REFERENCE 6

NEWFOUNDLAND AND LABRADOR HYDRO

REPORT ON 1981/82 CLIMATOLOGICAL MONITORING PROGRAM

PREPARED BY: Newfoundland and Labrador Hydro
Engineering & Construction Division
Transmission Line Design Group

#3-7-8

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1.0 SUMMARY

The climatological study concluded on 1982-05-31 was the fifth in an annual series conducted by Newfoundland and Labrador Hydro.

The study included the accumulation of data related to wind speed and direction, ice accumulation on passive and active collectors, air borne contamination and water droplet size.

This report summarizes the data collected during the period of 1981-06-01 to 1982-05-31 and recommends.

(1) The continuation of the Passive Ice Meter Program.

(2) Wind data to be collected only at Hawkes Bay and 4-Mile Pond during 1983.

(3) The Rosemount Ice Detector operated at 4-Mile Pond only.

(4) The test towers be monitored from December 1982 to May 1983 on both the Long Range Mountains and the Pinware Valley.

(5) Salt Contamination Program be terminated at year end 1982.

(6) The test spans be monitored as passive collectors only.

2.0 OBJECTIVES

The "Report on 1981/82 Climatological Monitoring Program" will review the individual components of the study funded under Work Order 9723 and Change Order 1 to Work Order 9723.

All the data collected during the 1981/82 observation period will be presented.

Conclusions will be drawn based on the accumulated data and recommendations will be made as to the future direction of the program.

3.0 INTRODUCTION

The development of the hydro electric potential of the Churchill River and the transmission of power across Labrador and to the Island of Newfoundland has been of continuing interest for the past number of years. In its review of the feasibility of this project the Lower Churchill Development Corporation and its predecessor, the Gull Island Power Corporation, have implemented a series of annual climatological monitoring studies. These studies, conducted by Newfoundland and Labrador Hydro, were designed to collect data necessary to optimize transmission line design and route selection parameters for the HVDC transmission system envisaged for this project.

The data gathering network includes both passive and active collectors. The passive collectors are monitored by trained observers while the active collectors are coupled to recording devices.

All collected data is summarized into an annual report such as this document which is entitled "Report on 1981/82 Climatological Monitoring Program".

4.0 DISCUSSION OF PROGRAM

4.1 PASSIVE ICE METER

The Passive Ice Meter Monitoring Program was active from 1981-10-15 to 1982-05-15 with 25 sites participating in the observation and reporting of atmospheric icing conditions.

The Stephenville and St. John's Airports dropped from this years program following the lead of two other Government Agencies at St. Anthony and St. Lawrence who left the program last year due to a heavy work load and insufficient staff. Consideration should be given to re-establishing these sites in the private sector with paid monitors to ensure continuity of service and reliable reporting.

The data collected during the past season is tabulated in Appendix 6.1 - Summary of Passive Ice Meter Data.

4.2 ANEMOMETER

The Bendix, propeller type, anemometers used at Savage Cove, Hawkes Bay, Sunnyside and 4-Mile Pond operated reasonably well throughout the 1981-82 season.

However, the frequent ice loads and exceptionally high winds experienced at the 4-Mile Pond site, have completely destroyed one unit and caused serious damage to a second, spare, unit. The apparent weaknesses in the unit have been discussed with the manufacturer who has suggested altering the design of future units to be used in similar conditions.

The 4-Mile Pond site has experienced winds of 172 kmh , 5 times within a 1 hour period and icing is known to occur on an average of every second day during some months.

The cup type anemometer at Levi's Gulch has produced good but sporadic information. The extreme weather conditions during the winter months and tampering by the local residents has made it impossible to maintain the continuity of the recorded data.

The data collected from the anemometer sites is tabulated in Appendix 6.2 - Summary of Anemometer Data.

4.3 ROSEMOUNT ICE DETECTOR

The Rosemount Ice Detector Program was curtailed for the 1981/82 season to include only the 4-Mile Pond site.

The information tabulated in Appendix 6.3 - Summary of Rosemount Ice Detector Data will be filed with earlier data until a correlation between actual ice accretion and the number of instrument operations is established.

4.4 TEST TOWER SITES

The Test Tower Program for the 1981/82 season began on 1981-11-25 with visits to Long Range Mountain Crossing area and then including the Labrador sites on 1982-01-07.

Site #4 was re-established on 1982-02-05, after having blown down at the end of the 1980/81 season.

All 18 sites were visited as regularly as weather would permit and the collected data is tabulated in Appendix 6.4 - Summary of Test Tower Data.

4.5 SALT CONTAMINATION

Four new Salt Contamination Sites were established at the proposed HVDC cable termination sites. These are located as follows:

IDENTIFICATION	DISTANCE FROM SEA (km)	ELEVATION (m)
Flowers Cove:		
F1	0.2 N	80+
F2	1.0 N 0.3 NNE	80+
Point Amour:		
L1	0.2 S	80+
L2	2.9 S 1.4 W 3.2 E	400+

Monitoring of these sites began in 1982-09 and after the completion of 12 months of collection and analysis the data was processed and is presented in graphic form in Appendix 6.5 - Contamination Data.

It is worthy of note that at Site F1 an extreme contamination level was reached during late October 1981. A review of the climatological conditions at that time revealed strong on-shore winds (64-72 kmh) occurred one day before the insulators were collected. Hence, it has been concluded that a heavy salt buildup had occurred and that no natural washing had taken place. Also that previous levels which have been recorded as being very low are due to the high frequency of natural washing.

4.6 SALT CORROSION

No Salt Corrosion Studies were undertaken during the 1980/81 observation period.

4.7 TEST SPANS

During the 1980/81 observation period the Inner Pond Test Span was instrumented and the accumulated data has been forwarded for analysis. When a report becomes available it will be presented as an addendum to this report.

The Brian's Pond Span was treated as a passive collector and visited regularly as was the remaining tower at the Parsons Pond Span.

4.8 CLOUD DROPLET SIZE

During the 1981/82 program work was initiated to determine the size of cloud water droplets occuring at higher elevations in Newfoundland. The reason for this investigation is best explained in the Weather Engineering Corporation of Canada Limited report, "WECAN - 116" Section 6.0 of that report says:

"In the case of icing caused by cloud droplets (i.e. rime, and cloud glaze) there is a theoretical upper limit to the thickness of ice which can accrete, because when the total diameter reaches a certain limiting size, the division of the air flow will be such that all the cloud droplets are swept around the obsticle and the accretion then stops. Stated another way, the collection drops off with increased icing diameter until at the critical diameter it becomes zero."

Collection mediums of different diameters were established at the 4-Mile Pond, Holyrood site which included:

(1) 17 cm Aluminum Pipe
(2) 25 cm (avg. at 1.5 m level) Wood Pole
(3) 43 cm Aluminum Shield
(4) 61 cm Aluminum Shield

At the Portland Creek Site #2 an aluminum shield of 56 cm diameter was placed approximately 3 m above ground level on the existing test tower.

4.8 CLOUD DROPLET SIZE (CONT'D)

The information collected from each of these sites has been made available to Mr. B. Power of Weather Engineering for analysis.

Mr. Power concluded from his analysis that there is a diameter limit for cloud droplet size. The average droplet size would be less than 10 microns.

4.9 REVIEW OF MONITORING PROGRAM

As recommended by the 1980/1981 report, a complete review of the Climatological Study Program was undertaken. This study was carried out by Mr. B. Power of WECAN with a report entitled "Study of Climatological Monitoring Program (1977 - 1981)". The salient recommendations of that report (see Appendix 6.7) are as follows:

(a) Maintain current wind data program.

(b) Maintain PIM program, test tower program and RID program at Holyrood only.

5.0 CONCLUSIONS AND RECOMMENDATIONS

With the completion of the 1981/1982 Climatological Data Collection Program another year of ice and wind information has been added to the existing data base established to enhance the HVDC Transmission Line Design Parameters and Route Selection.

Within the limits of financial restraints it is recommended that the Climatological Program continue for 1982/1983 with scope of the Program to be as follows:

(1) Maintain PIM Program.

(2) Maintain wind data collection at Hawkes Bay and 4-Mile Pond - Holyrood.

(3) Continue the monitoring of the test towers and test spans (Passive) along the Long Range Mountains and Pinware Valley, Labrador.

(4) Maintain the RID at 4-Mile Pond, Holyrood.

