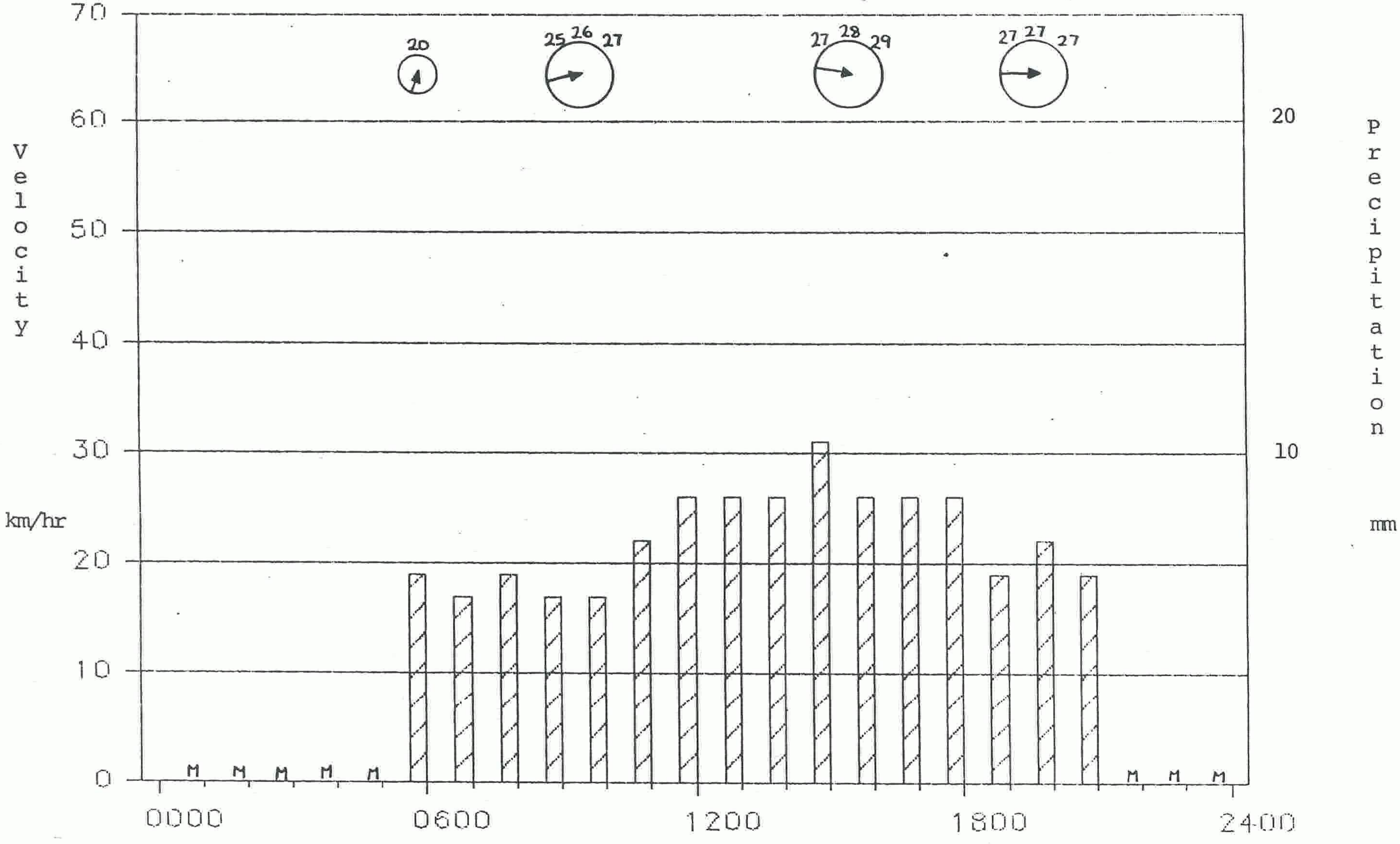
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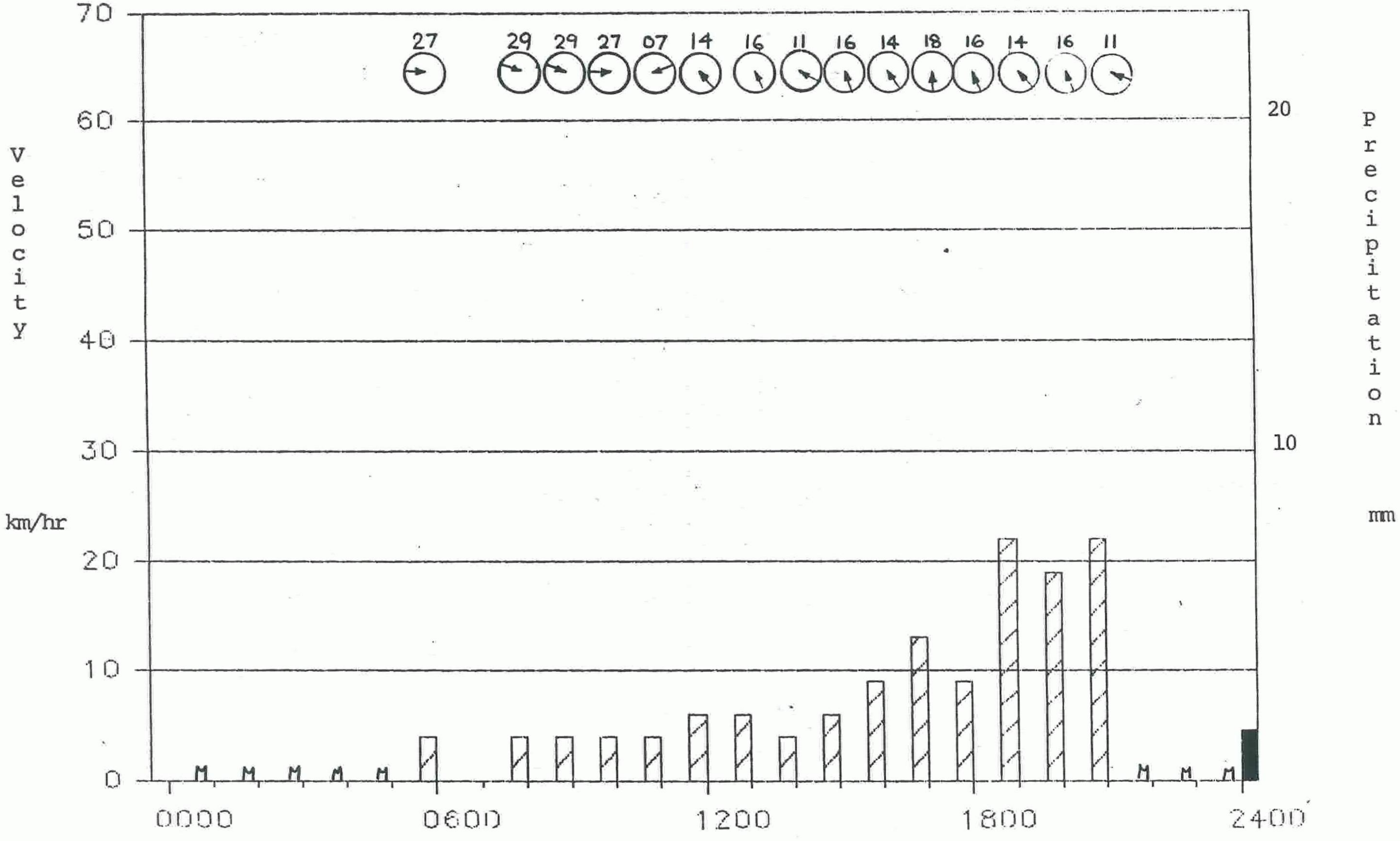
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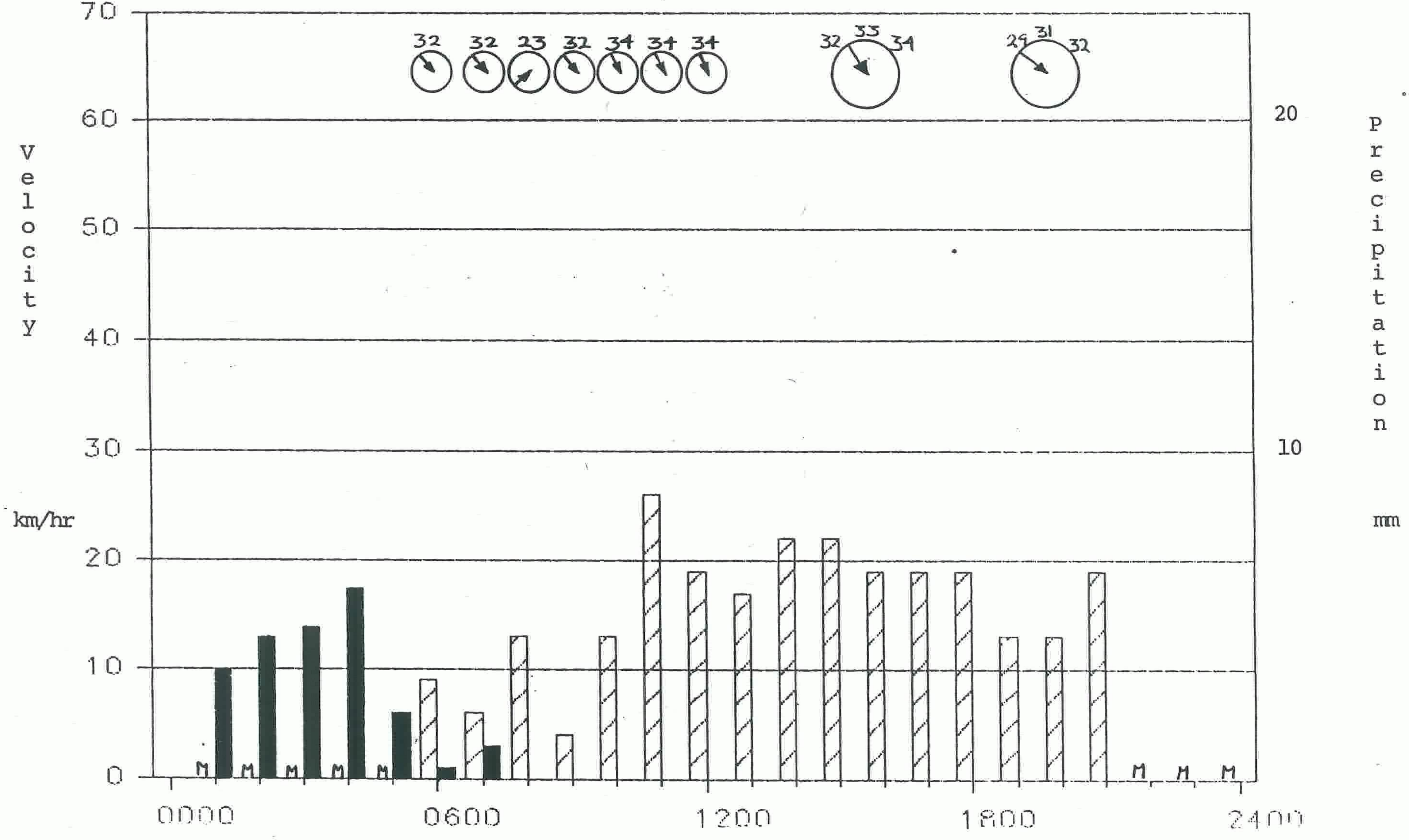
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M