APPENDIX 6.1

SUMMARY OF PASSIVE ICE METER DATA

SUMMARY OF PASSIVE ICE METER REPORTS

(1981 - 1982)

LOCATION	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY
Wabush	No Accum.	Trace Glaze - 1 day Trace Rime - 3 days	Trace Rime - 3 days 0.3 cm Glaze - 1 day	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.
Churchill Falls	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	Trace Glaze - 2 days	
Goose Bay	No Accum.	0.2 cm Glaze - 1 day	2-5 cm Glaze - 2 days	Trace Glaze - 1 day	-	-	1-2 cm glaze - 2 days	Trace 1-day
Point Amour	No Accum.	0.8-1.3 cm Wet Snow - 1 day	4.6 cm Wet Snow - 1 day	No Accum.	No Accum.	1.3-1.9 cm Glaze - 1 day		
Plum Point	No Accum	No Accum.	0.5-0.8 cm Wet Snow - 1 day	No Accum.	0.1 cm Glaze - 1 day	2.4-8.0 cm Wet Snow - 2 days	Trace -2 days	No Accum.
St. Anthony	----------	----------	NOT MONITORED	----------	----------	----------	----------	----------
Yankee Point	No Accum.	No Accum	No Accum.	0.3-0.6 cm Wet Snow - 2 days	0.3-1.3 cm Wet Snow - 2 days 0.6 cm Glaze - 1 day			
Hawkes Bay	No Accum	No Accum.	No Accum	No Accum	No Accum	1.3 cm Glaze - 1 day	Trace - 1.6 cm Glaze - 3 days	No Accu
Daniel's Hr.	No Accum	No Accum.	Trace Glaze - 1 day	Trace Glaze - 1 day				
Gros Morne Park	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accu

SUMMARY OF PASSIVE ICE METER REPORTS

(1981 - 1982)

LOCATION	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY
Stephenville	---------- NOT MONITORED ----------							
Port Aux Basque	No Accum.	No Accum.	No Accum.	0.3 cm Wet Snow - 1 day	Trace -3 days	2-3 cm - 2 days	Trace -2 days 2 cm -1 day	No Accum.
Burnt Pond	No Accum.	Trace Glaze - 1 day	No Accum.	No Accum.	No Accum.	No Accum.	No Accu.	No Accum.
Buchans	No Accum.	No Accum.	0.3 cm Glaze - 1 day	0.5 cm Glaze - 1 day	Trace Glaze 4.5 cm - 1 day	2.5 cm Glaze - 1 day	0.5-0.3 cm Glaze - 2 days	
Deer Lake	No Accum.	No Accum.	No Accum	No Accum	0.4 cm Glaze - 1 day	Trace Glaze - 1 day	No Accum.	No Accum.
Hampden	No Accum.	No Accum.	---------- NOT MONITORED ----------					
Springdale	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	Trace - 1 day	Trace - 1 day	No Accum.
Stony Brook	No Accum.	No Accum.	Trace Glaze - 2 days	No Accum.	No Accum.	No Accum.	Trace - 0.4 cm - 2 days	No Accum.
Gander	No Accum.	No Accum.	Trace - 1 day	Trace Glaze 0.1 cm - 1 day	Trace - 1 day	Trace Glaze -0.5 cm - 3 days	Trace Glaze - 4 cm - 4 days	No Accum.
Bay D'Espoir	No Accum.	No Accum	No Accum.	0.3 cm Wet Snow - 1 day	No Accum.	No Accum.	No Accum.	No Accum
Sunnyside	No Accum.	No Accum.	No Accum.	No Accum.	Trace - 1 day	No Accum.	No Accum.	No Accum
St. Lawrence	---------- NOT MONITORED ----------							

SUMMARY OF PASSIVE ICE METER REPORTS

(1981 - 1982)

LOCATION	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY
"S" Turn	-	-	-	-	-	-	-	-
Long Harbour	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.
Western Avalon	No Accum.	No Accum.	No Accum.	No Accum.	0.4 cm Glaze - 1 day	No Accum.	No Accum.	No Accum.
Holyrood	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.
St. John's Airport	----------	----------	----------	NOT MONITORED	----------	----------	----------	----------
Harbour Deep	No Accum.	1.1-2.0 cm Wet Snow - 2 days	1.2 cm Wet Snow - 2 days	No Accum.	No Accum.	No Accum.	No Accum.	No Accum.
Port Blandford	No Accum.	No Accum.	No Accum.	Trace Glaze - 1 day	No Accum.	No Accum.	No Accum.	No Accum.

APPENDIX 6.2

SUMMARY OF ANEMOMETER DATA

ABSTRACT OF THE WIND

SUMMARY

SUNNYSIDE

	JUNE 81	JULY 81	AUG. 81	SEPT. 81	OCT. 81	NOV. 81	DEC. 81	JAN. 82	FEB. 82	MAR. 82	APR. 82	MAY 82
Total Mileage for Month	5908	6233	6932	6921	7344	7429	7028	10518	9388	8234	8443	5517
Greatest Mileage in 24 Hrs.	329	391	372	600	561	523	572	756	644	522	524	328
Greatest Mileage & Prevailing Dir. for 1 Hr.	SW 20	SW 24	SW 24	SW 38	SW 20	NE 35	N 35	SW 50	NW 45	SW 42	S 38	S 18
Date of Greatest Mileage for 1 Hr.	15	29	27	20	15	27	31	10	14	5	22	26
Average Speed for Month (mph)	10	9.6	9.2	9.6	9.9	10.3	9.4	14.1	14.0	11.1	11.5	7.4
Longest Continued - Direction	SW	SW	NE	SW	SW	NE	SW	NE	NW	SW	SW	NE
- Hours	138	63	86	70	98	64	65	59	55	49	54	119
Prevailing Direction - By Mileage	SW	SW	SW	SW	SW	SW	SW	SW	W	SW	SW	S
- By Total Hrs.	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	NE
Peak Gust (mph)	20	25	30	30	40	35	45	65	55	45	52	35

NOTE: Instrument records in imperial units.

ABSTRACT OF THE WIND

SUMMARY

SAVAGE COVE

	JUNE 81	JULY 81	AUG. 81	* SEPT. 81	** OCT. 81	NOV. 81	*** DEC. 81	JAN. 82	FEB. 82	MAR. 82	APR. 82	*** MAY 82
Total Mileage for Month	6411	5385	6309	2350	1483	OUT OF SERVICE	9365	10831	7303	6378	7501	7892
Greatest Mileage in 24 Hrs.	506	514	520	872	435		650	988	896	578	648	534
Greatest Mileage & Prevailing Dir. for 1 Hr.	SW 26	W 26	E 26	W 40	SW 26		32	W 50	W 40	W 40	E 30	22.3
Date of Greatest Mileage for 1 Hr.	24	22	23	21	18		22	8	24	4	5	15
Average Speed for Month (mph)	9.0	8.4	9.0	12.2	10.3		13.0	21.5	13.8	12.7	13.2	13.7
Longest Continued - Direction	W	W	W	W	NE		—	NW	NW	E	W	—
- Hours	52	70	55	43	31		—	42	40	37	76	—
Prevailing Direction - By Mileage	W	W	W	W	NE		—	W	W	E	W	—
- By Total Hrs.	W	E	W	W	NE		—	W	W	E	W	—
Peak Gust (mph)	42	40	40	62	44		52	78	50	58	50	36

NOTE: Instrument records in imperial units.

* 8 days only
** 6 days only
*** Wind Speeds Only Recorded

ABSTRACT OF THE WIND

SUMMARY

4-MILE POND

	JUNE 81	JULY 81	AUG. 81	SEPT. 81	OCT. 81	NOV. 81	DEC. 81	JAN. 82	FEB. 82	MAR. 82	APR. 82	MAY 82
Total Mileage for Month	14,020	12,352	10,899	14,911	10,989	9,632*	NOT OPERATIONAL	18,505	13,058*	10,132*	NOT OPERATIONAL	NOT OPERATIONAL
Greatest Mileage in 24 Hrs.	659	828	706	631	948	1,288		1,032	996	748		
Greatest Mileage & Prevailing Dir. for 1 Hr.	SW 34	S 50	S 40	S 60	S 52	S 65		SW 76	E 64	SE 70		
Date of Greatest Mileage for 1 Hr.	22	15	17	20	4	7		16	7	8		
Average Speed for Month (mph)	24.4	18.0	17.7	26.3	18.5	17		29.1	24.7	19.2		
Longest Continued - Direction - Hours	SW 148	SW 32	SW 84	SE 78	NW 39	SW 64		SW 44	NW 45	SW 38		
Prevailing Direction - By Mileage	SW	SW	SW	SW	NW	SW		SW	NW	SW		
- By Total Hrs.	SW	SW	SW	SW	W	SW		SW	SW	W		
Peak Gust (mph)	43	40	38	50	40	86		107	40*	50		

NOTE: Instrument records in imperial units.
* Partial month

ABSTRACT OF THE WIND

SUMMARY

HAWKES BAY

	JUNE 81	JULY 81	AUG. 81	SEPT. 81	OCT. 81	NOV. 81	DEC. 81	JAN. 82	FEB. 82	MAR. 82	APR. 82	MAY 82
Total Mileage for Month	8551	8939	8233	8665	10608	9962	10043	12583	4491*	9049	10340	9271
Greatest Mileage in 24 Hrs.	498	522	432	814	636	554	706	828	525	624	432	474
Greatest Mileage & Prevailing Dir. for 1 Hr.	SE 32	SW 28	SW 32	SW 44	SW 44	SE 36	NW 36	NW 56	W 42	SW 40	SW 40	SW 36
Date of Greatest Mileage for 1 Hr.	26	27	27	20	24	21	26	10	8	5	17	24
Average Speed for Month (mph)	11.9	12.0	11.1	12.0	14.3	13.8	13.6	16.9	11.2	12.7	14.4	12.5
Longest Continued - Direction	SW	SW	SW	NW	NW	NE	NW	SE	W	W	SW	E
- Hours	35	35	38	47	66	48	50	31	19	22	36	93
Prevailing Direction - By Mileage	SW	SW	SW	SW	SW	SW	NW	W	W	SW	SW	E
- By Total Hrs.	SW	SW	SW	E	NE	SW	E	W	W	SW	SW	E
Peak Gust (mph)	SE 45	SW 45	SW 40	SW 56	SW 52	SE 51	NW 44	NW 71	W 48	SW 48	E 50	SW 42

NOTE: Instrument records in imperial units.

* Recorder out of service for 11 days

ABSTRACT OF THE WIND
SUMMARY
LEVI'S GULCH

Highest Hourly Average

Aug. 25 - 31/81	-	E 50
Sept. 1 - 27/81	-	E 80
Nov. 25 - 31/81	-	NW 26
Dec. 1 - 31/81	-	NE 55
Jan. 1 - 4/82		
& 8 17/82	-	NE 52

APPENDIX 6.3

SUMMARY OF ROSEMOUNT ICE DETECTOR DATA

ROSEMOUNT ICE DETECTOR

4-MILE POND

DATE	TIME	NO. OF ICING SIGNALS	CALCULATED ACCUMULATION (INCHES)
23/10/81	3:00 pm	Start	-
01/12/81	4:00 am	Down	-
11/12/81	2:05 pm	Start	-
11/12/81	6:20 pm - 6:25 pm	4	2.0
12/12/81	8:40 am	1	0.5
15/12/81	1:34 pm	1	0.5
16/12/81	2:15 am - 3:40 am	11	5.6
19/12/81	5:55 am -11:10 am	23	11.7
20/12/81	4:34 am - 4:26 am	2	1.0
20/12/81	6:55 am	1	0.5
20/12/81	3:05 pm	1	0.5
23/12/81	3:00 am - 4:15 am	4	2.0
30/12/81	1:00 pm	1	0.5
30/12/81	4:36 pm - 8:10 pm	137	69.6
31/12/81	2:38 am -10:28 am	16	8.1
31/12/81	2:00 pm	1	0.5
02/01/82	9:16 am - 9:18 am	2	1.0
02/01/82	11:08 am		
03/01/82	- 6:05 pm	21	10.7
03/01/82	7:16 pm		
04/01/82	- 4:30 am	16	8.1
04/01/82	8:56 pm -10.40 pm	6	3.0
05/01/82	2:48 am - 2:08 pm	90	45.7
05/01/82	3:40 pm - 5:00 pm	5	2.5
06/01/82	12:05 am	1	0.5
06/01/82	11:05 am	1	0.5
06/01/82	11:15 am	1	0.5
08/01/82	3:12 pm - 8:45 pm	18	9.1

ROSEMOUNT ICE DETECTOR

4-MILE POND

DATE	TIME	NO. OF ICING SIGNALS	CALCULATED ACCUMULATION (INCHES)
10/01/82	4:36 am - 8:50 am	11	5.6
10/01/82	7:30 pm	1	0.5
14/01/82	7:08 pm	2	1.0
15/01/82	4:50 am - 7:45 am	26	13.2
15/01/82	3:55 pm - 4:30 pm	2	1.0
15/01/82	9:55 pm -10:25 pm	4	2.0
15/01/82	11:30 pm -11:45 pm	3	1.5
16/01/82	2:06 am	1	0.5
16/01/82	1:35 pm - 1:38 pm	2	1.0
17/01/82	6:48 pm -11:20 pm	8	4.1
24/01/82	9:05 pm -		
25/01/82	-12:25 am	16	8.1
25/01/82	5:20 am - 5:24 am	4	2.0
26/01/82	7:55 am - 8:10 am	5	2.5
27/01/82	10:40 am -10:55 am	10	5.1
27/01/82	1:23 pm	1	0.5
27/01/82	11:00 pm -		
28/01/82	3:05 am	8	4.1
28/01/82	6:23 am	1	0.5
28/01/82	8:50 am - 9:00 am	2	1.0
28/01/82	1:36 pm	1	0.5
28/01/82	7:06 pm	1	0.5
29/01/82	7:50 am - 7:55 am	2	1.0
29/01/82	1:55 pm	1	0.5
29/01/82	7:00 pm	1	0.5
02/02/82	9:12 am - 9:55 am	12	6.1
02/02/82	12:36 pm	1	0.5
03/02/82	10.40 pm	1	0.5

ROSEMOUNT ICE DETECTOR

4-MILE POND

DATE	TIME	NO. OF ICING SIGNALS	CALCULATED ACCUMULATION (INCHES)
04/02/82	3:10 am - 3:40 am	11	5.6
04/02/82	11:50 am - 1:50 am	15	7.6
05/02/82	8:05 am - 8:10 am	4	2.0
07/02/82	8:12 am - 9:20 am	12	6.1
10/02/82	11:00 pm	1	0.5
11/02/82	2:03 am - 2:10 am	4	2.0
11/02/82	1:30 pm	1	0.5
12/02/82	7:48 pm - 8:00 pm	5	2.5
14/02/82	10.48 pm -		
15/02/82	12:18 am	7	3.6
16/02/82	1:50 pm - 2:05 pm	9	4.6
16/02/82	5:36 pm	1	0.5
16/02/82	8:06 pm - 8:10 pm	4	2.0
18/02/82	7:40 am - 8:24 am	4	2.0
18/02/82	1:08 pm - 1:10 pm	2	1.0
18/02/82	4:05 pm - 4:15 pm	10	5.1
19/02/82	10.20 am -10.24 am	3	1.5
20/02/82	8:05 pm	1	0.5
21/02/82	2:23 am - 9:00 am	60	30.5
22/02/82	3:58 am -12:05 pm	78	39.6
22/02/82	9:23 pm	1	0.5
23/02/82	10:48 am -10:55 am	3	1.5
23/02/82	4:24 pm -		
24/02/82	4:55 am	99	50.3
24/02/82	7:35 am -12:40 pm	47	23.9
20/03/82	4:12 pm - 5:46 pm	2	1.0
23/03/82	10:00 pm	1	0.5
25/03/82	5:36 am	1	0.5

ROSEMOUNT ICE DETECTOR

4-MILE POND

DATE	TIME	NO. OF ICING SIGNALS	CALCULATED ACCUMULATION (INCHES)
25/03/82	6:45 am	1	0.5
25/03/82	6:45 pm - 8:25 pm	9	4.6
26/03/82	4:30 pm - 4:35 pm	3	1.5
26/03/82	11:50 pm	1	0.5
01/04/82	7:12 am	1	0.5
02/04/82	6:00 am	1	0.5
02/04/82	9:22 am	1	0.5
02/04/82	7:20 pm -		
03/04/82	12:55 am	16	8.1
05/04/82	6:30 am	1	0.5
05/04/82		52	26.4
05/04/82	4:55 pm - 5:04 pm	8	4.1
05/04/82	7:24 pm - 7:28 pm	3	1.5
06/04/82	12:15 am - 7:30 am	24	12.2
07/04/82	3:12 pm - 9:50 pm	68	34.5
10/04/82	12:30 pm -12:48 pm	12	6.1
11/04/82	7:04 am - 7:35 am	20	10.2
12/04/82	2:05 pm - 8:40 pm	31	15.8
13/04/82	9:25 am -10:00 am	22	11.2

APPENDIX 6.4

SUMMARY OF TEST TOWER DATA

TABLE OF DATA

SITE #2 PORTLAND CREEK

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. ^{o}C	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
25-11/81	-	195^{o}	-4	2" X 7" soft rime pennants at 5' level of leg	195^{o}
07-01-82	-	-	-8	8" X 10" hard rime completely encasing tower at 5' level	225^{o}
06-02-82	12	200^{o}	-	Tower filled with 36" of hard rime at 5' level of leg	240^{o}
18-02-82	12	60^{o}	-22	Residue from previous trip shield installed	240^{o}
19-03-82	20	30^{o}	-15	6" hard rime at 5' level of tower leg 2" hard rime on cylinder	210^{o}
04-05-82	4	235^{o}	8	Bare	-

TABLE OF DATA

SITE #2a PORTLAND CREEK

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. ^oC	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
15/11/81	-	195^o	-2	1½" X 3" hard rime on ground	15^o
18-02-82	21	330^o	-24	2" glaze at 5' level of leg	0^o
19-03-82	10	60^o	-15	1" hard rime at 5' level of leg	240^o
04-05-82	3	235^o	8	Bare	-

TABLE OF DATA

SITE #2b PORTLAND CREEK

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. ^{O}C	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
25-11/81	-	195^{O}	-4	1" hard rime at 5' level of leg 1½" soft rime over hard rime	15^{O} 195^{O}
07/01/82	-	-	-8	4" X 5" hard rime at 5' level of leg 6" X 8" soft rime at 5' level of leg	135^{O} 225^{O}
18/02/82	21	315^{O}	-24	Tower filled with 28" of hard rime at 5' level of leg	240^{O}
19-03-82	12	60^{O}	-15	6" hard rime at 5' level of leg 2" - 3" hoar frost over rim	240^{O}
04-05-82	4	235^{O}	8	Bare	-

TABLE OF DATA

SITE #2c PORTLAND CREEK

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. $^{\circ}C$	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
25-11-81	-	195°	-2	Bare	-
18-02-82	9	330°	-23	Trace Glaze	-
19-03-82	8	60°	-14	½" to 1" hard rime at 5' level of leg	200°
04-05-82	3	235°	8	Bare	-

TABLE OF DATA

SITE #2d PORTLAND CREEK

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. °C	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
25-11-81	-	195°	-2	1" X 5" hard rime at 5' level of leg	15°
18-02-82	9	330°	-24	2½" of glaze at 5' level of leg	-
				1½" of glase at 5' level of leg	-
18-03-82	8	60°	-15	1" hard rime at 5' level of leg	200°
04-05-82	4	235°	10	Bare	-

TABLE OF DATA

SITE #2e PORTLAND CREEK

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. °C	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
25-11-81	-	195°	0	Bare	-
18-02-82	12	290°	-21	Bare	-
18-03-82	-	-	-7	Bare	-
04-05-82	2	235°	12	Bare	-