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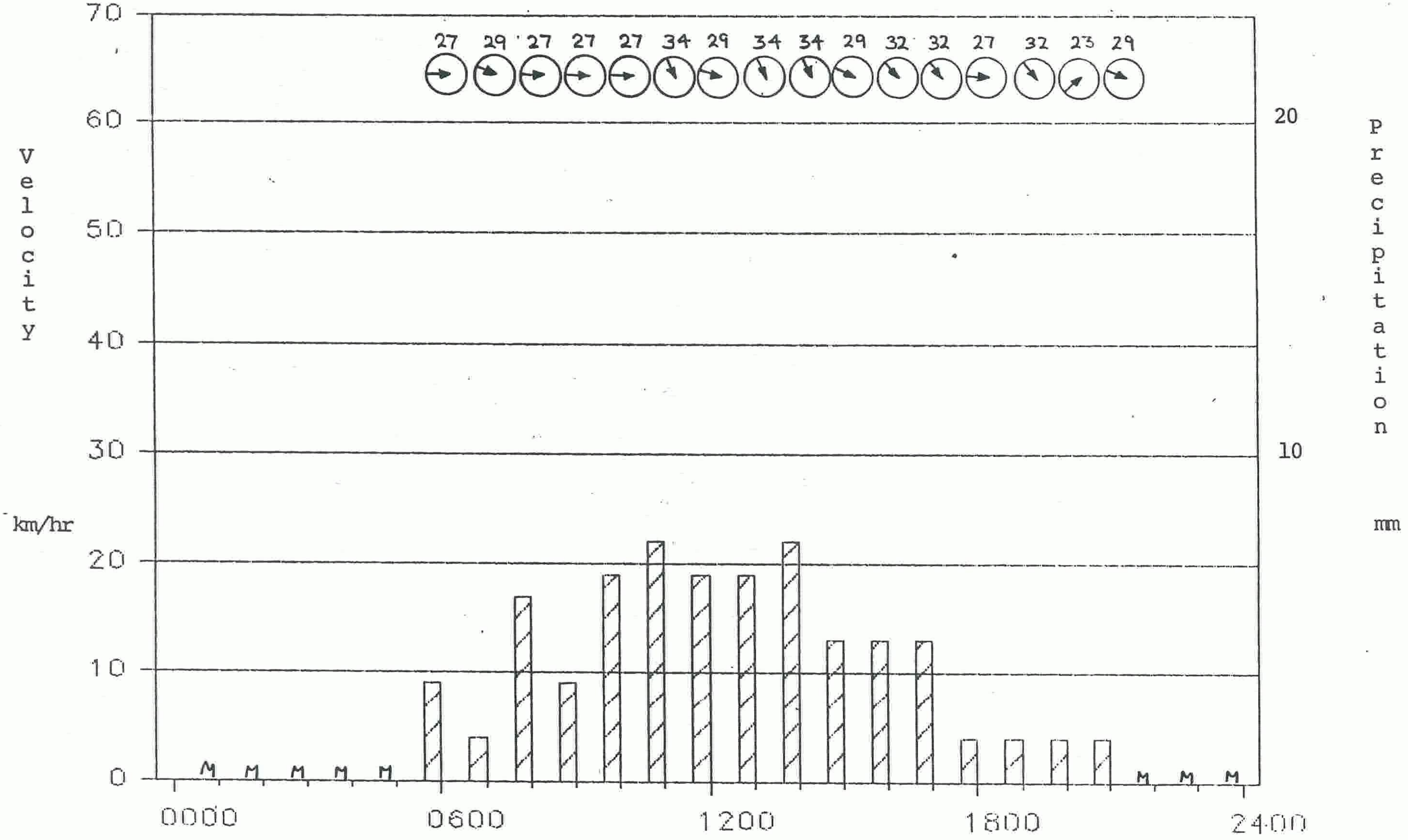
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1800
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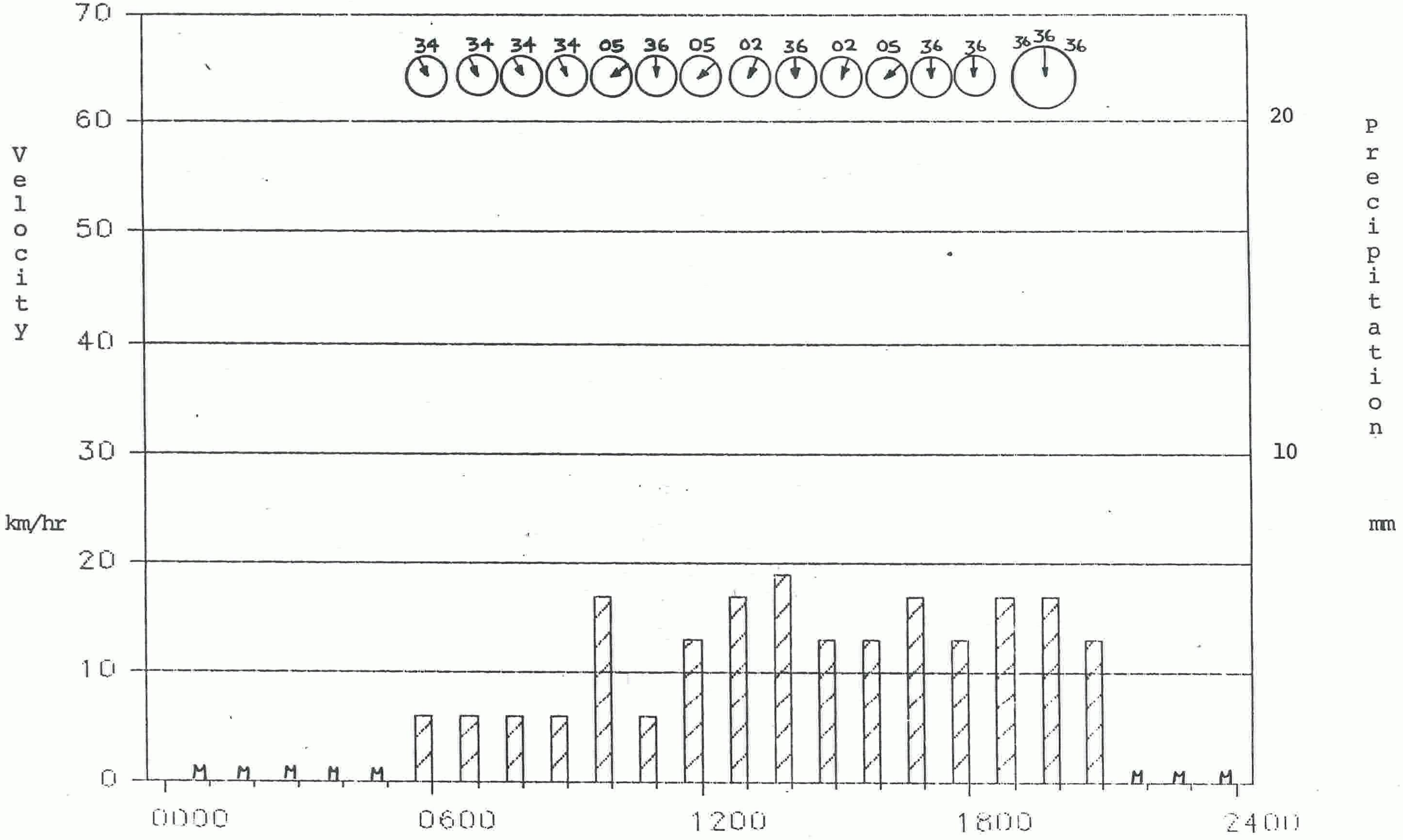
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02
36
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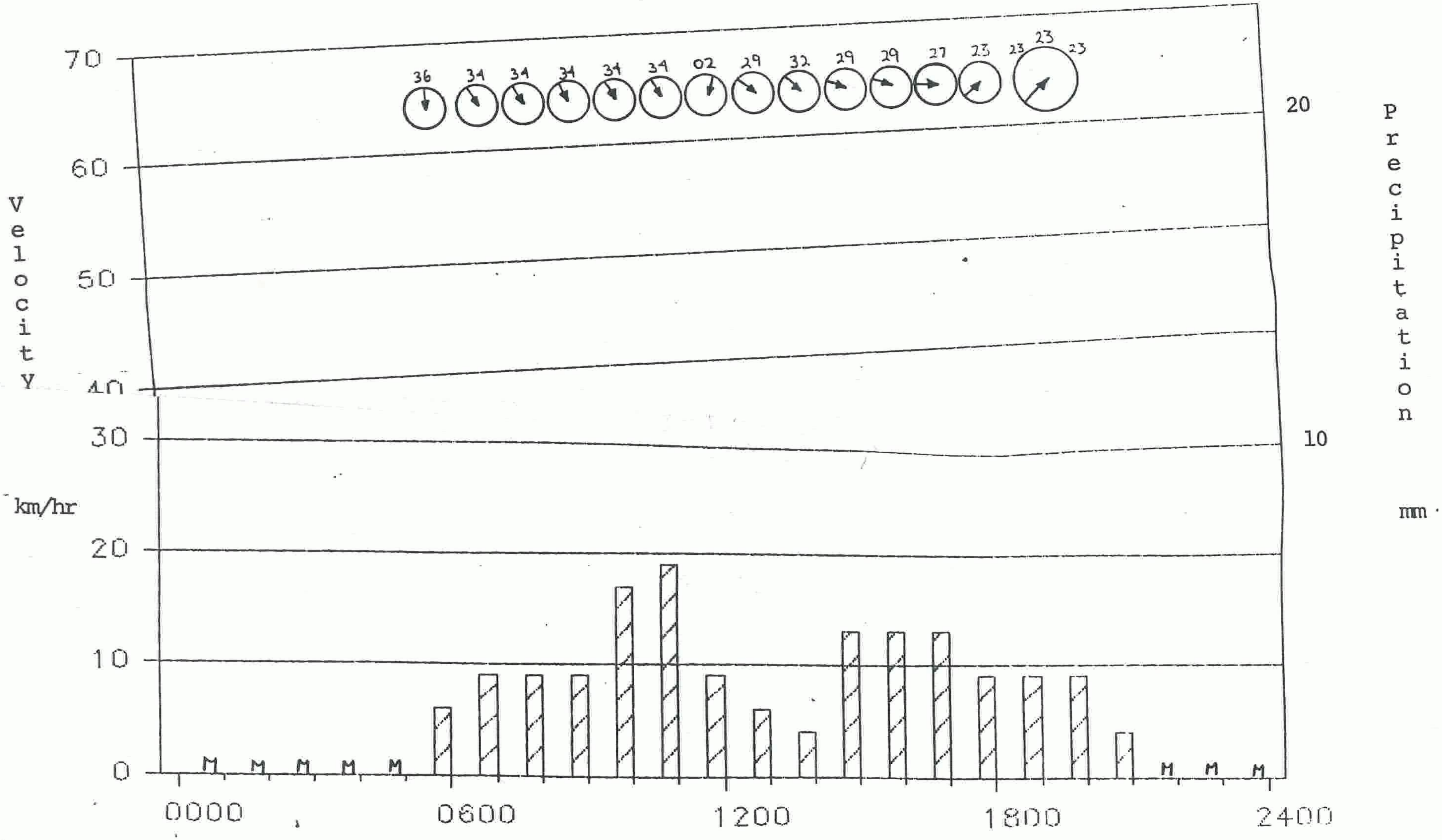
1800
2400

78 01 21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2400

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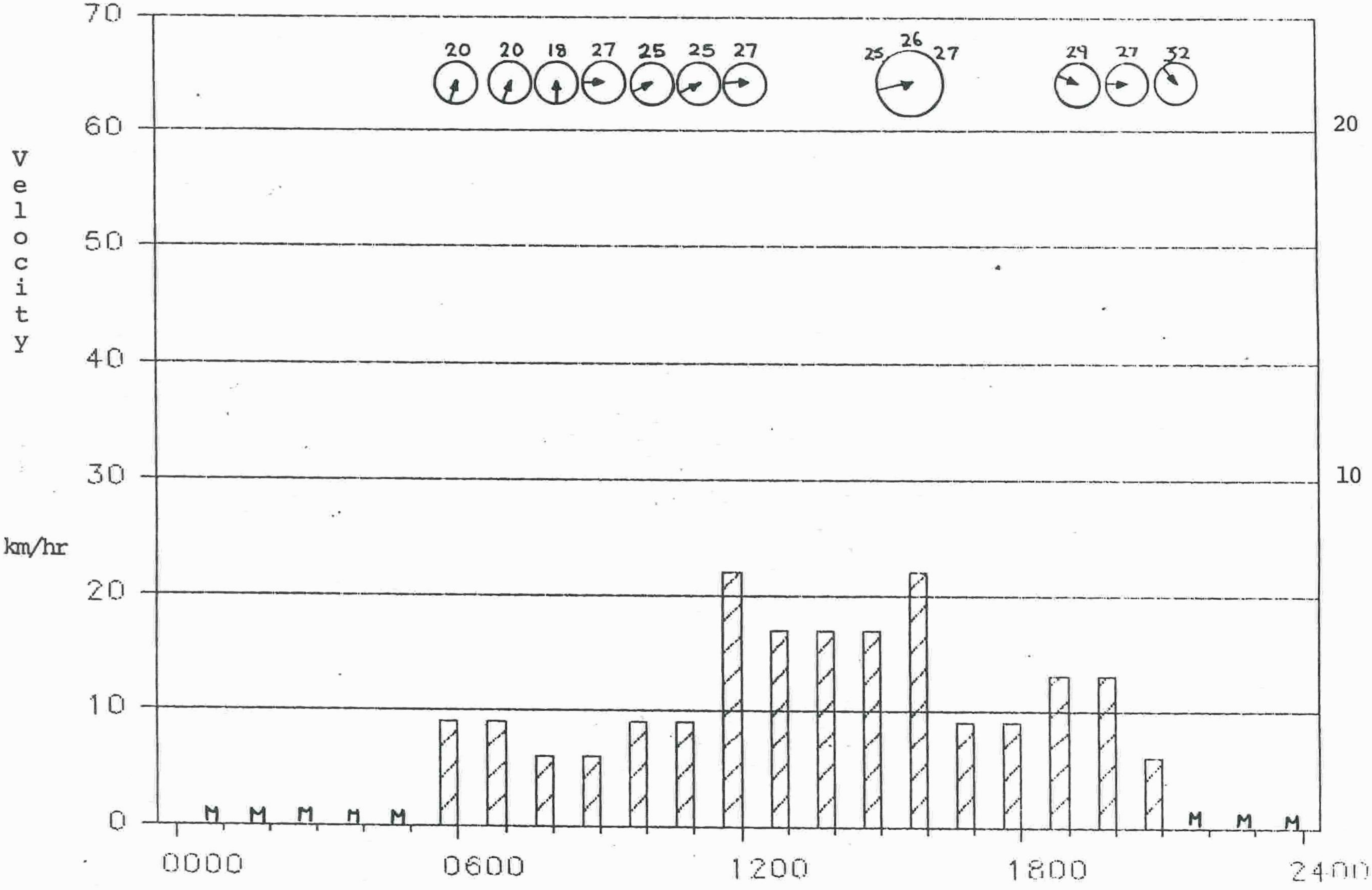
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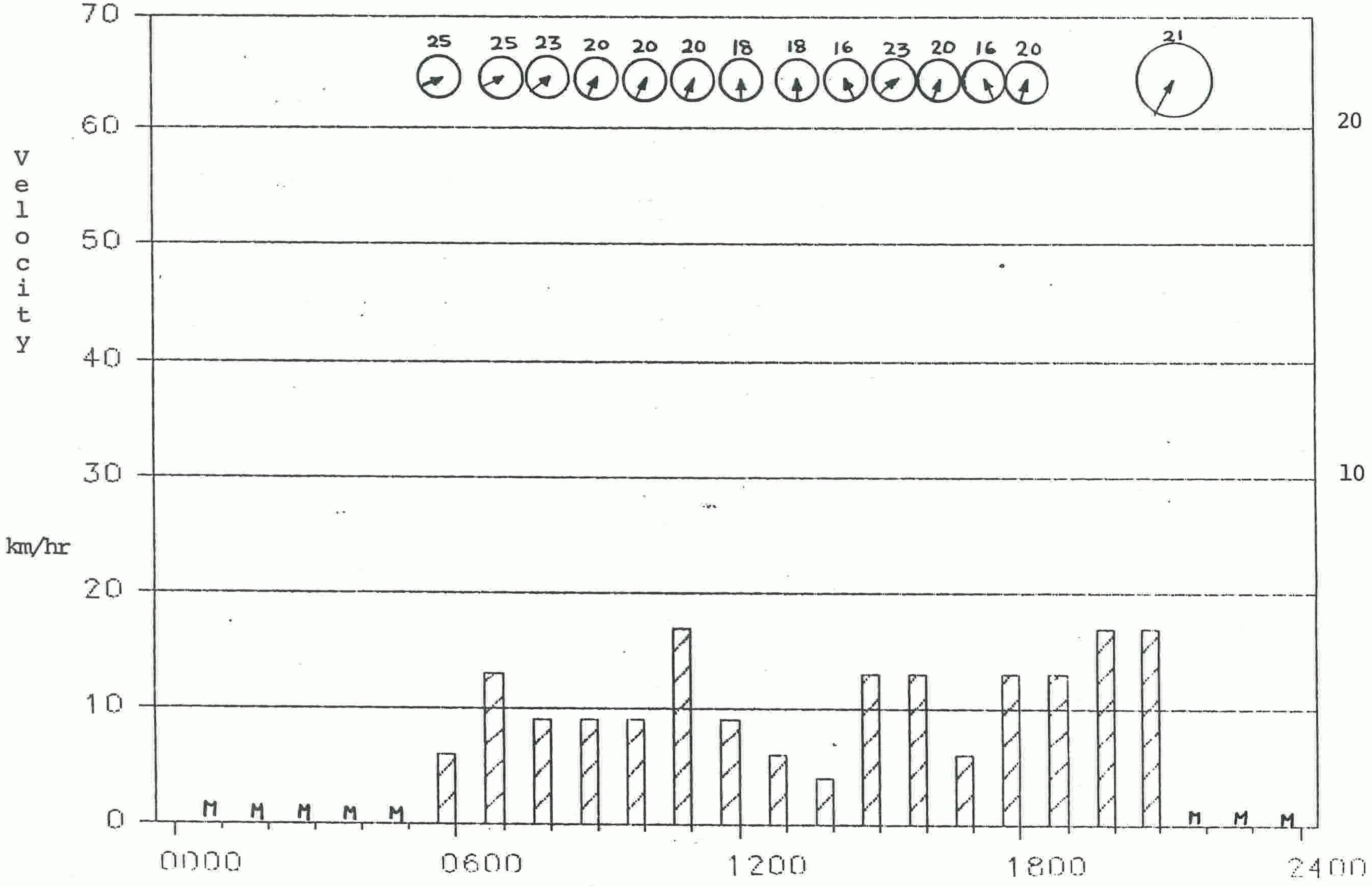
78 01 23

1983 STORM PERIOD
DATA RECORDED AT ST. ALBANS
PERIOD: 83 01 11 TO 83 01 21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1800
2400

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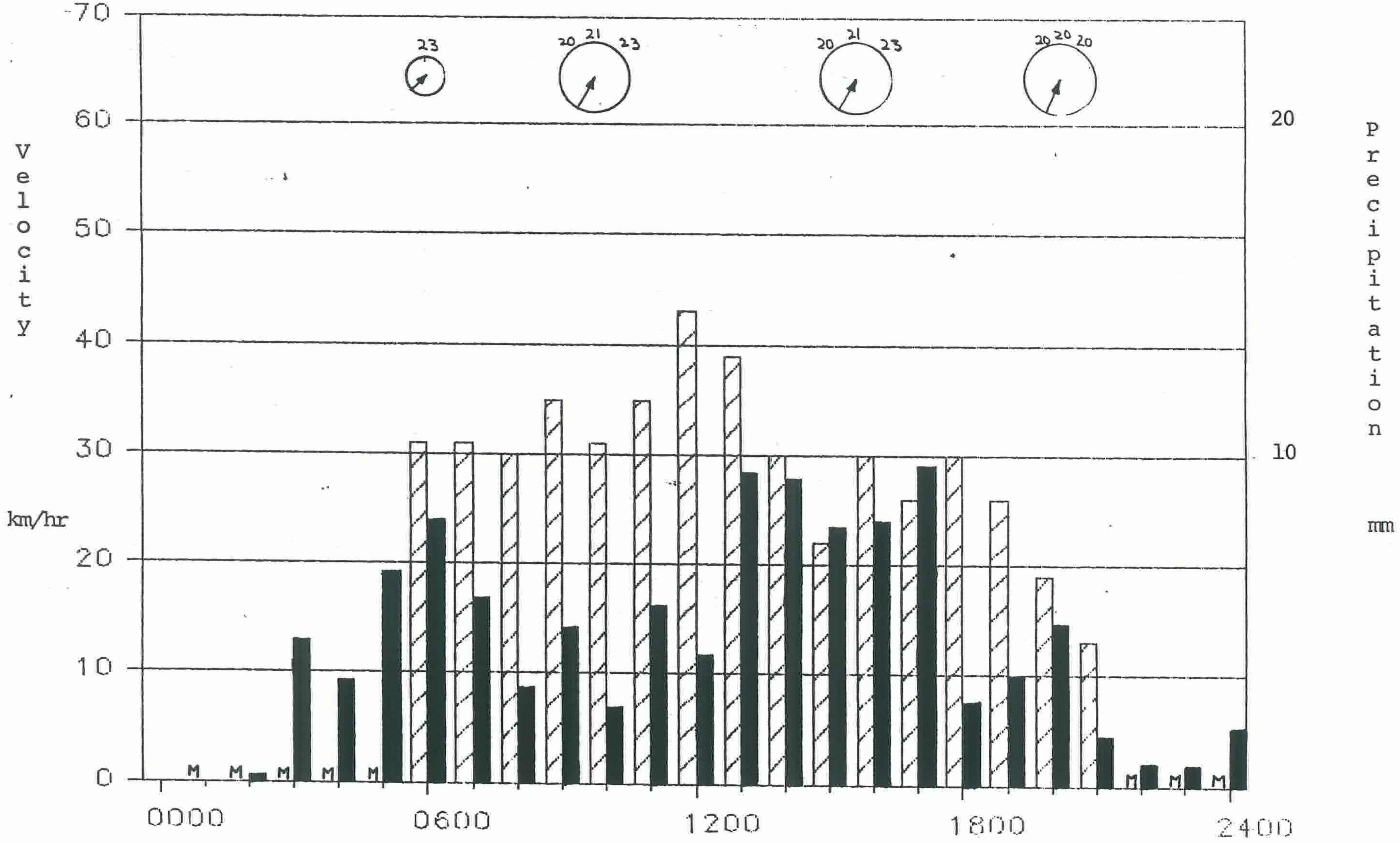
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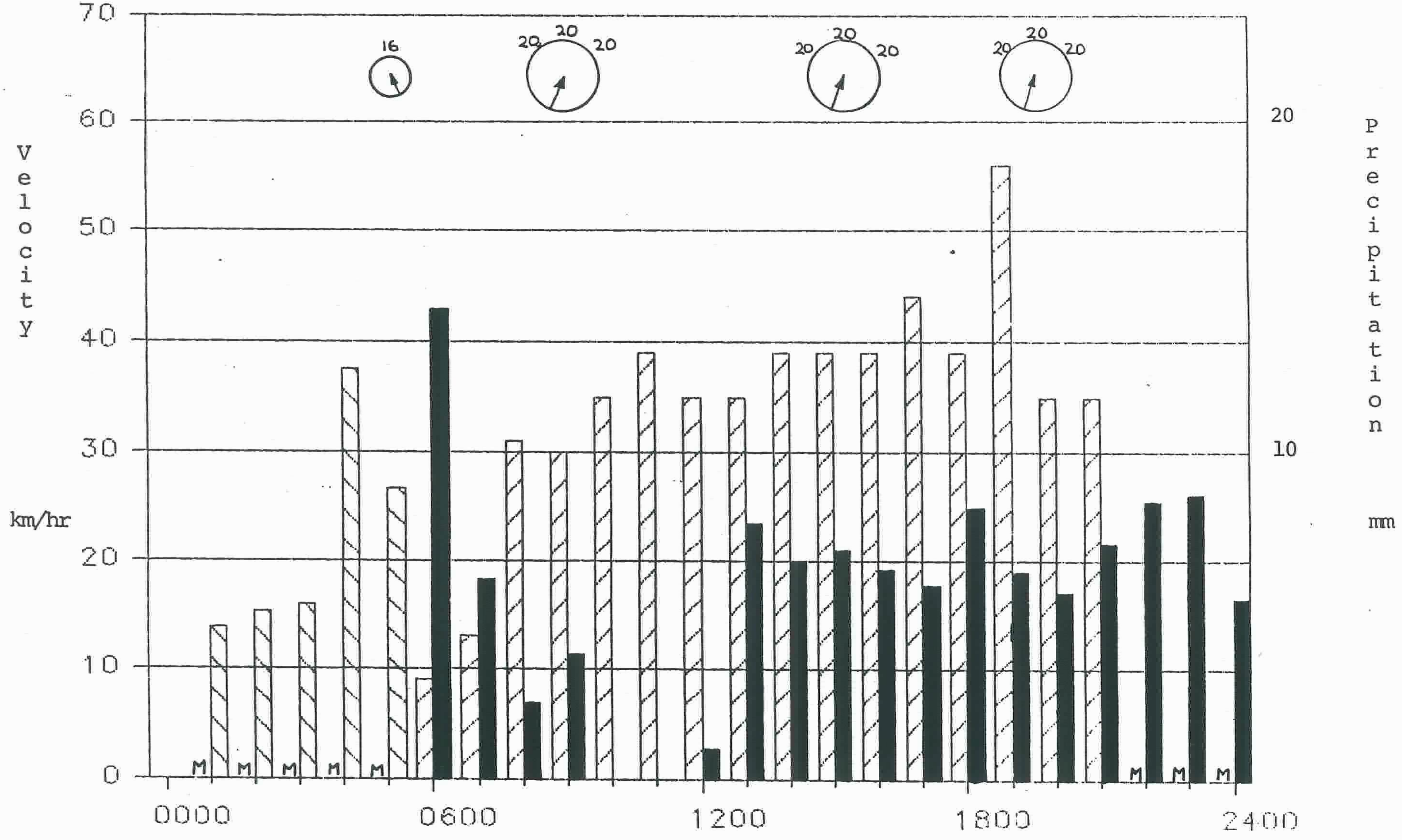
83 10 12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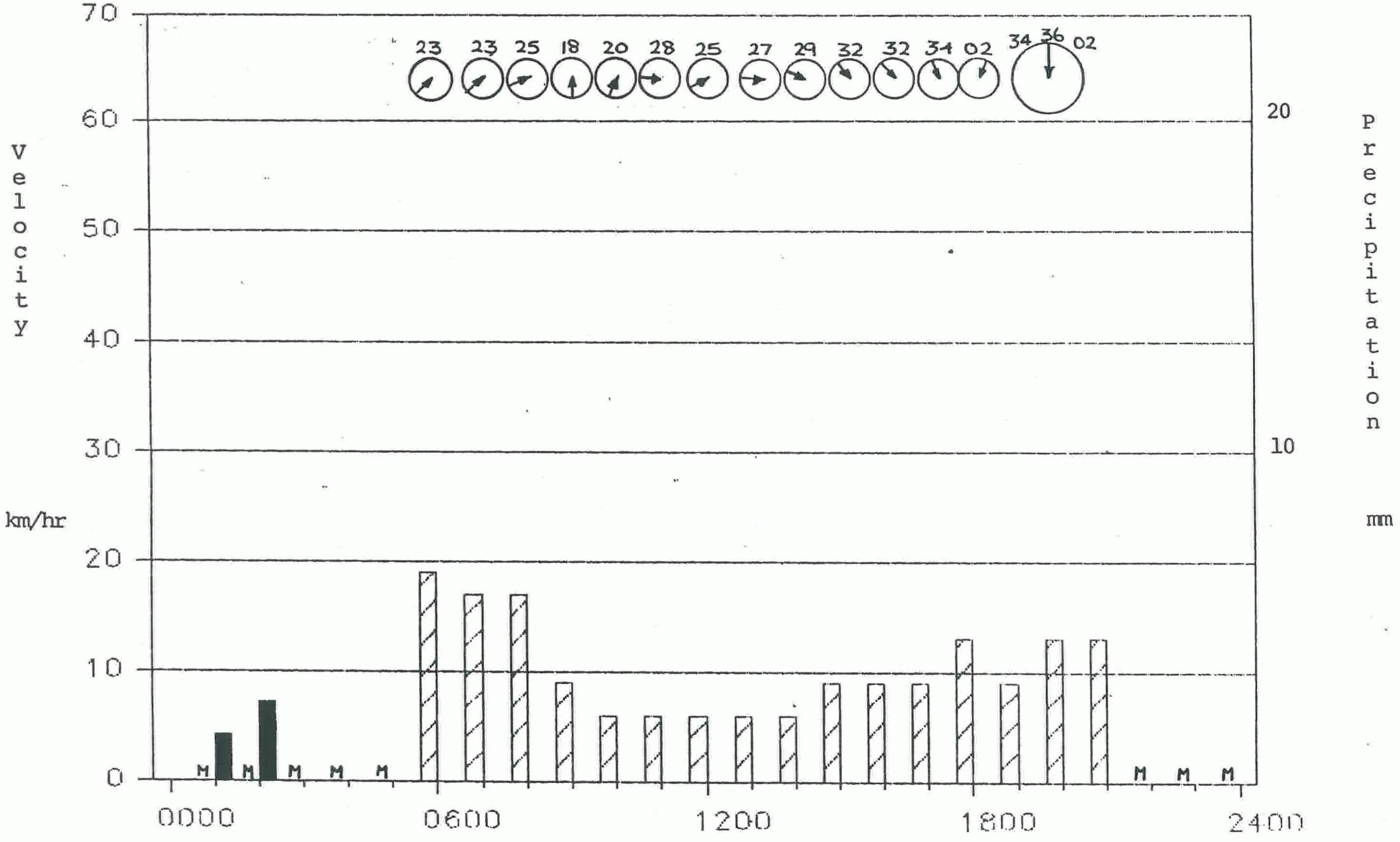
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Velocity
km/hr
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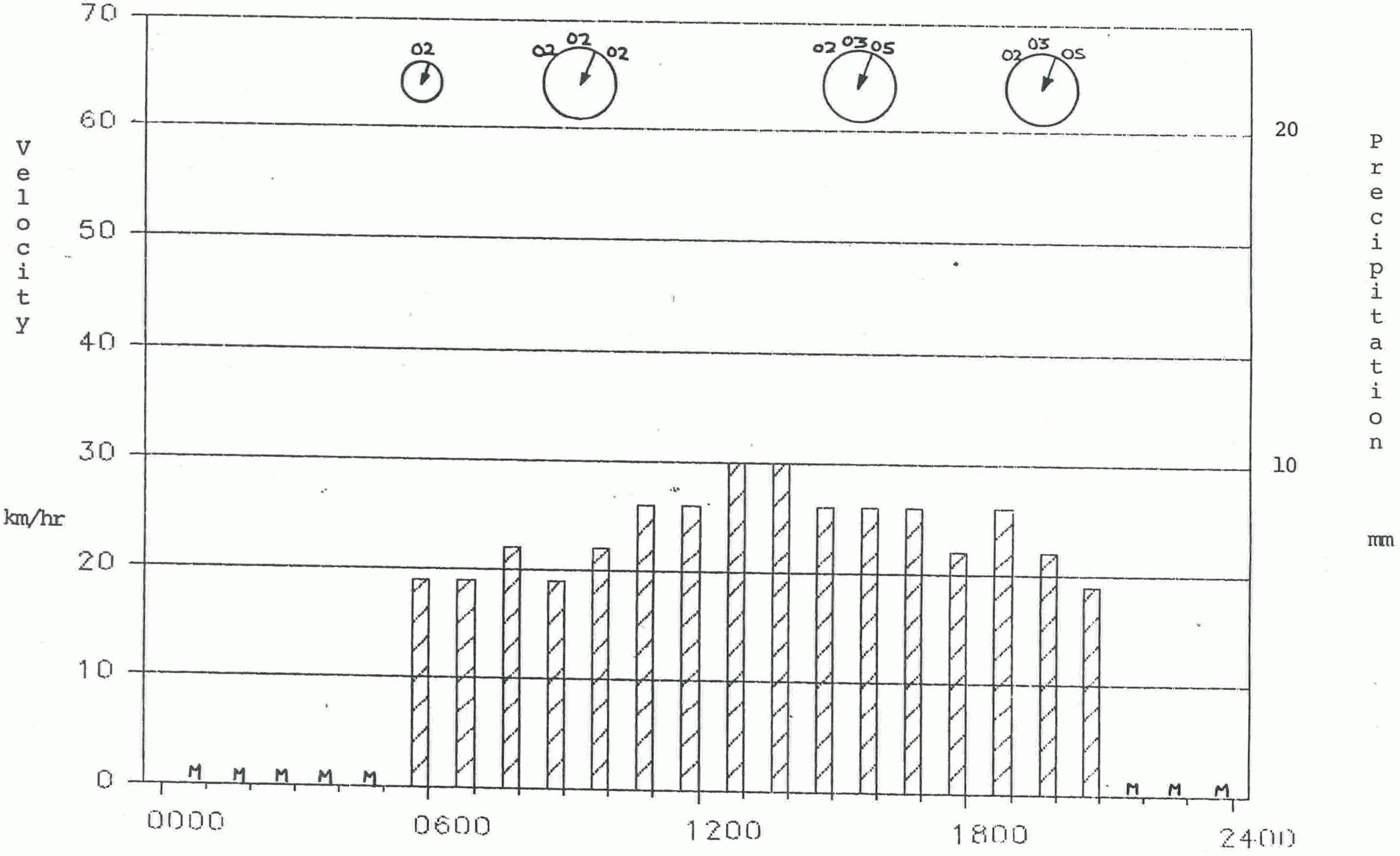
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km/hr