TABLE OF DATA

SITE #3 HILLS OF ST. JOHN'S

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. °C	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
07-01-82	-	-	-8	1" X 4" hard rime at 5' level of leg	135°
05-02-82	40	280°	-19	2" X 2" hard rime at ground level	150°
18-02-82	29	310°	-7	½" soft rime at 5' level of leg	240°
04-05-82	1	180°	10	Bare	-

TABLE OF DATA

SITE #4 L'ANSE AU LOUP

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. ^{o}C	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
25-11-81				Tower Down	
07-01-82	-	-	-10	6" soft rime at ground level	180^{o}
05-02-82	23	330^{o}	-26	Tower Erected	-
17-03-82	5	300^{o}	-6	6" soft rime at 5' level of leg	120^{o}
04-05-82	5	45^{o}	6	Bare	-

TABLE OF DATA

SITE #4a L'ANSE AU LOUP

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. ^oC	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
07-01-82	-	-	-8	6" soft rime at 5' level of leg	180^o
05-02-82	12	330^o	-24	2" hard rime at 5' level of leg	210^o
17-03-82	5	300^o	-8	2" soft rime at 5' level of leg	120^o
04-05-82	5	45^o	6	Bare	-

TABLE OF DATA

SITE #PW1 PINWARE RIVER

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. °C	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
07-01-82	-	-	-9	Bare	
05-02-82	6	330°	-21	1/8" glaze at 5' level of leg	330°
17-03-82	-	-	-7	Trace of Glaze	90°
04-05-82	5	45°	6	Bare	-

TABLE OF DATA

SITE # PW2 PINWARE RIVER

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. ^{o}C	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
07-01-82	-	-	-8	¼" hard rime at 5' level of leg	180^{o}
05-02-82	5	330^{o}	-23	Trace of Glaze	330^{o}
17-03-82	-	-	-7	¼" To ½" glase at 5' level of leg	90^{o}
04-05-82	5	45	6	Bare	-

TABLE OF DATA

SITE #PW3 PINWARE RIVER

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. $^{\circ}C$	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
07-01-82	-	-	-10	1" hard rime at 5' level of leg	180°
05-02-82	5	330°	-22	Bare	-
17-03-82	-	-	-6	Trace of Glaze	150°
04-05-82	5	45	6	Bare	-

TABLE OF DATA

SITE #PW4 PINWARE RIVER

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. °C	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
07-01-82	-	-	-10	BARE	-
05-02-82	5	330°	-22	BARE	-
17-03-82	-	-	-7	BARE	-
04-05-82	5	45°	6	BARE	-

TABLE OF DATA

SITE#9 28 MILE SECTION

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. °C	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
25-11-81	-	195°	-2	1" X 3" hard rime at 5' level of leg	15°
18-02-82	20	330°	-25	BARE	-
18-03-82	7	300°	-6	3/4" glaze at 5' level of leg Trace soft rime	150° 330°
04-05-82	-	300°	10	Bare	-

TABLE OF DATA

SITE #10 MAIN RIVER

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. °C	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
18-02-82	-	-	-23	BARE	-
18-03-82	-	-	-3	BARE	-
04-05-82	7	90°	+10	BARE	-

TABLE OF DATA

SITE #13 PARSONS POND

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. ^{o}C	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
25-11-81	-	-	-	BARE	-
18-02-82	-	330°	-24	BARE	-
18-03-82	-	-	-7	½" hard rime at 5' level of leg	180°
04-05-82	4	180°	10	Bare	-

TABLE OF DATA

SITE #14 PARSONS POND

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. ^oC	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
25-11-81	-	195^o	-4	3" X 3" hard rime at 5' level of leg	15^o
18-02-82	23	330^o	-25	7" pennent of hard rime at 5' level of leg	225^o
19-03-82	13	60^o	-15	1½" hard rime covered by 3"-4" soft rime at 5' level of leg	310^o
04-05-82	4	180^o	10	Bare	-

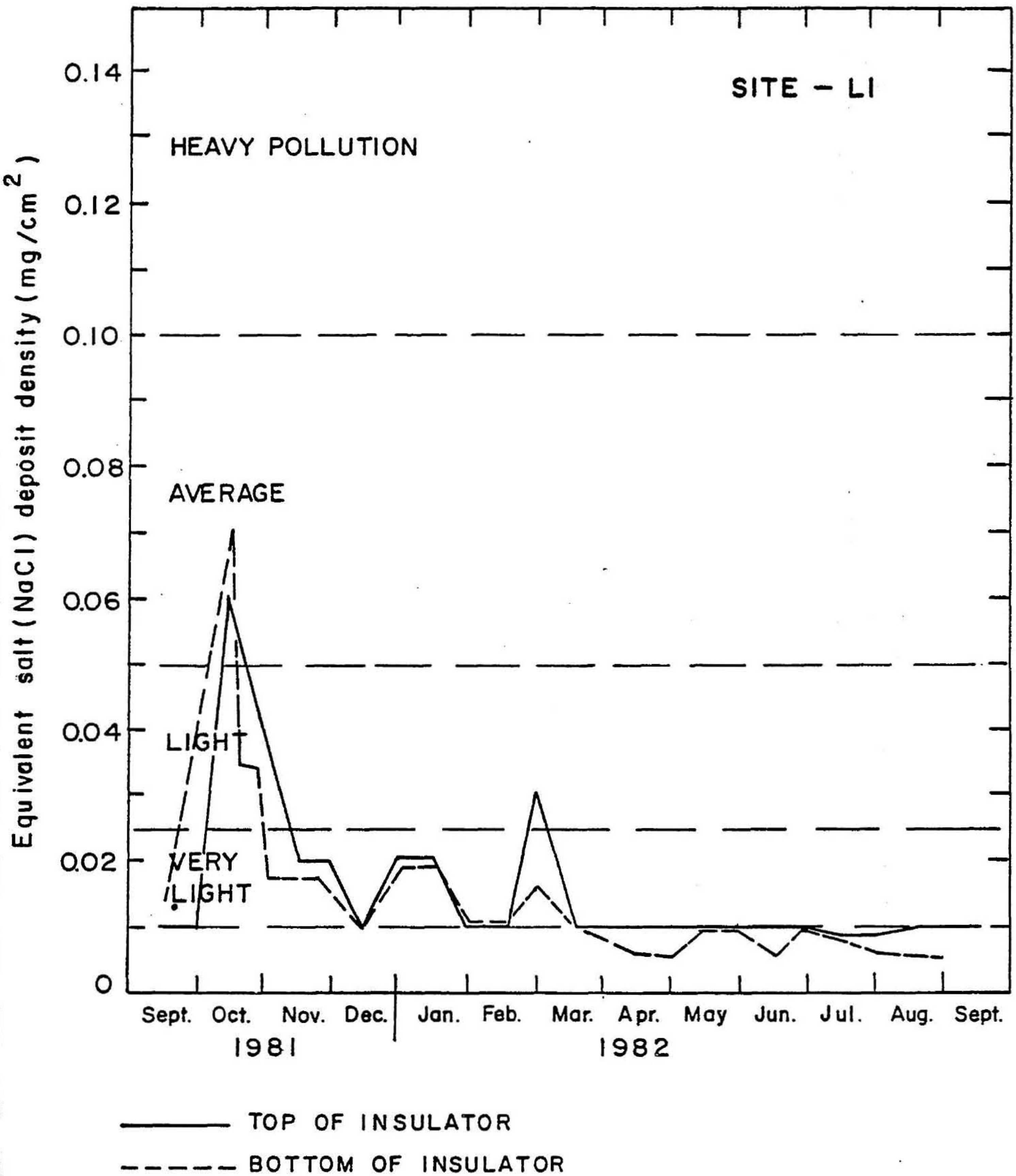
TABLE OF DATA

SITE #15 PARSONS POND

DATE	WIND SPEED (MPH)	WIND DIR. (TRUE)	TEMP. ^{o}C	ACCUMULATION NOTED	DIRECTION OF ACCUMULATION
25-11-81	-	-	-	BARE	
19-03-82	-	-	-15	Trace hard rime at 5' level of leg	150^{o}
04-05-82	4	180^{o}	10	BARE	-