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mm
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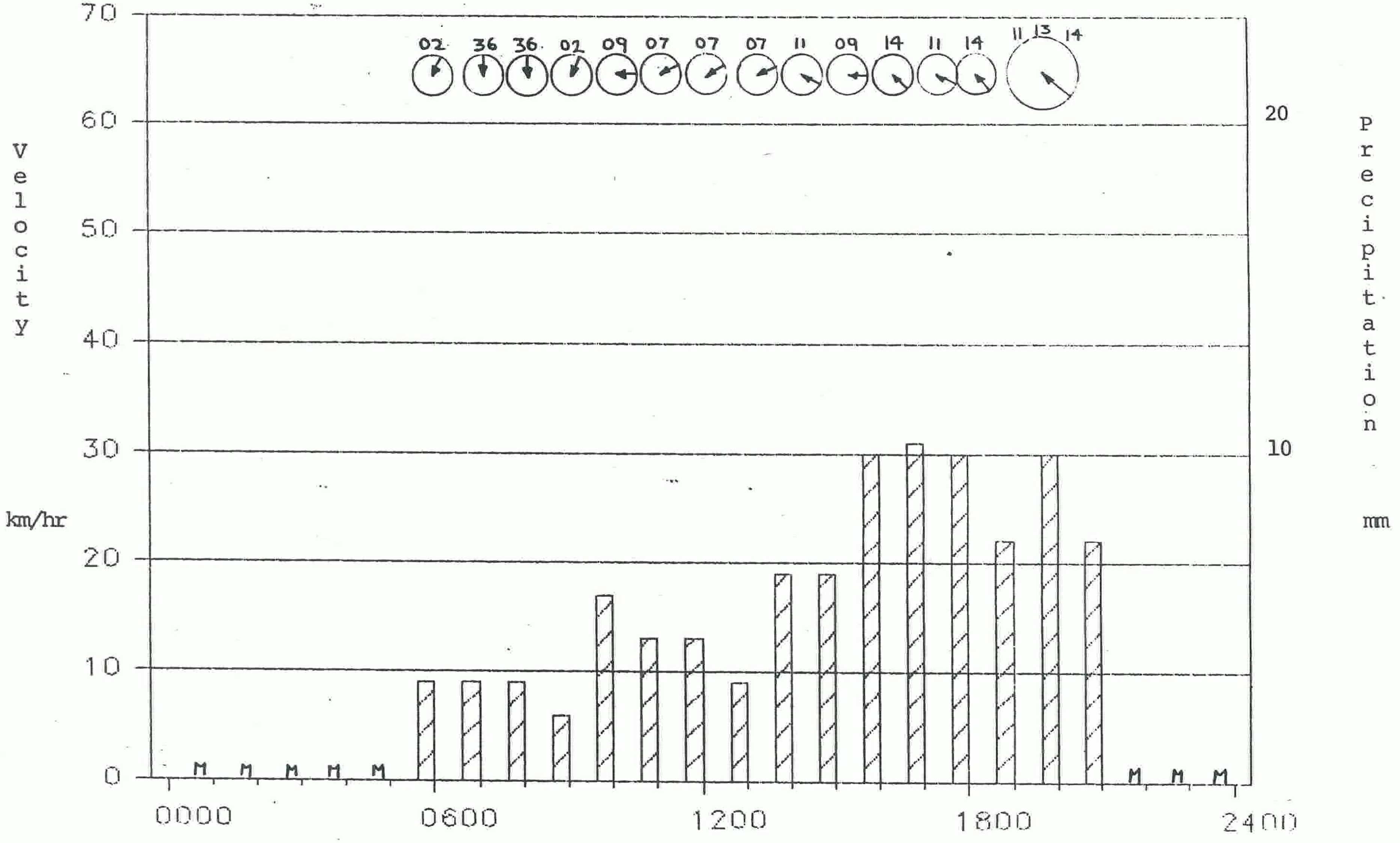
83 10 15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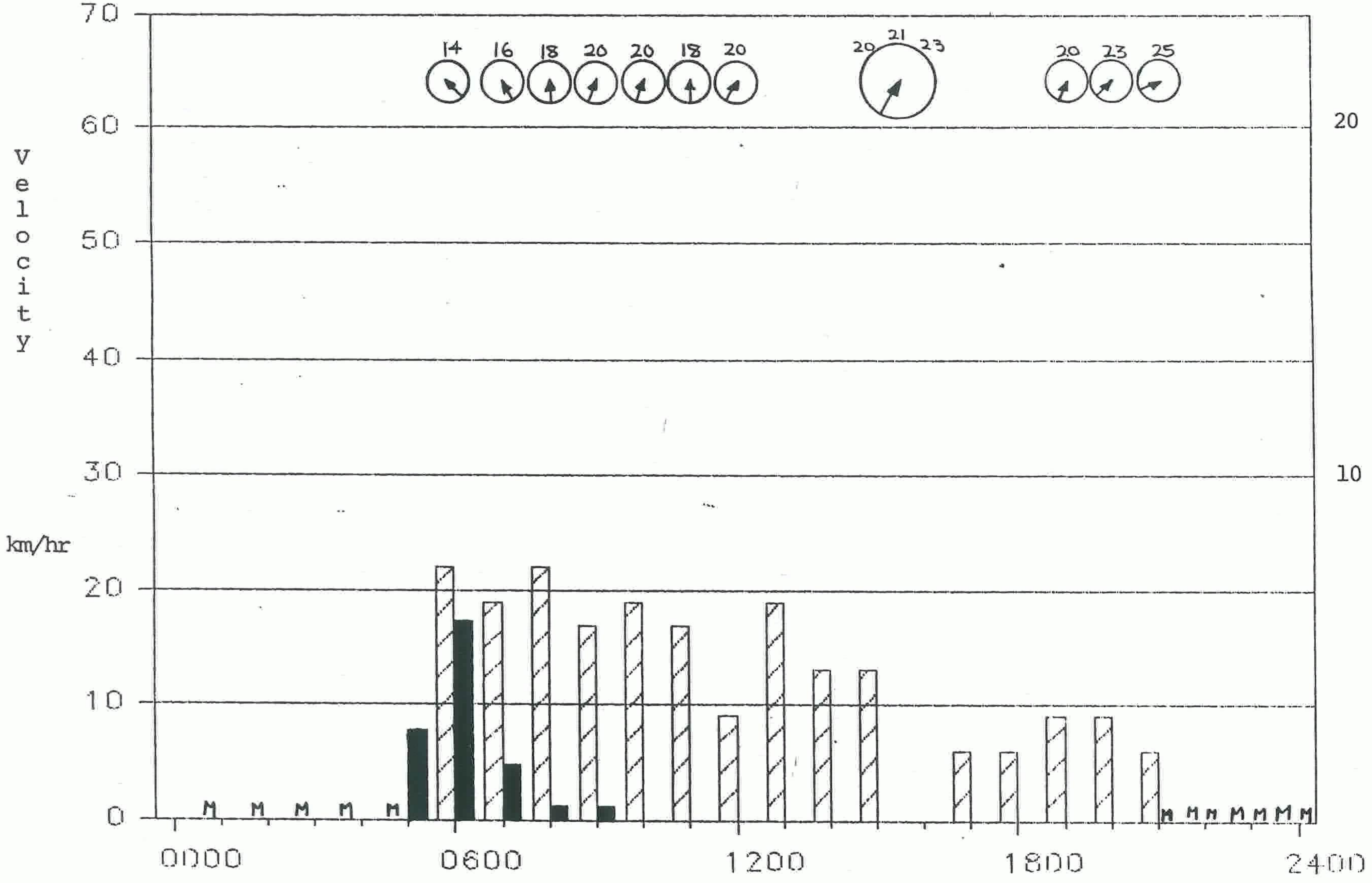
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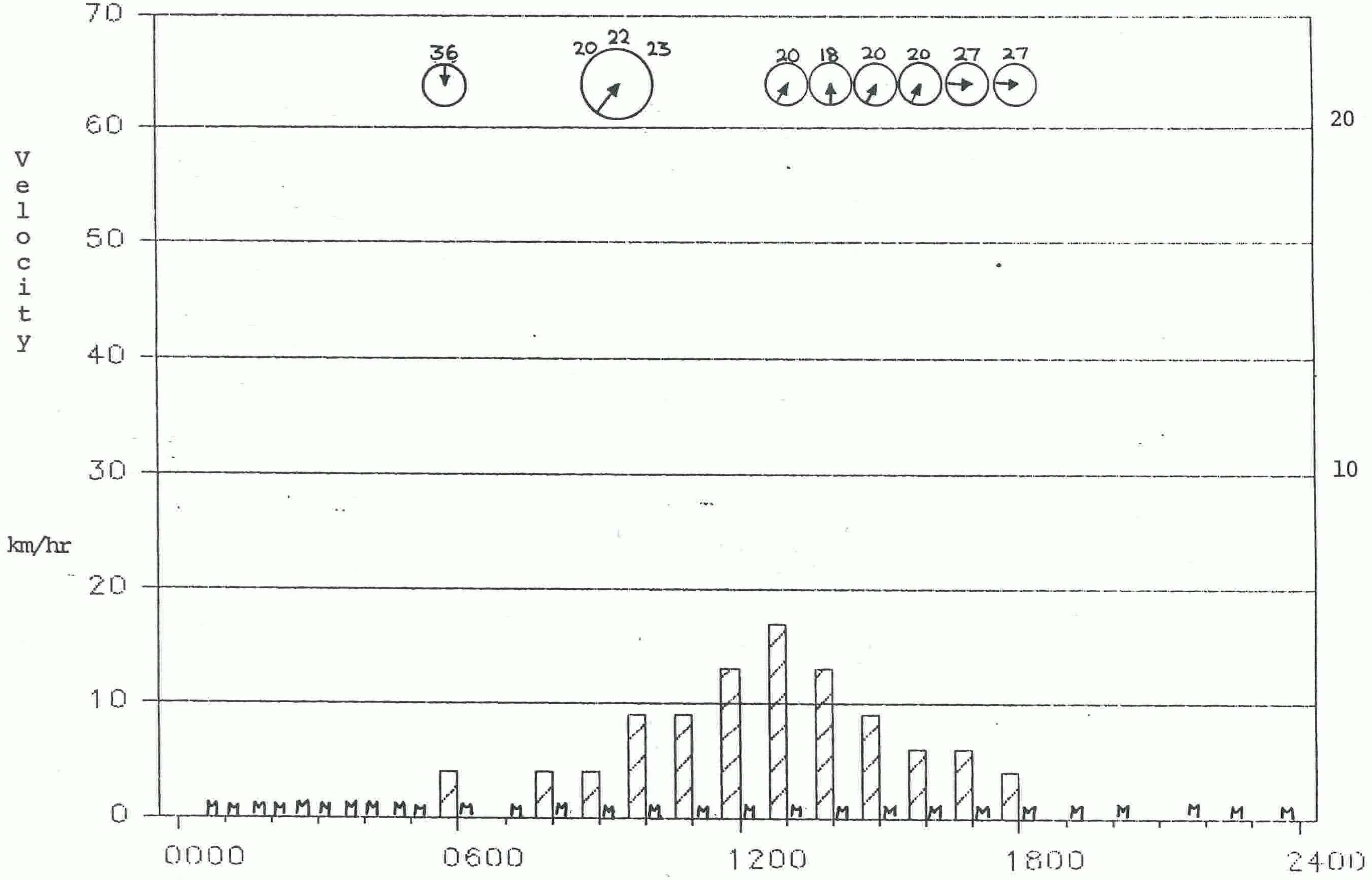
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km/hr
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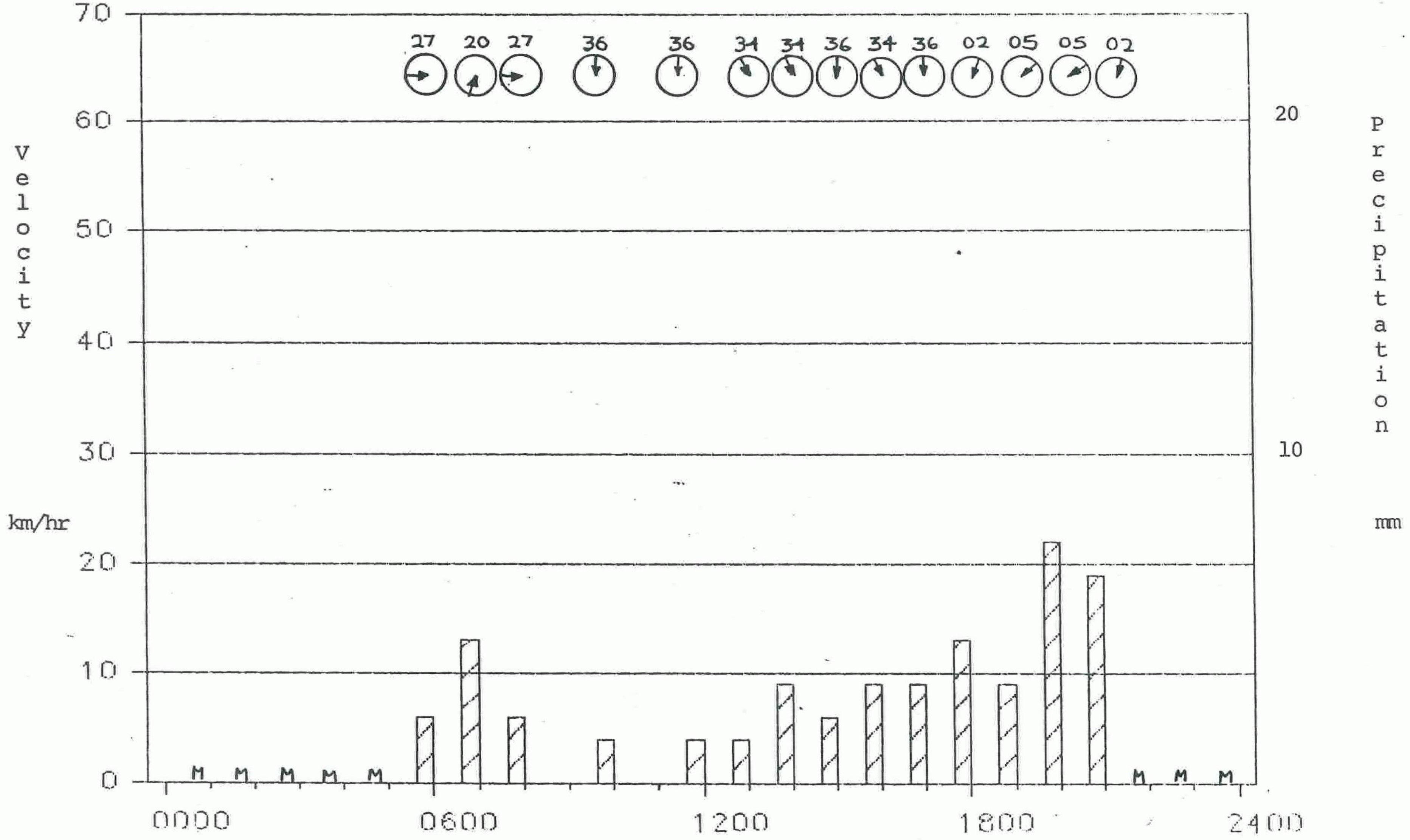
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km/hr
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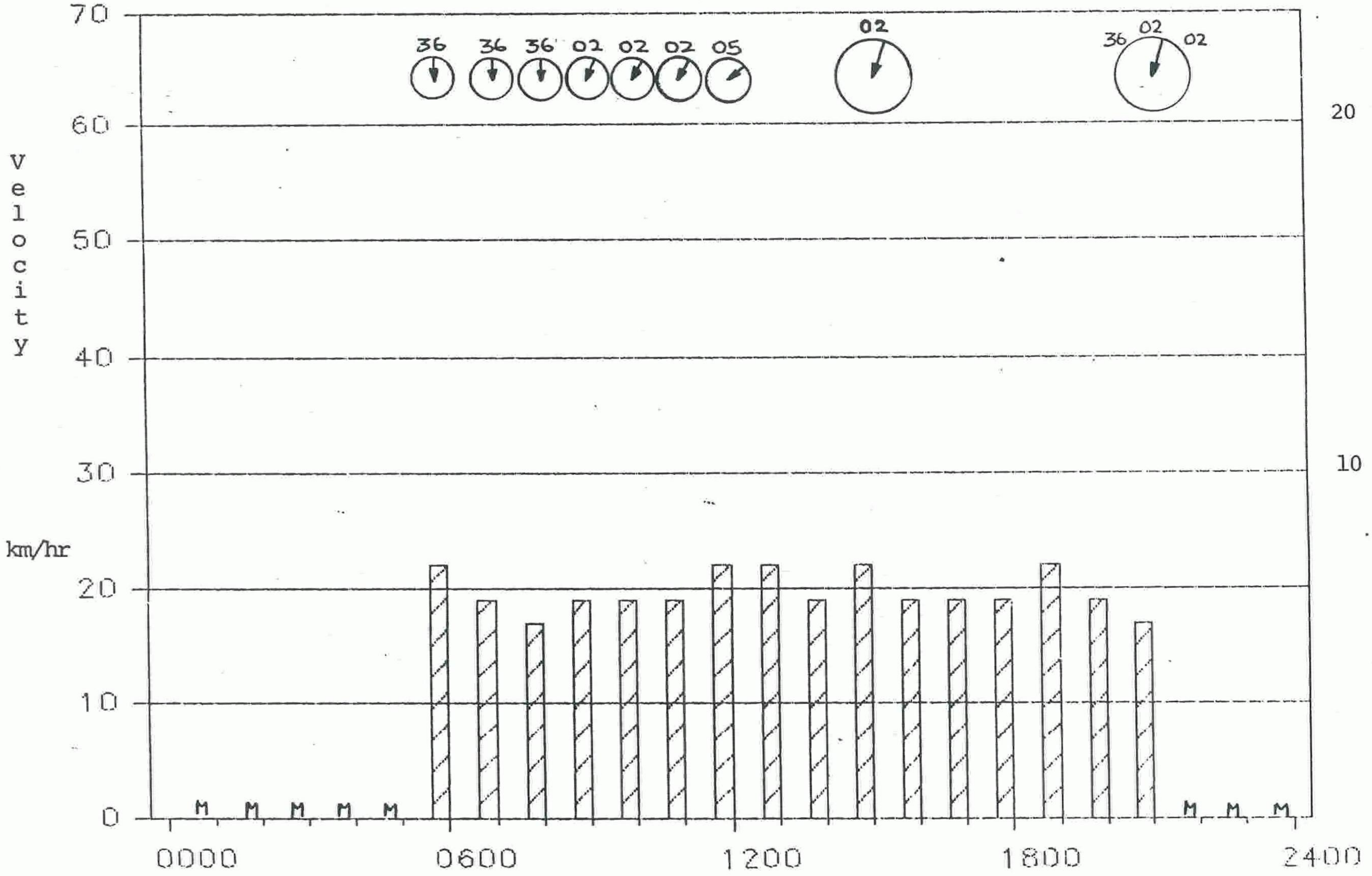
1800
2400