APPENDIX 6.5

CONTAMINATION DATA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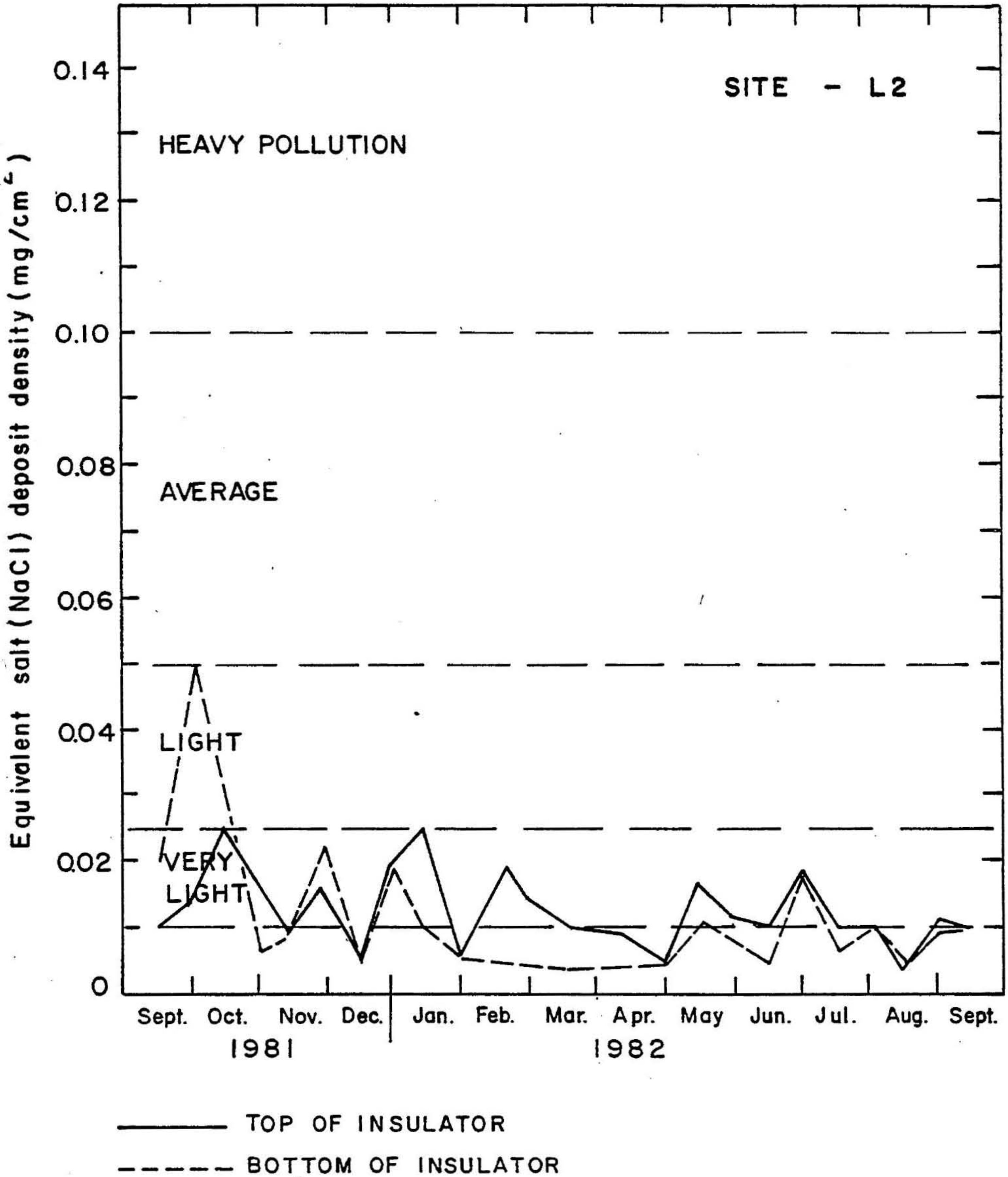
HEAVY POLLUTION
AVERAGE
LIGHT
VERY LIGHT
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0
Equivalent salt (NaCl) deposit density (mg/cm²)
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sept.
1981
1982
TOP OF INSULATOR
BOTTOM OF INSULATOR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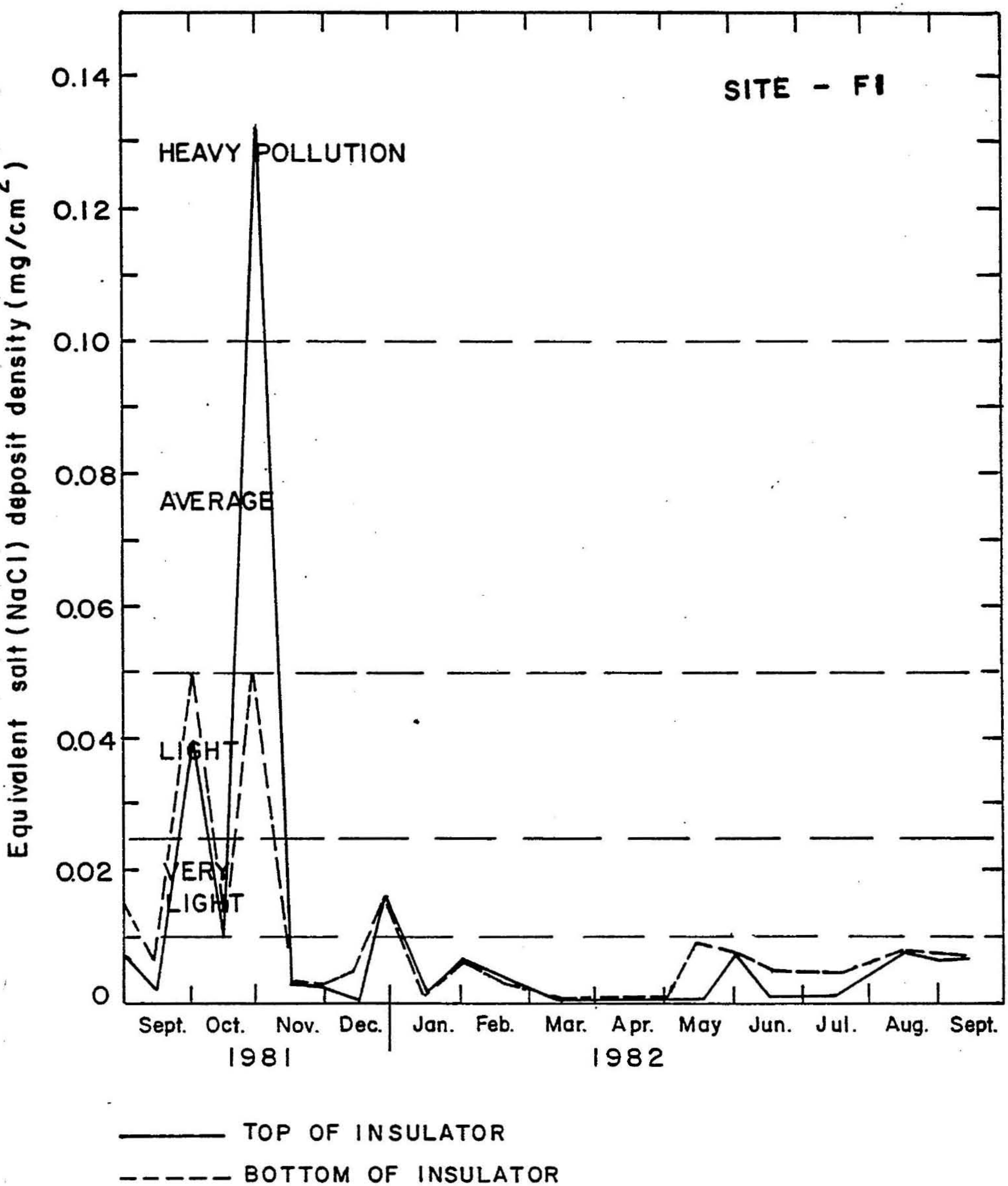
HEAVY POLLUTION
AVERAGE
LIGHT
VERY LIGHT
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0
Equivalent salt (NaCl) deposit density (mg/cm²)
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug. Sept.
1981
1982
TOP OF INSULATOR
BOTTOM OF INSULATOR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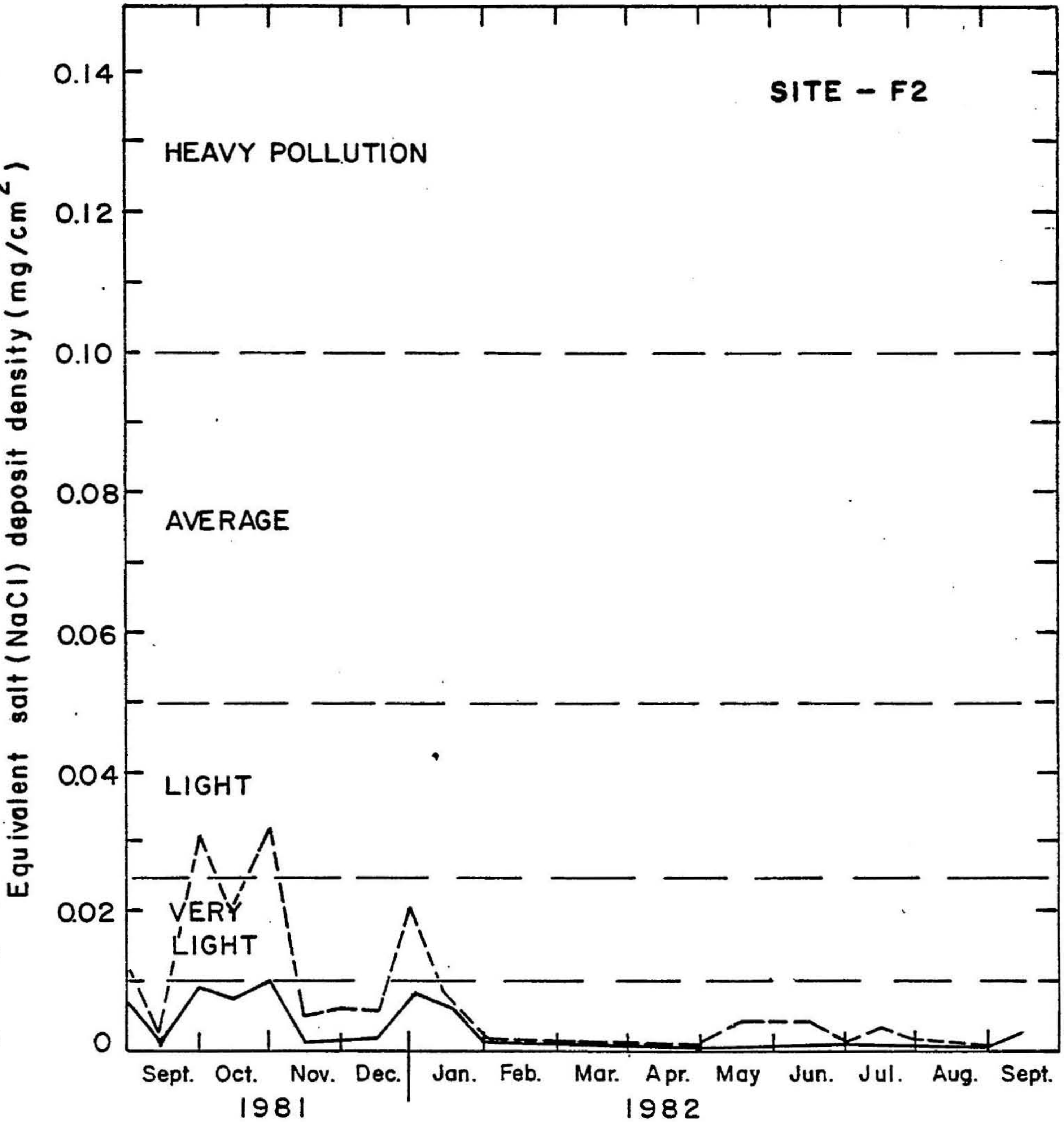
HEAVY POLLUTION
AVERAGE
LIGHT
VERY LIGHT
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0
Equivalent salt (NaCl) deposit density (mg/cm2)
Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug. Sept.
1981
1982
TOP OF INSULATOR
BOTTOM OF INSULATOR