83 01 19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M M M M M
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1800
2400

83 01 20


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km/hr
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Precipitation
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83 01 21

APPENDIX C
DETAILED CALCULATION SHEETS

Table C-1

RESERVOIR: LONG POND

STRUCTURE: NORTH WEST CUT OFF DAM

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	NNW-NNE	NNW-NNE	
U (km/h)	38.8	29.3	77.0	unadj.
(m/s)	10.8	8.1	21.4	unadj.
U (km/h)	49.2	40.4	79.6	adj.
(m/s)	13.7	11.2	22.1	adj.
Ua (m/s)	17.7	13.9	32.0	adj.
F (km)	10.8	10.8	10.8	
D (m)	20.0	20.0	20.0	
Ds (m)	39.0	39.0	39.0	
MFL (m)	182.73	182.73	182.73	
PSH (m)	185.31	185.31	185.31	
Dfb (m)	2.58	2.58	2.58	
Ho (m)	0.94	0.74	1.70	
Hrms (m)	0.66	0.52	1.20	
T (s)	3.59	3.31	4.38	
t min (h)	1.67	1.81	1.37	
t (h)	9	9	9	
Ho/gT^2	0.0074	0.0068	0.0090	
Ds/Ho	41.48	52.85	22.95	
R/Ho	0.94	0.97	0.86	adj.
H cr (m)	2.71	2.64	3.40	
R (m)	0.89	0.72	1.46	
R cr (m)	2.56	2.57	2.53	
P(R>R cr)	.0000	.0000	0.0003	
N (wvs/h)	0	0	0	
Ntot (wvs)	0	0	2	
E min (m)			0.22	
WSet (m)	0.021	0.014	0.054	

Table C-2

RESERVOIR: LONG POND

STRUCTURE: SE CUT OFF DAMS : west section

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	NNW-NNE	NNW-NNE	
U (km/h)	38.8	29.3	77.0	unadj.
(m/s)	10.8	8.1	21.4	unadj.
U (km/h)	49.1	40.4	79.6	adj.
(m/s)	13.6	11.2	22.1	adj.
Ua (m/s)	17.7	13.9	32.0	adj.
F (km)	8.1	8.1	8.1	
D (m)	30.0	30.0	30.0	
Ds (m)	5.5	5.5	5.5	
MFL (m)	182.73	182.73	182.73	
PSH (m)	185.31	185.31	185.31	
Dfb (m)	2.58	2.58	2.58	
Ho (m)	0.81	0.64	1.47	
Hrms (m)	0.57	0.45	1.04	
T (s)	3.26	3.01	3.98	
t min (h)	1.38	1.50	1.13	
t (h)	9	9	9	
Ho/gT^2	0.0078	0.0072	0.0095	
Ds/Ho	6.77	8.61	3.74	
R/Ho	0.85	0.85	0.79	adj.
H cr (m)	3.02	3.02	3.90	
R (m)	0.69	0.54	1.17	
R cr (m)	2.57	2.57	2.55	
P(R>R cr)	.0000	.0000	.0000	
N (wvs/h)	0	0	0	
Ntot (wvs)	0	0	0	
E min (m)				
WSet (m)	0.010	0.007	0.027	

Table C-3

RESERVOIR: LONG POND

STRUCTURE: SE CUT OFF DAMS : east section

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	NNW-NNE	NNW-NNE	
U (km/h)	38.8	29.3	77.0	unadj.
(m/s)	10.8	8.1	21.4	unadj.
U (km/h)	49.1	40.4	79.6	adj.
(m/s)	13.6	11.2	22.1	adj.
Ua (m/s)	17.7	13.9	32.0	adj.
F (m)	14.0	14.0	14.0	
D (m)	30.0	30.0	30.0	
Ds (m)	7.0	7.0	7.0	
MFL (m)	182.73	182.73	182.73	
PSH (m)	185.31	185.31	185.31	
Dfb (m)	2.58	2.58	2.58	
Ho (m)	1.07	0.84	1.93	
Hrms (m)	0.75	0.59	1.37	
T (s)	3.91	3.61	4.77	
t min (h)	1.99	2.16	1.63	
t (h)	9	9	9	
Ho/gT^2	0.0071	0.0066	0.0087	
Ds/Ho	6.55	8.33	3.62	
R/Ho	0.92	0.94	0.86	adj.
H cr (m)	2.80	2.72	3.16	
R (m)	0.98	0.79	1.66	
R cr (m)	2.56	2.57	2.53	
P(R>R cr)	.0000	.0000	0.0048	
N (wvs/h)	0	0	4	
Ntot (wvs)	0	0	32	
E min (m)			0.74	
WSet (m)	0.018	0.012	0.047	

Table C-4 (a)

RESERVOIR: LONG POND

STRUCTURE: POWER CANAL EMBANKMENT

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	WSW-WNW	WSW-WNW	
U (km/h)	38.8	32.1	97.0	unadj.
(m/s)	10.8	8.9	26.9	unadj.
U (km/h)	49.1	42.5	100.4	adj.
(m/s)	13.6	11.8	27.9	adj.
Ua (m/s)	17.7	14.8	42.6	adj.
F (km)	5.3	5.3	5.3	
D (m)	20.0	20.0	20.0	
Ds (m)	12.0	12.0	12.0	
MFL (m)	182.73	182.73	182.73	
PSH (m)	184.10	184.10	184.10	
Dfb (m)	1.37	1.37	1.37	
Ho (m)	0.66	0.55	1.58	
Hrms (m)	0.46	0.39	1.12	
T (s)	2.83	2.67	3.80	
t min (h)	1.04	1.11	0.78	
t (h)	18	18	18	
Ho/gT^2	0.0084	0.0079	0.0112	
Ds/Ho	18.26	21.81	7.58	
R/Ho	0.82	0.82	0.68	adj.
H cr (m)	1.65	1.66	1.95	
R (m)	0.54	0.45	1.08	
R cr (m)	1.36	1.36	1.33	
P(R>R cr)	.0000	.0000	0.0480	
N (wvs/h)	0	0	45	
Ntot (wvs)	0	0	819	
E min (m)			0.83	
WSet (m)	0.010	0.008	0.043	

Table C-4 (b)

RESERVOIR: LONG POND

STRUCTURE: POWER CANAL EMBANKMENT : fetch reduced 25 %

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	WSW-WNW	WSW-WNW	
U (km/h)	38.8	32.1	97.0	unadj.
(m/s)	10.8	8.9	26.9	unadj.
U (km/h)	49.1	42.5	100.4	adj.
(m/s)	13.6	11.8	27.9	adj.
Ua (m/s)	17.7	14.8	42.6	adj.
F (km)	3.9	3.9	3.9	
D (m)	20.0	20.0	20.0	
Ds (m)	12.0	12.0	12.0	
MFL (m)	182.73	182.73	182.73	
PSH (m)	184.10	184.10	184.10	
Dfb (m)	1.37	1.37	1.37	
Ho (m)	0.56	0.47	1.36	
Hrms (m)	0.40	0.33	0.96	
T (s)	2.56	2.41	3.43	
t min (h)	0.85	0.90	0.63	
t (h)	18	18	18	
Ho/gT^2	0.0088	0.0083	0.0118	
Ds/Ho	21.29	25.43	8.83	
R/Ho	0.82	0.82	0.68	adj.
H cr (m)	1.66	1.66	2.20	
R (m)	0.46	0.39	0.93	
R cr (m)	1.36	1.36	1.34	
P(R>R cr)	.0000	.0000	0.0052	
N (wvs/h)	0	0	5	
Ntot (wvs)	0	0	98	
E min (m)			0.39	
WSet (m)	0.007	0.006	0.031	

Table C-5

RESERVOIR: LONG POND

STRUCTURE: SALMON RIVER DAM

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	NNE-ENE	NNE-ENE	
U (km/h)	38.8	29.3	80.0	unadj.
(m/s)	10.8	8.1	22.2	unadj.
U (km/h)	49.1	40.4	82.8	adj.
(m/s)	13.6	11.2	23.0	adj.
Ua (m/s)	17.7	13.9	33.6	adj.
F (km)	4.5	4.5	4.5	
D (m)	20.0	20.0	20.0	
Ds (m)	39.0	39.0	39.0	
MFL (m)	182.73	182.73	182.73	
PSH (m)	184.70	184.70	184.70	
Dfb (m)	1.97	1.97	1.97	
Ho (m)	0.61	0.48	1.15	
Hrms (m)	0.43	0.34	0.81	
T (s)	2.68	2.48	3.32	
t min (h)	0.93	1.01	0.75	
t (h)	24	24	24	
Ho/gT^2	0.0086	0.0079	0.0106	
Ds/Ho	64.41	81.88	33.87	
R/Ho	1.12	1.15	1.12	adj.
H cr (m)	1.75	1.71	1.74	
R (m)	0.68	0.55	1.29	
R cr (m)	1.96	1.96	1.95	
P(R>R cr)	.0000	.0000	0.0105	
N (wvs/h)	0	0	11	
Ntot (wvs)	0	0	273	
E min (m)			0.77	
WSet (m)	0.009	0.006	0.025	

Table C-6

RESERVOIR: BURNT POND

STRUCTURE: BURNT POND DAM

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	NNE-ENE	NNE-ENE	
U (km/h)	38.8	29.3	80.0	unadj.
(m/s)	10.8	8.1	22.2	unadj.
U (km/h)	49.1	40.4	82.8	adj.
(m/s)	13.6	11.2	23.0	adj.
Ua (m/s)	17.7	13.9	33.6	adj.
F (km)	3.3	3.3	3.3	
D (m)	15.0	15.0	15.0	
Ds (m)	17.0	17.0	17.0	
MFL (m)	315.47	315.47	315.47	
PSH (m)	317.30	317.30	317.30	
Dfb (m)	1.83	1.83	1.83	
Ho (m)	0.51	0.40	0.98	
Hrms (m)	0.36	0.29	0.69	
T (s)	2.41	2.22	2.98	
t min (h)	0.75	0.82	0.61	
t (h)	24	24	24	
Ho/gT^2	0.0091	0.0084	0.0112	
Ds/Ho	33.04	42.00	17.37	
R/Ho	1.12	1.12	1.12	adj.
H cr (m)	1.63	1.63	1.61	
R (m)	0.58	0.45	1.10	
R cr (m)	1.82	1.82	1.81	
P(R>R cr)	.0000	.0000	0.0044	
N (wvs/h)	0	0	5	
Ntot (wvs)	0	0	126	
E min (m)			0.50	
WSet (m)	0.008	0.006	0.024	

Table C-7(a)

RESERVOIR: BURNT POND

STRUCTURE: BURNT POND DYKE : vulnerable section

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	NNE-ENE	NNE-ENE	
U (km/h)	38.8	29.3	80.0	unadj.
(m/s)	10.8	8.1	22.2	unadj.
U (km/h)	49.1	40.4	82.8	adj.
(m/s)	13.6	11.2	23.0	adj.
Ua (m/s)	17.7	13.9	33.6	adj.
F (km)	2.8	2.8	2.8	
D (m)	7.0	7.0	7.0	
Ds (m)	9.0	9.0	9.0	
MFL (m)	315.47	315.47	315.47	
PSH (m)	315.50	315.50	315.50	
Dfb (m)	0.03	0.03	0.03	
Ho (m)	0.48	0.38	0.91	
Hrms (m)	0.34	0.27	0.64	
T (s)	2.29	2.11	2.84	
t min (h)	0.68	0.74	0.55	
t (h)	24	24	24	
Ho/gT^2	0.0093	0.0086	0.0115	
Ds/Ho	18.84	23.95	9.91	
R/Ho	1.25	1.29	1.17	adj.
H cr (m)	0.01	0.01	0.00	
R (m)	0.60	0.48	1.06	
R cr (m)	0.01	0.02	-0.01	
P(R>R cr)	0.9983	0.9969	1.00	
N (wvs/h)	1570	1698	1269	
Ntot (wvs)	37673	40755	30456	
E min (m)	1.12	0.89	1.84	
WSet (m)	0.015	0.010	0.044	

Table C-7(b)

RESERVOIR: BURNT POND

STRUCTURE: BURNT POND DYKE : vulnerable section upgraded as dam

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	NNE-ENE	NNE-ENE	
U (km/h)	38.8	29.3	80.0	unadj.
(m/s)	10.8	8.1	22.2	unadj.
U (km/h)	49.1	40.4	82.8	adj.
(m/s)	13.6	11.2	23.0	adj.
Ua (m/s)	17.7	13.9	33.6	adj.
F (km)	2.8	2.8	2.8	
D (m)	7.0	7.0	7.0	
Ds (m)	17.0	17.0	17.0	
MFL (m)	315.47	315.47	315.47	
PSH (m)	317.30	317.30	317.30	
Dfb (m)	1.83	1.83	1.83	
Ho (m)	0.48	0.38	0.91	
Hrms (m)	0.34	0.27	0.64	
T (s)	2.29	2.11	2.84	
t min (h)	0.68	0.74	0.55	
t (h)	24	24	24	
Ho/gT^2	0.0093	0.0086	0.0115	
Ds/Ho	35.60	45.25	18.72	
R/Ho	0.89	0.92	0.83	adj.
H cr (m)	2.04	1.98	2.15	
R (m)	0.43	0.35	0.75	
R cr (m)	1.81	1.82	1.79	
P(R>R cr)	.0000	.0000	.0000	
N (wvs/h)	0	0	0	
Ntot (wvs)	0	0	0	
E min (m)				
WSet (m)	0.015	0.010	0.044	

Table C-7(c)

RESERVOIR: BURNT POND

STRUCTURE: BURNT POND DYKE : vulnerable section
(SWL AT FSL)

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	NNE-ENE	NNE-ENE	
U (km/h)	38.8	29.3	80.0	unadj.
(m/s)	10.8	8.1	22.2	unadj.
U (km/h)	49.1	40.4	82.8	adj.
(m/s)	13.6	11.2	23.0	adj.
Ua (m/s)	17.7	13.9	33.6	adj.
F (km)	2.6	2.6	2.6	
D (m)	5.5	5.5	5.5	
Ds (m)	9.0	9.0	9.0	
FSL (m)	313.94	313.94	313.94	
PSH (m)	315.50	315.50	315.50	
Dfb (m)	1.56	1.56	1.56	
Ho (m)	0.46	0.36	0.88	
Hrms (m)	0.33	0.26	0.62	
T (s)	2.23	2.06	2.77	
t min (h)	0.65	0.70	0.52	
t (h)	24	24	24	
Ho/gT^2	0.0094	0.0087	0.0117	
Ds/Ho	19.56	24.86	10.28	
R/Ho	1.25	1.29	1.17	adj.
H cr (m)	1.24	1.20	1.47	
R (m)	0.57	0.47	1.02	
R cr (m)	1.54	1.55	1.51	
P(R>R cr)	.0000	.0000	0.0035	
N (wvs/h)	0	0	5	
Ntot (wvs)	0	0	109	
E min (m)			0.32	
WSet (m)	0.018	0.012	0.052	

Table C-8(a)

RESERVOIR: BURNT POND

STRUCTURE: BURNT POND CANAL DYKE : assumed 0.98 m of freeboard

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	SE-S	SE-S	
U (km/h)	38.8	22.6	105.0	unadj.
(m/s)	10.8	6.3	29.2	unadj.
U (km/h)	49.1	23.4	108.7	adj.
(m/s)	13.6	6.5	30.2	adj.
Ua (m/s)	17.7	7.1	46.9	adj.
F (km)	0.6	0.6	0.6	
D (m)	6.1	6.1	6.1	
Ds (m)	7.6	7.6	7.6	
MFL (m)	314.30	314.30	314.30	
PSH (m)	315.28	315.28	315.28	
Dfb (m)	0.98	0.98	0.98	
Ho (m)	0.21	0.09	0.56	
Hrms (m)	0.15	0.06	0.40	
T (s)	1.33	0.98	1.84	
t min (h)	0.23	0.31	0.17	
t (h)	22	22	22	
Ho/gT^2	0.0122	0.0090	0.0169	
Ds/Ho	35.90	89.34	13.51	
R/Ho	1.09	1.29	0.93	adj.
H cr (m)	0.90	0.76	1.08	
R (m)	0.23	0.11	0.52	
R cr (m)	0.98	0.98	0.96	
P(R>R cr)	.0000	.0000	0.0006	
N (wvs/h)	0	0	1	
Ntot (wvs)	0	0	27	
E min (m)			0.13	
WSet (m)	0.003	0.001	0.017	

Table C-8(b)

RESERVOIR: BURNT POND

STRUCTURE: BURNT POND CANAL DYKE : assumed 0.03 m of freeboard

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	SE-S	SE-S	
U (km/h)	38.8	22.6	105.0	unadj.
(m/s)	10.8	6.3	29.2	unadj.
U (km/h)	49.1	23.4	108.7	adj.
(m/s)	13.6	6.5	30.2	adj.
Ua (m/s)	17.7	7.1	46.9	adj.
F (km)	0.6	0.6	0.6	
D (m)	6.1	6.1	6.1	
Ds (m)	7.6	7.6	7.6	
MFL (m)	315.25	315.25	315.25	
PSH (m)	315.28	315.28	315.28	
Dfb (m)	0.03	0.03	0.03	
Ho (m)	0.21	0.09	0.56	
Hrms (m)	0.15	0.06	0.40	
T (s)	1.33	0.98	1.84	
t min (h)	0.23	0.31	0.17	
t (h)	22	22	22	
Ho/gT^2	0.0122	0.0090	0.0169	
Ds/Ho	35.90	89.34	13.51	
R/Ho	1.09	1.29	0.93	adj.
H cr (m)	0.02	0.02	0.01	
R (m)	0.23	0.11	0.52	
R cr (m)	0.03	0.03	0.01	
P(R>R cr)	0.9738	0.8675	0.9988	
N (wvs/h)	2634	3180	1950	
Ntot (wvs)	57951	69955	42908	
E min (m)	0.39	0.18	1.07	
WSet (m)	0.003	0.001	0.017	

Table C-9(a)

RESERVOIR: VICTORIA LAKE

STRUCTURE: VICTORIA CONTROL DYKES : reduced fetch to account for shallow flooded area

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	NNW-NNE	NNW-NNE	
U (km/h)	38.8	29.3	77.0	unadj.
(m/s)	10.8	8.1	21.4	unadj.
U (km/h)	49.1	40.4	79.6	adj.
(m/s)	13.6	11.2	22.1	adj.
Ua (m/s)	17.7	13.9	32.0	adj.
F (km)	2.7	2.7	2.7	
D (m)	15.0	15.0	15.0	
Ds (m)	4.6	4.6	4.6	
MFL (m)	327.36	327.36	327.36	
PSH (m)	327.96	327.96	327.96	
Dfb (m)	0.60	0.60	0.60	
Ho (m)	0.47	0.37	0.85	
Hrms (m)	0.33	0.26	0.60	
T (s)	2.26	2.09	2.76	
t min (h)	0.66	0.72	0.55	
t (h)	9	9	9	
Ho/gT^2	0.0093	0.0086	0.0114	
Ds/Ho	9.81	12.47	5.41	
R/Ho	0.89	0.92	0.78	adj.
H cr (m)	0.71	0.72	0.75	
R (m)	0.42	0.34	0.66	
R cr (m)	0.59	0.60	0.58	
P(R>R cr)	0.0101	0.0005	0.2132	
N (wvs/h)	16	1	278	
Ntot (wvs)	145	7	2506	
E min (m)	0.20	0.05	0.70	
WSet (m)	0.007	0.005	0.018	

Table C-9(b)