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APPENDIX 6.6

SUMMARY OF TEST SPAN OBSERVATIONS

APPENDIX 6.7

SUMMARY OF CLIMATOLOGICAL MONITORING PROGRAM

(1977- 1981)

FINAL REPORT

Study

of

Climatological Monitoring Program

(1977-1981)

for

Lower Churchill Development Corporation

Weather Engineering Corporation of Canada, Ltd.

Dorval, Quebec

April 8, 1982

Contents

SECTION 1

1.0 INTRODUCTION AND SCOPE:

The Newfoundland and Labrador Hydro (N&LH) "Report on 1980/81 Climatological Monitoring Program" states (p.10)

> "........it is strongly recommended that a complete review be made of the program and findings to date by a meteorological expert to determine the effectiveness of the data collection techniques and establish the necessity and direction for a long term collection program."

This present report constitutes that review. Its tasks follow the recommendations of the report quoted:

Task No. 1: Review the program and findings to determine the effectiveness of the collection techniques.

Task No. 2: Determine the necessity and direction of a long term collection program.

SECTION 2

2.0 REVIEW OF THE PROGRAM AND FINDINGS (Task No. 1):

A. THE PROGRAM: To facilitate the review a composite tabulation of the various program observational elements by years has been made (Appendix A, Table 1).

The program arose out of a necessity to confirm the wind and ice loading estimates made for the HVDC Transmission Line by Meteorology Research Inc. (MRI) in 1973 for segments of the line where no actual weather observations existed.

MRI instrumented four test sites for the winter of 1974/75 (Sites 1, 2. 3, 4). The installations involved two 30 foot steel, guyed towers at each site, with 54 feet of conductor strung between them; icing rate meters, recording anemometers, thermometers, and hygrometers.

The Climatological Monitoring Program (CMP) then instituted a follow-up and greatly expanded program in the winter of 1977/78 which had four observational elements. The first involved the installation of recording anemometers (Bendix Aerovane propeller type, 120 volt operated) at 4-Mile Pond-Holyrood, Sunnyside, Yankee Point, and the taking-over of an existing anemometer at Hawkes Bay.

The second element involved the installation of thirty (30) Passive Ice Meters (PIM) of Hydro Québec design (described in Annual Report, Year 1, 1977/78 on p. 4, and Fig. 1 on p. 56). The 30 locations are listed in the same report.

The third element involved three (3) Rosemount Ice Detectors (RID) described in Year 1 Report, 1977/78, p. 5, and in photographs. These detectors were installed at Sunnyside, 4-Mile Pond-Holyrood, and at Yankee Point.

The fourth element involved ten (10) Ice Accretion Test Towers. These were 30 foot, guyed, lattice steel masts. (They are described in Year 1 Report, 1977/78, p. 6 and in photographs). This element included the towers at the four original MRI test locations (Sites 1, 2, 3, 4) plus six towers at new Sites 2a, 4a, 5, 6, 7, 8.

In Year 2, (1978/79), the number of Test Towers was increased from 10 to 15 by the addition of Sites 2b, 9, 10, 11, 12. Two new program elements were added. The Salt Contamination Program was installed using insulator strings, (Report Year 2, 1978/79, pp. 9-13, and photo p. 63). The exposed insulator strings were periodically removed, washed, and the washings analyzed for the salt content of the air. Thirteen (13) of these sites were installed as follows: Pt. Amoure (1), L'Anse au Loup (1) Yankee Pt. (1), Roddickton Rd. (2), Zinc Mine Road (5), Sally's Cove (1), CNT Trans-

mitter Road at Green Point (2).

The second new program element was for Salt Corrosion. It used the ALCAN CLIMAT units (Year 2 Report, 1978/79, pp. 13-15, and photo p. 64). Six (6) of these units were installed as follows: Yankee Pt. (1), Daniel's Harbour (1), Zinc Mine Road (3), Sunnyside (1).

In Year 3, (1979/80) the Test Tower program was increased to 22 sites with the addition of Sites 2c, 13, 14, PW-1, PW-2, PW-3, PW-4. These additions were designed to confirm alternate route possibilities in the Pinware Valley, and along the Parson's Pond alternative in the Long Range Crossing area. These routes were selected by the SNC-Lavallin line designers in order to avoid areas of heavy icing which had been found to exist from the observations of Years 1 and 2 of the CMP. (Details, Ann. Report, Year 3, 1979/80, pp. 6-7 and photos pp. 49-50).

A new program element was added with three (3) test spans. These were single spans and consisted of two 10-meter specially designed steel, lattice type towers with 40 m of conductor (1192.5 MCM ASCR 54/19) strung between them (Ann. Report, Year 3, 1979/80, pp. 8-10, and photo p. 52).

These spans were installed at Brian's Pond (elev. 1600+ ft.), Inner Pond (1850+ ft.), and Parsons Pond (1900+ ft.). All three, although at high elevation, were somewhat sheltered from the storm winds. Load cells were installed in two of the guys at the Brian's Pond span, and a propane heated shelter for the recorder was provided.

In Year 4 (1980/81), an additional anemometer was installed off the mouth of Levi's Gulch on the coastal plain to the west of the Long Range escarpment along the Parson's Pond alternative. This is in an area where strong winds were suspected to exist because of the areas of blow-down among the trees.

The test span instrumentation at Brian's Pond was moved to Inner Pond, since no ice had occurred at the former site in Year 3.

The total number of Test Towers was decreased to a total of 18, including a new one installed at Site 15.

The Salt Contamination and Salt Corrosion programs were terminated as having accomplished their objectives. A new Salt Contamination program at the Straits Crossing has been instituted.

Year 5, (1981/82), is now under way. One additional anemometer has been installed in the Codroy Valley near the site of previous wind damage to two towers along transmission line TL-214.

B. THE FINDINGS: The findings of the CMP are summarized as follows:

B. 1. Wind: The existing six (6) installations use two types of standard anemometers which both give excellent data under ice free conditions. These are:

a) The Bendix Aerovane, Model 120 Transmitter is installed at 4 of the sites with 120 volt power (Sunnyside, 4-Mile Pond-Holyrood, Hawke s Bay, and Yankee Point (lately moved to Savage Cove). The unit is sensitive to gusts as short as 2 seconds.

b) The AES three-cup anemometer type is installed at Levi's Gulch and in the Codroy Valley along TL-214. This unit records "mile-run" of wind, and so gives an excellent true hourly average speed. It operates off batteries at these two locations.

At the present time, there is no anemometer on the market which is able to run reliably under moderate to severe icing conditions. However, a new CEA prototype anemometer is currently under development.

The four recording anemometers which were operated in Years 1 through 4 have provided reliable wind speed and direction data in standard format to fill in the AES basic meteorological network at the major observing sites (i.e. St. John's-Torbay, Gander, Argentia, Deer Lake, Stephenville, Daniel's Harbour, Battle Harbour, Goose Bay).

The new wind data have not yet been systematically compared with existing long-term stations and data. But, an inspection of the summaries presented in each of the four Annual Reports, and of the Review Report ("Review of 1977-80 Climatological Monitoring Program") shows that the observations do not, in general, conflict with or exceed the previous estimates as to the prevailing wind speeds which were made by MRI from their analysis of the AES basic stations, and from their own supplementary observations at Sites 1, 2, 3, 4 in 1974-75 (See Table 1 below).

The various wind speed observations represent averages taken over different periods of time. Specifically, the four CMP anemometers at 4-Mile Pond, Holyrood, Sunnyside, Hawkes Bay, and Yankee Point (Savage Cove), record the 2-second wind speed on a chart. The hourly wind speed is then read off as the visual average of the speed trace in each hour. This process is described in CMP, Year 1 Report, 1977-78, Appendix IX, p. 5 as follows:

> "2.5.3 MEAN WIND SPEED - The mean wind speed for any period (one (1) minute, ten (10) minutes, one (1) hour, etc.) shall be determined from the speed trace of the recorder chart. A transparent strait-edge may be used as an aid in determining the mean wind speed. The straight-edge should be placed on the speed trace for the period, parallel to the horizontal edge of the chart, and in such a position that the edge of the ruler divides the speed trace into equal areas above and below the average. The edge of the ruler, so placed now indicates the measured speed."