RESERVOIR: VICTORIA LAKE

STRUCTURE: VICTORIA CONTROL DYKES : full fetch

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	NNW-NNE	NNW-NNE	
U (km/h)	38.8	29.3	77.0	unadj.
(m/s)	10.8	8.1	21.4	unadj.
U (km/h)	49.1	40.4	79.6	adj.
(m/s)	13.6	11.2	22.1	adj.
Ua (m/s)	17.7	13.9	32.0	adj.
F (km)	3.2	3.2	3.2	
D (m)	15.0	15.0	15.0	
Ds (m)	4.6	4.6	4.6	
MFL (m)	327.36	327.36	327.36	
PSH (m)	327.96	327.96	327.96	
Dfb (m)	0.60	0.60	0.60	
Ho (m)	0.51	0.40	0.93	
Hrms (m)	0.36	0.28	0.65	
T (s)	2.39	2.21	2.92	
t min (h)	0.74	0.81	0.61	
t (h)	9	9	9	
Ho/gT^2	0.0091	0.0084	0.0111	
Ds/Ho	9.01	11.45	4.97	
R/Ho	0.89	0.92	0.78	adj.
H cr (m)	0.66	0.60	0.70	
R (m)	0.45	0.37	0.72	
R cr (m)	0.59	0.59	0.58	
P(R>R cr)	0.0333	0.0114	0.3172	
N (wvs/h)	50	19	391	
Ntot (wvs)	451	167	3522	
E min (m)	0.30	0.11	0.82	
WSet (m)	0.008	0.006	0.022	

Table C-9(c)

RESERVOIR: VICTORIA LAKE

STRUCTURE: VICTORIA CONTROL DYKES : reduced fetch
- 0.91 m riprap added

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	NNW-NNE	NNW-NNE	
U (km/h)	38.8	29.3	77.0	unadj.
(m/s)	10.8	8.1	21.4	unadj.
U (km/h)	49.1	40.4	79.6	adj.
(m/s)	13.6	11.2	22.1	adj.
Ua (m/s)	17.7	13.9	32.0	adj.
F (km)	2.7	2.7	2.7	
D (m)	15.0	15.0	15.0	
Ds (m)	4.6	4.6	4.6	
MFL (m)	327.36	327.36	327.36	
PSH (m)	328.87	328.87	328.87	
Dfb (m)	1.51	1.51	1.51	
Ho (m)	0.47	0.37	0.85	
Hrms (m)	0.33	0.26	0.60	
T (s)	2.26	2.09	2.76	
t min (h)	0.66	0.72	0.55	
t (h)	9	9	9	
Ho/gT^2	0.0093	0.0086	0.0114	
Ds/Ho	9.81	12.47	5.41	
R/Ho	0.93	0.93	0.84	adj.
H cr (m)	1.61	1.62	2.16	
R (m)	0.44	0.34	0.72	
R cr (m)	1.50	1.51	1.49	
P(R>R cr)	.0000	.0000	.0000	
N (wvs/h)	0	0	0	
Ntot (wvs)	0	0	0	
E min (m)				
WSet (m)	0.007	0.005	0.018	

Table C-9(d)

RESERVOIR: VICTORIA LAKE

STRUCTURE: VICTORIA CONTROL DYKES : full fetch
-0.91 m riprap added

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	NNW-NNE	NNW-NNE	
U (km/h)	38.8	29.3	77.0	unadj.
(m/s)	10.8	8.1	21.4	unadj.
U (km/h)	49.1	40.4	79.6	adj.
(m/s)	13.6	11.2	22.1	adj.
Ua (m/s)	17.7	13.9	32.0	adj.
F (km)	3.2	3.2	3.2	
D (m)	15.0	15.0	15.0	
Ds (m)	4.6	4.6	4.6	
MFL (m)	327.36	327.36	327.36	
PSH (m)	328.87	328.87	328.87	
Dfb (m)	1.51	1.51	1.51	
Ho (m)	0.51	0.40	0.93	
Hrms (m)	0.36	0.28	0.65	
T (s)	2.39	2.21	2.92	
t min (h)	0.74	0.81	0.61	
t (h)	9	9	9	
Ho/gT^2	0.0091	0.0084	0.0111	
Ds/Ho	9.01	11.45	4.97	
R/Ho	0.93	0.93	0.84	adj.
H cr (m)	1.61	1.61	2.16	
R (m)	0.48	0.37	0.78	
R cr (m)	1.50	1.50	1.49	
P(R>R cr)	.0000	.0000	.0000	
N (wvs/h)	0	0	0	
Ntot (wvs)	0	0	0	
E min (m)				
WSet (m)	0.008	0.006	0.022	

Table C-10

RESERVOIR: VICTORIA

STRUCTURE: VICTORIA DAM

CRITERIA	TEST WIND	MAXIMUM OF MONTHLY MEAN WINDS	MAXIMUM OF HOURLY WINDS	NOTES
Sector	----	S-SW	S-SW	
U (km/h)	38.8	25.2	97.0	unadj.
(m/s)	10.8	7.0	26.9	unadj.
U (km/h)	49.1	36.2	100.4	adj.
(m/s)	13.6	10.1	27.9	adj.
Ua (m/s)	17.7	12.1	42.6	adj.
F (km)	3.0	3.0	3.0	
D (m)	40.0	40.0	40.0	
Ds (m)	41.0	41.0	41.0	
MFL (m)	327.36	327.36	327.36	
PSH (m)	328.88	328.88	328.88	
Dfb (m)	1.52	1.52	1.52	
Ho (m)	0.49	0.34	1.19	
Hrms (m)	0.35	0.24	0.84	
T (s)	2.34	2.07	3.14	
t min (h)	0.71	0.81	0.53	
t (h)	44	44	44	
Ho/gT^2	0.0092	0.0081	0.0123	
Ds/Ho	82.94	120.66	34.41	
R/Ho	0.92	0.92	0.81	adj.
H cr (m)	1.65	1.65	2.10	
R (m)	0.45	0.31	0.96	
R cr (m)	1.52	1.52	1.51	
P(R>R cr)	.0000	.0000	0.0020	
N (wvs/h)	0	0	2	
Ntot (wvs)	0	0	100	
E min (m)			0.18	
WSet (m)	0.003	0.002	0.012	

APPENDIX D
STABILITY CRITERIA

STABILITY CRITERIA - CONCRETE STRUCTURES

1 - GENERAL

Preliminary criteria adopted for the assessment of selected concrete structures are summarized herein.

2 - LOADING CRITERIA

2.1 - Gravel Fill Properties

Submerged weight	- 65 pcf
Weight above water level	- 120 pcf

2.2 - Weights of Materials

Mass concrete	- 145 pcf
Water	- 62.5 pcf

2.3 - Water Pressures

Vertical and horizontal water pressures vary in accordance with discharge conditions.

2.4 - Uplift Pressure

Hydrostatic pressure assumed to vary linearly from headwater at the upstream side to tailwater plus one-third of headwater minus tailwater at the line of pressure relief drains, then varying linearly to tailwater on the downstream side. Hydrostatic pressure is applied on full area of the plane of concrete or rock being considered.

2.5 - Earthquake Loads

Concrete and water loads are assumed to be affected by earthquake as follows.

Additional horizontal load due to dead weight of structure is 0.05 times weight of structure or member, acting at its center of gravity.

Additional horizontal load from a depth H feet of water is 0.05 x 0.555 x 62.5H2/ft width, acting at a depth of 0.57H.

Horizontal earthquake forces can act in any direction, including either upstream or downstream. Influence in the vertical direction is ignored.

2.6 - Ice Pressure

Static ice load is assumed to be 10,000 pounds per linear foot on piers and 5,000 pounds per linear foot acting on gates and single span of bridge, all 1 ft below water level.

3 - LOAD COMBINATIONS

Extreme load cases considered with water at MFL are as follows.

A - Dead loads + hydrostatic
B - Dead loads + hydrostatic + ice
C - Zontal fill pressure
    - coefficient (at rest) - ko 0.5
    - coefficient (active) - ka 0.30

Table S.1

Summary of Results of Freeboard Study Under PMF Conditions

Basin	Structure	Assumed MFL (m)	Required Freeboard Increase	Action Recommended
Long Pond	Salmon Dam	182.73	None	None
	South Cut off Dams	182.73	None	None
	North West Cut off Dam	182.73	None	None
	Power Canal Embankment	182.73	None	None
Burnt Pond	Burnt Dam	315.47	None	None
	Burnt Canal Dyke u/s of bridge	315.47	0.9 m	1) check freeboard under normal operating conditions 2) raise crest
	Burnt Canal Dyke d/s of bridge	varies	cannot be determined	Hydraulic analysis to determine water levels in PMF conditions
Victoria	Victoria Dam	327.36 (proposed)	None	None
	Victoria Dykes near control structure	327.36	0.2 m	Set MFL lower or add riprap

APPENDIX E
LOCATION MAPS

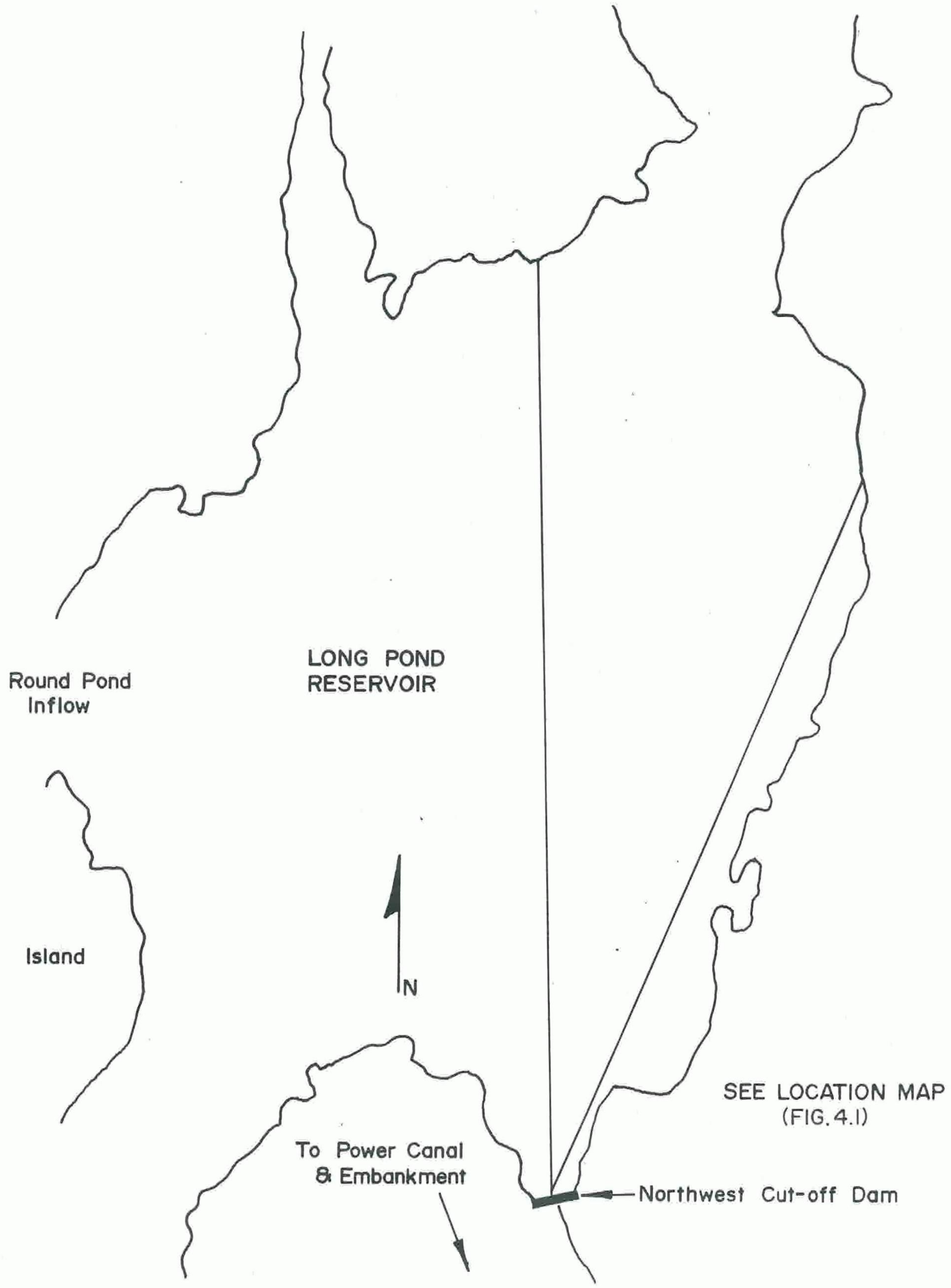
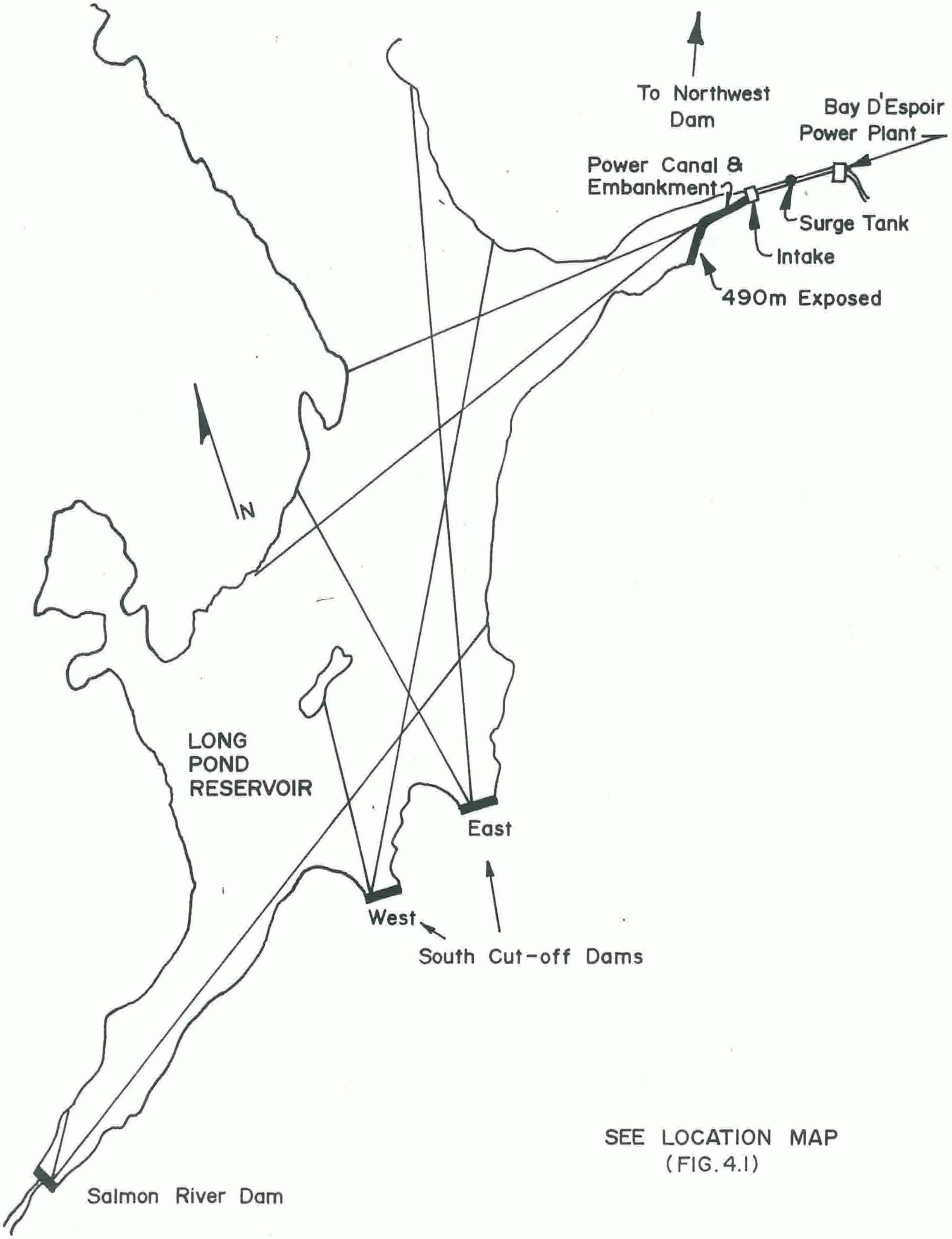