Table 1

Summary of Wind Data

Station	Maximum Wind (mph)		Maximum Gust	HVDC Loading Estimates (Note 3)				
				Segment	10-Year		50-Year	
	1 hr	1 min	2 sec		Wind	Gust	Wind	Gust
4-Mile Pond, Holyrood (2 1/2 yrs)	S 70	88.	SW 104	1	75	91	93	110
Sunnyside (3 1/2 yrs)	S 45	56	S 71	2	80	97	98	116
Hawkes Bay (3 yrs)	SW 60	75	SE 65	10	68	83	80	97
Yankee Point (17 mos)	NE 43	54	88	11	75	91	93	110
Savage Cove (5 mos)	NE 50	63	68	11	75	91	93	110
Levi's Gulch (5 mos)	E 93	116 (4)	N/A	9	126	143	140	157
AES Stations (Note: 1) (1953-71)								
St. John's-Torbay		W 88	120					
Argentia		N 70	85					
Gander		E 65	100					
Buchan's		SSE 65						
Deer Lake		SE 45						
Stephenville		NNW 61						
Daniel's Harbour		SSW 68						
Battle Harbour		NNE 80						
Goose Bay		SW 52						
Bonavista		WSW 70	88					
St. Andrew's		SE 90						
St. Anthony		NNW 70						
Twillingate		SSW 72						

Notes:
1. Taken from Table 1 of MRI 73 FR-1131, p. 22.
2. Anemometers are not all at same height above ground. See Table in MRI 73
3. HVDC Wind Estimates are 1 minute winds; gusts are 2-second gusts.
4. Wind calculated from $V_{1\,min} = 1.25\ V_{1\,hr}$.

The maximum gust speed is the highest peak on the chart. The Levi's Gulch and Codroy Valley anemometers record the "miles of wind" which blow past the instrument each hour. Thus, they give a true hourly average wind speed directly, but no gusts. The winds at these two stations are directly comparable to the speeds at the other four installations taken from the charts in the manner described in the extract quoted above.

However, the AES stations record an "hourly wind speed" which is a 1-minute average. It is taken by the weather observer at the various airports and stations sometime during the 10 minute period immediately preceding each hour. This "hourly windspeed" tends to be some 25% higher than the "hourly wind speed" taken by the visual averaging of areas on the chart described above. Thus, Column (2) in Table 1 shows both the hourly average, and the same value corrected to a 1-minute speed by the factor 1.25, so that a valid comparison can be made with the HVDC wind loading estimates and with the AES observations in the same Table, which are both 1-minute averages.

4-Mile Pond-Holyrood has experienced the strongest winds of any of the 4 CMP sites. This is, undoubtedly, a speed-up effect reflecting the topographic exposure of the station. While the 4-Mile Pond station may be unrepresentative of the general surrounding area, it is a very valuable station for determining the wind speed-up effect due to topography; it is readily accessible and is only 30 miles southwest of St. John's Torbay where hourly winds are recorded and twice daily Rawinsonde observations of gradient wind speed are taken. Thus, correlations between 4-Mile Pond and the AES long term station can readily be made.

<u>To summarize the findings with respect to wind:</u> three of the stations are in general agreement with the basic data from the AES airports and with the HVDC estimates made by MRI. The winds at 4-Mile Pond-Holyrood station are stronger than the estimates and show marked effects

of topography in causing speed-up.

The two new stations at Levi's Gulch and in the Codroy Valley are both designed to provide data on the local effect of strong downslope flow from the Long Range Mountains. It is too early to assess the results of these installations, except to note that Levi's Gulch has already confirmed that hurricane strength winds blow down from the escarpment, 93 mph having been recorded on two occasions. A study of the downslope wind mechanism is currently under way by WECAN for N&LH in the Codroy Valley; the results there should be applicable to the Levi's Gulch areas as well.

Thus, sufficient wind data are now available to provide general design load estimates in the whole system area. Local topographic effects on wind must still be corrected for by special studies and sometimes by special field observations.

B. 2 Ice Instrumentation and Findings:

a) The Passive Ice Meter (PIM) network has shown the general pattern of glaze ice accretion from freezing rain over the island. There have been no surprises relative to the findings of previous studies done by MRI and WECAN. The largest glaze ice amount recorded was at Hampden on Jan. 8, 1979, where 9.5 cm (3.74") accumulated on the flat plate of the PIM and 3.75" diameter on the 1" rod. This corresponds to about a 1.5 to 2 year return period loading on the estimates for the nearest segment of the HVDC line (Seg. 20). (See Appendix B, Fig. 20, Segment 20 HVDC maximum glaze curve.

The PIM was designed by Hydro Québec, and it has given valuable data on the severity and the geographical distribution of glaze ice caused by freezing rain at some 30 inhabited locations.

The ice accumulations must be read and recorded manually so that their usefulness is more or less restricted to inhabited areas. Some PIM's were installed at the remote Test Tower sites, but they were not rugged enough to withstand the severe ice loadings and the extreme winds at these sites and were badly damaged.

However, for the detection and standardized measurement of glaze from freezing rain, they have given excellent results.

b) The Rosemount Ice Detector (RID): This is a relatively sophisticated, rather delicate automatic recording device for detecting and recording ice accretion events at sites where 120 volt power is available. The device uses the principle of magnetostriction whereby ice accretion on the sensor changes its natural frequency of vibration and produces an ice recording signal.

The interpretation of the data in terms of ice thicknesses is as yet uncertain. On three occasions in Year 2 (1978/79) at 4-Mile Pond-Holyrood, the ice accumulation on structural members at the site was observed and these were compared with the RID readings as follows:

Table 2

Rosemount Ice Detector
Comparison of Calculated and Observed Ice

Date	Ice Diameter		Number of Ice Event Signals
	Measured	Calculated (RID) (1)	
Feb. 2-3/79	2.5" glaze	2.2"	110
March 22-23/79	1" rime	0.88"	44
April 6/79	1-2"	1.28"	64

Note: 1) The RID ice amount is calculated from the assumption that each event represents 0.02" of ice. Thus, 110 events = 110 X 0.02 = 2.2".

Following this, an attempted comparison was made between the RID amounts and the PIM observed amounts at Sunnyside (Year 1, Annual Report, pp. 28-29); these were on much smaller mounts of ice, and the results were not reassuring. The Annual Report for Year 4, (1980-81), refers to tests on the RID by the U.S. Air Force made in an icing wind tunnel. These tests showed an excellent correlation between ice mass observed and that calculated from the RID ice event numbers.

If continued USAF tests confirm the correlation with the mass of ice accreted, the RID could become a standard ice detector. At that time, the existing CMP records should be re-examined and again compared with the concurrent PIM or other available ice accretion records.

This instrument, even if its quantitative correlation is confirmed, would probably still be restricted in use to a few, fully instrumented "bench mark" test sites. For these purposes, however, it could prove to be very valuable.

It is possible that part of the past difficulty with poor correlations between PIM and RID is that both are expressed in terms of ice thickness, whereas the USAF tests show a correlation with ice mass. However, there may also be real differences between RID mass accreted and the concurrent mass which will accumulate on a cylindrical conductor because of the "diameter effect". This refers to the fact that rime and cloud glaze both depends critically on the total diameter of the obstacle presented to the storm wind. The RID probe diameter is kept small by heating and melting, so that its accretion rate remains high, whereas a real conductor experiences decreasing growth rate with increasing diameter. Thus, the RID may indeed be overpredicting the ice accretion on an unheated cylindrical object such as a conductor.

The RID has shown a general frequency of ice occurrence at Sunnyside, Yankee Point and 4-mile Pond-Holyrood in the ratio of 1: 1.5: 8.3 (See data in Review Report, 1977-80, Map 38, p.4). These data are summarized in Table 3.

Table 3

Ice Accretion Frequency, Rosemount Detector

Station	Total Events	Ratio	Frequency (1)
Sunnyside	22	1	1 in 16 days
Yankee Point	32	1.5	1 in 11 days
4-Mile Pond	183	8.3	1 in 2 days

However, the RID does not discriminate between types of ice (i.e. between glaze and rime). Also, 4-Mile Pond-Holyrood, because of its elevation and exposure, experiences rime ice frequently whereas the other two stations are at low elevations and do not. The 4-Mile Pond-Holyrood station experienced 183 days of ice in 2 seasons. This is about one occurrence every two days, a value probably not too far from an average value for the higher elevations in the whole system area.

To summarize, the RID appears to be a successful ice event detector, i.e. it measures ice frequency quite well. While this may be of operational use on some occasions, for line design it is the frequency of the amount of ice which is required. The first season of RID operation at

4-Mile Pond indicated that there was a good correlation between frequency of ice and thickness of ice. In later seasons, however, the results were more confusing. The results of a recent study by the U.S. Air Force are that the RID measures ice mass quite well. If further tests are also positive, then re-analysis of the RID results may be warranted.

c) Test Spans: These are single, 40-meter spans of conductor (1192.5 MCM ASCR 54/19) strung between two 10-meter, guyed steel towers (Annual Report Year 3, 1979-80, pp. 8-10, and photo p.52). Load cells were installed in two of the guys and the loads recorded in a nearby propane-heated shelter.