FIG. E-1

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FREEBOARD STUDY
LOCATION MAP – NORTHWEST DAM

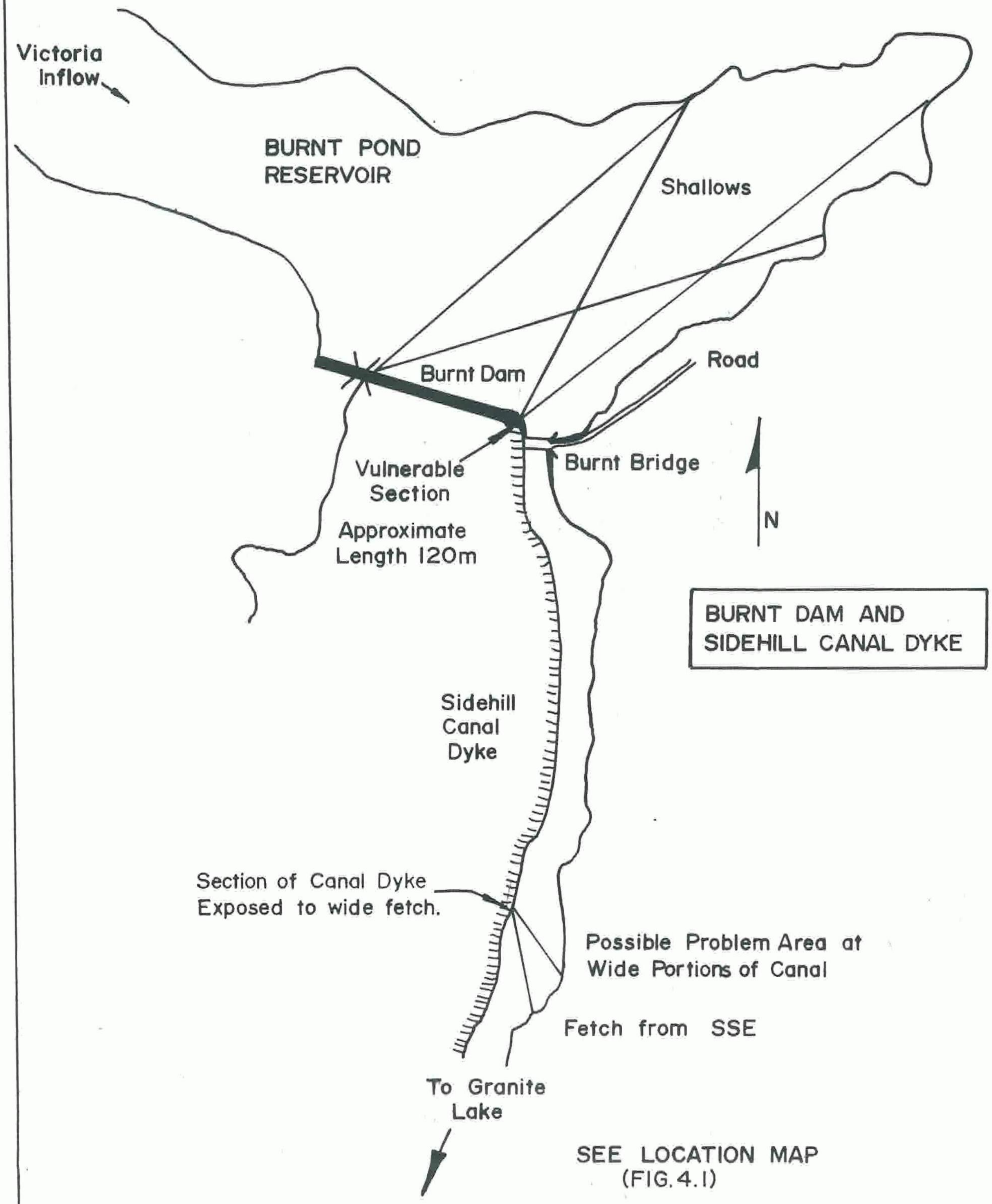


SEE LOCATION MAP
(FIG. 4.1)

FIG. E-2

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FREEBOARD STUDY
LOCATION MAP– LONG POND SOUTH

ACRES



SEE LOCATION MAP
(FIG. 4.1)

FIG. E-3

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FREEBOARD STUDY
LOCATION MAP– BURNT POND

ACRES

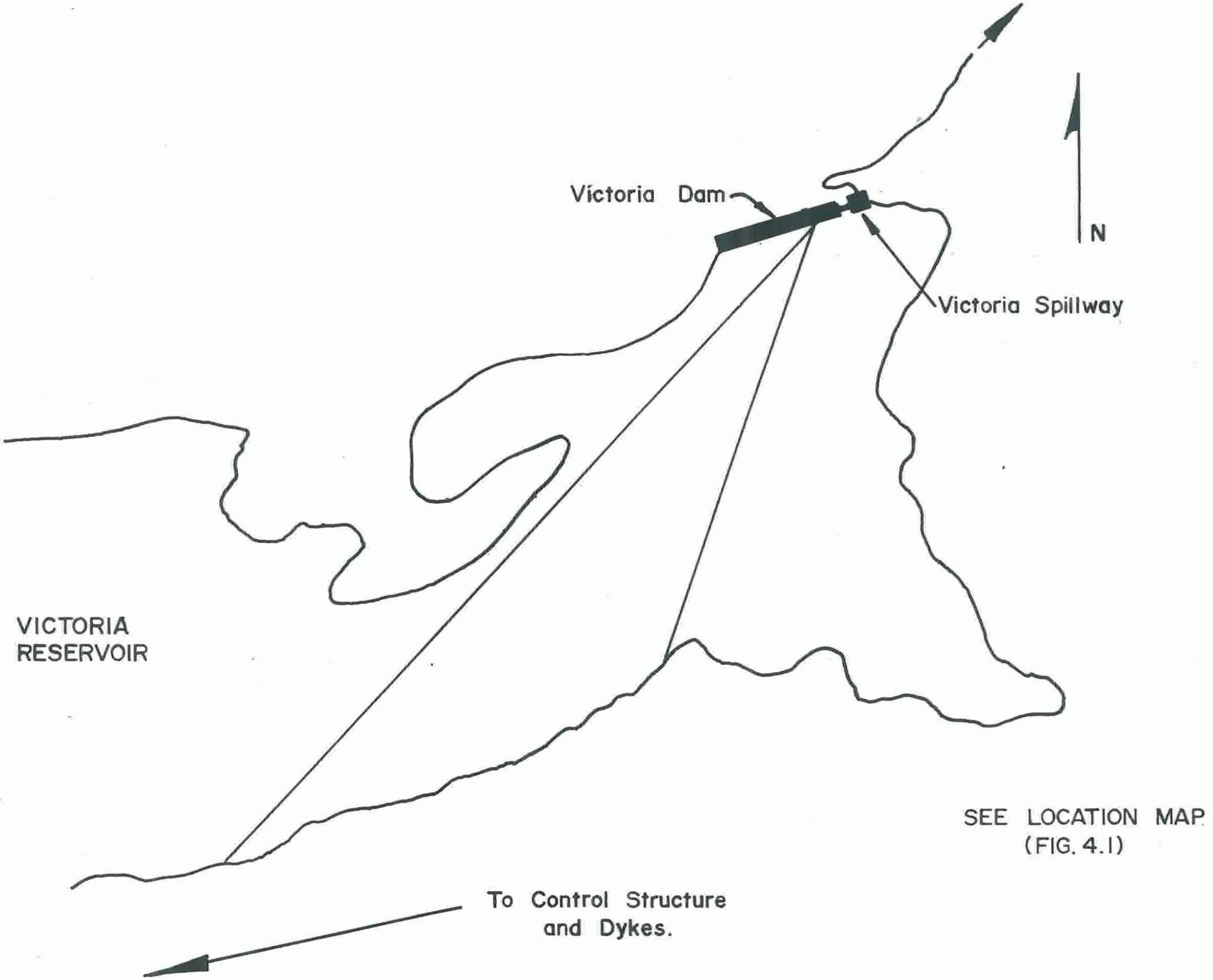


FIG.E-4

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FREEBOARD STUDY
LOCATION MAP – VICTORIA DAM

ACRES

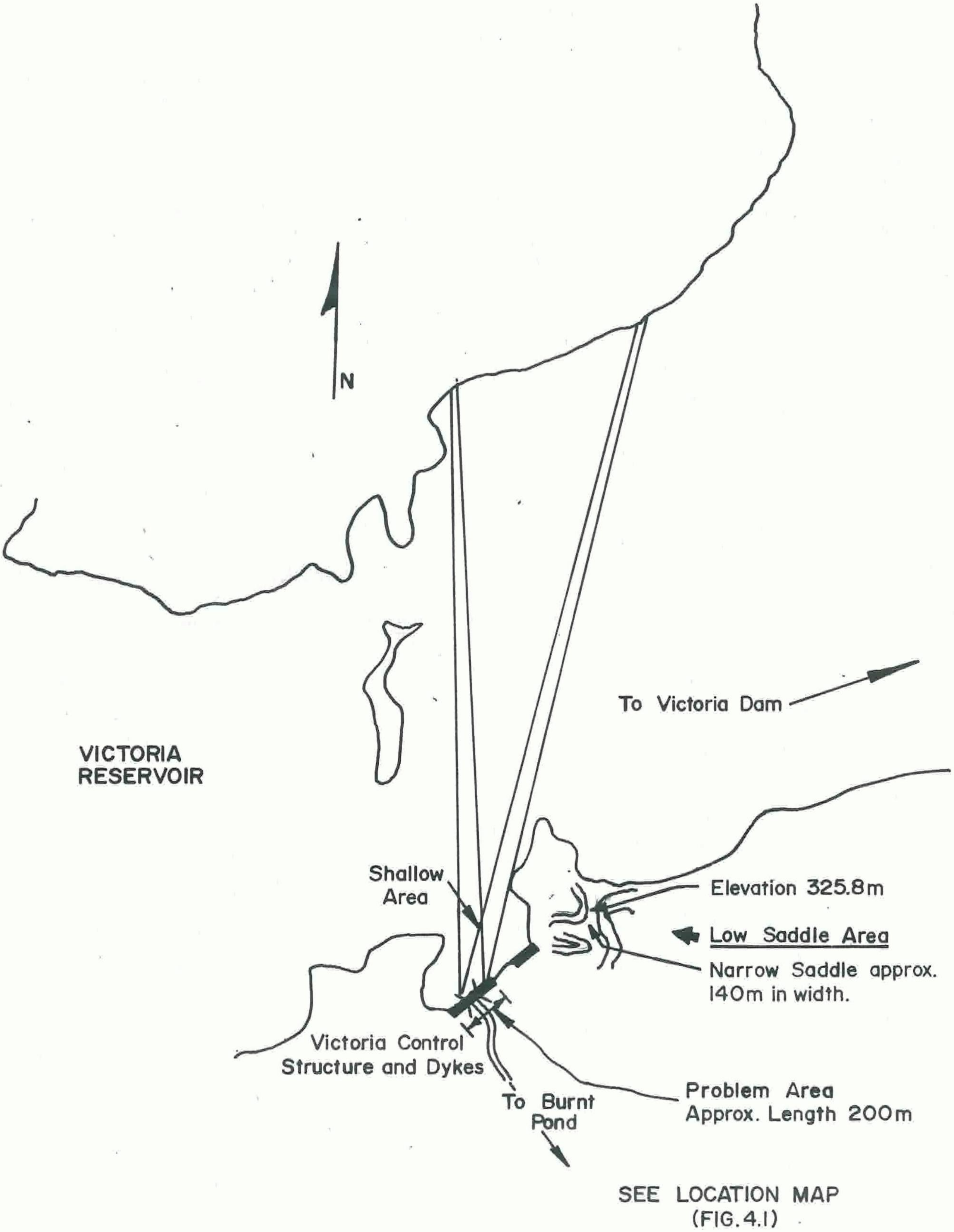


FIG. E-5

NEWFOUNDLAND AND LABRADOR HYDRO
BAY D'ESPOIR FREEBOARD STUDY
LOCATION MAP – VICTORIA CONTROL

ACRES