These installations were made at high elevations in the Long Range Crossing segment, but in fairly sheltered terrain, typical of the majority of the line route in that area. During two winters (1979-80, 1980-81), they have experienced very little ice, and have thus served to demonstrate the reality of the dramatic effect of very slight or moderate terrain shelter (100 to 500 ft.) in reducing the ice loading from that occurring at fully exposed sites.

However, the load cells and recorders have not been tested under severe ice loadings and a realistic assessment cannot, therefore, as yet be made of the effectiveness of instrumented test spans as a data collection device under Newfoundland icing conditions.

These installations have experienced very little ice accumulation during the three years they have operated. This has confirmed the reality of the effect of slight to moderate topographic shelter from the storm cloud and storm winds (100' to 500') in dramatically reducing the ice loadings. In any future test, it might be advisable to install two test spans at each location, one fully exposed and one in moderate or light shelter, so that a more meaningful comparison could be made.

d) <u>Test Towers:</u> These installations are 30 foot guyed steel towers which serve as passive accumulators of icing loads. They have been very successful, producing the basic icing data for the HVDC route selection and line design in the severe loading segments of the Long Range Crossing, the Highlands of St. John's and in the Labrador Up-slope areas. They are simple, rugged, and reliable and can be considered as the prototype for successful ice determinations for line design under extreme ice conditions in remote, relatively inaccessible areas.

The accomplishments are:

1) Mapping of the quantitative distribution of icing at high, exposed sites.
2) Good indications of the directions of the storm icing winds.
3) Revealed dramatic differences in ice type (rime, glaze) between different regions which had been unsuspected (e.g. Cat Arm).
4) Demonstrated the effects of shelter in reducing ice loadings.
5) Enabled a rational selection of HVDC routes and route alternatives.
6) Provided data on the seasonal variation in ice severity.
7) Provided data on the physics of ice accretion on various structural shaped members.

Future work with these towers could well take the form of improvements in parts of the tower geometry in an attempt to improve the ice accumulation measurements so that they can be better interpreted in terms of equivalent ice accumulation on cylindrical conductors. Such innovation is strongly recommended for the Cat Arm Development area, where the need is present, and manpower and helicopter availability would be assured for the next several years.

The loading results are:

1) Fully exposed sites (2, 2b, 4, 11, 12, 5, 8) receive 12-18" of diameter of rime and/or glaze every 2 to 3 years. (Table 2, Appendix A).

2) The Long Range Crossing receives the heaviest accumulation of rime ice, whereas the eastern slope (Cat Arm area) and the Labrador up-slope receive mainly cloud glaze.

For convenience, the results of the Test Tower observations of the Annual Reports have been regrouped in Table 2 of Appendix A. A concise summary is shown in Table 4 below:

Table 4

Summary
of
Maximum Ice Loadings on Test Towers

Area, Site Number	Diameter (1)		Mass (2)			
	Glaze	Rime	Glaze	Rime	Maximum Mass	Ratio to Site 1
1. Sheffield (Site 1)	6"	-	9.8 lbs/ft	-	9.8	1
2. Long Range Crossing: (2, 2a, 2b, 2c, 2d, 2e, 9, 10, 13, 14, 15	7"	18"	13.8 "	43.6 lbs/ft	43.6	4.5
3. Labrador (4, 4a, PW-1, PW-2 PW-3, PW-4)	16"	6"	77.2 "	4.4 "	77.2	7.9
4. Cat Arm-Lake Michel: (5, 6, 8, 11, 11a, 12)	12"	-	42.9 "	-	42.9	4.4
5. Highlands of St. John: (3, 7)	7"	7"	13.8 "	6.1 "	13.8	1.4

Notes:

1) Diameters are taken from " Review of 1977-80 Climatological Monitoring Program". They are the maximum diameters reported from each site area.

2) For purposes of illustration only, the mass of ice corresponding to the maximum diameter of ice recorded at any one site in each of the five general areas has been computed by the following formula:

$$W = \rho\pi \quad 62.43[R_t^2 - r_c^2]$$, where , W is the mass in

pounds per linear foot of conductor, ρ is the density (0.9 for glaze and 0.4 for rime), R_t is the total radius of ice plus conductor, r_c is the conductor radius , assumed here to be 1 inch. R_t and r_c are entered as feet.

3) The heavy loadingsin the Labrador area come from Site 4 only. The other sites designated as Pinware Valley(PW-) have recorded much lower ice loadings.

SECTION 3

3.0 NECESSITY AND DIRECTION OF LONG TERM PROGRAM (Task No. 2):

I. WIND: The present state of knowledge of wind for the system area is as follows:

1. The extreme value wind speed estimates for standard design return periods derived from the data of the basic AES observing stations have been done (MRI FR-1131, FR-1378: WECAN Report, "Ice and Wind Study", March, 1972).

2. The basic wind frequency distributions for speeds less than the extreme values have not been done. These are of somewhat marginal value for design purposes, but, since they can readily be procured from AES, either in printed form for some stations, or as computer print outs for the rest, they should probably be obtained and kept on file for any future needs.

3. The gradient wind basic frequency distributions for the island Rawinsonde stations (St. John's-Torbay, Argentia, Stephenville) have been done by WECAN (LCDC Memo May 4/81; Interim Report on TL-214, Nov./81).

4. The extreme value estimates of gradient wind speed for standard return periods have been done (Ref. as in No. 3 above).

5. The general details of the basic wind speeds at the 4 additional stations of the CMP (Sunnyside, 4-Mile Pond-Holyrood, Hawke's Bay and Yankee Pt. (Savage Cove) are quite well known. (Table 1 of this report).

6. The CMP data for Levi's Gulch and Codroy Valley are still fragmentary but the WECAN study for the Codroy Valley on TL-247 should produce a workable method to deal with special wind mechanism operating there.

Conclusions as to Wind: The general wind field over the whole province is known in quite good detail both for operational (i.e. day-to-day) purposes, and for design purposes (i.e. the extreme values).

The "grey areas" remaining are:

1. The deviations from the general wind flow caused by local topographic irregularities are not known in sufficient detail. This refers to speed-up factors to use in increasing the wind speed over hills, in valleys, etc. (WECAN has done some preliminary work here on the Cat Arm study for N&LH, and currently, for Cat Arm Consultants for the 12.5 kV distribution system loadings. The final reports of these studies will contain sections on these wind effects.).

A major area of special wind effect is the downslope flow which occurs along the western coastal plain at the foot of the Long Range escarpment, from Wreckhouse and the Codroy Valley to the Parson's Pond area (Levi's Gulch), and on up to the Highlands of St. John when the general gradient flow is from the east.

Up-slope wind increases, for example, in the Cat Arm area and on the eastern slopes of the Long Range Mountains, constitute another incompletely solved problem.

The knowledge of wind behaviour over irregular topography, and of practical, empirical speed-up factors to use are still in the realm of research.

Two new specialized studies of pronounced local wind effects are currently under way. First, the problem of the Codroy Valley (Wreckhouse) extreme winds along TL-214 is under study by WECAN where N&LH have installed a recording anemometer in the area of previous tower damage and have arranged for some local supplementary wind observations. The WECAN Interim Report on this study has been submitted (Interim Report, TL-214, Nov. 15, 1981, WECAN-103).

Second, the extremely strong winds along the Long Range western escarpment have also been confirmed at Levi's Gulch by the CMP anemometer installed there.

It is WECAN's opinion that these two special wind problems represent essentially the same physical mechanism, namely, downslope wind flow off the Long Range plateau (1800') to the western coastal plain (300'), when the gradient wind flow is from the east or south east. This wind phenomena is known in Europe as the "Bora", (from the Latin "boreas" for "north").

It is anticipated that the theory and structural details of the wind flow currently being studied by WECAN in the Codroy Valley case should be available shortly. These should also apply to the Levi's Gulch area, and, in fact, to the whole of the western escarpment of the Long Range Mountains.

Another grey area of importance is that of the wind flow along the general coastal escarpment for the Cat Arm Development. The general wind loadings in the area can be estimated from the basic surface wind data already done and summarized above. But, the speed-up factors along the escarpment during on-shore flow are not known. WECAN has estimated these factors on theoretical reasoning; but experimental confirmation is required.

Finally, in regard to wind speed-up in general, it should be mentioned that the 4-Mile Pond-Holyrood installation is ideally situated for correlation studies with the standard AES anemometer at St. John's-Torbay airport, and with the Rawinsonde there. The two locations are only some 30 miles apart, and analysis should clearly reveal the topographic speed-up factors involved.

Considering the above comments, it is recommended that:

1) The anemometer program should be continued, using the same type equipment as in the past. The 4-Mile Pond station should be viewed as a potential key research station for the study of local wind effects which could be then applied widely elsewhere across the province.

2) Consideration should be given to installing two anemometers at the Cat Arm Development, one on the coast, and one at some exposed location inland up the escarpment, possibly along the route of the 12.5 kV line. Eventually, the Lake Michel district will also require some on-the-spot wind data. (It may be noted here that the Hawkes Bay wind data are relevant to the Lake Michel area and provide valuable back-up information to the AES data at Daniel's Harbour).

3) The various wind data, analyses, estimates, and studies should be filed, collated, and indexed by N&LH. The AES data for monthly and annual extreme winds recorded each year should be added routinely to the files. Periodically, say on a 5-year basis, the annual extremes should then be added to the MRI/ WECAN extreme value series, and new estimates calculated to provide up-to-date design figures.

4) The speed-up factors for winds in the Long Range Crossing area under easterly and northeasterly flow during the winter should be determined as soon as it is instrumentally possible to do so. One season of data from two stations, one on the approaches to the general slope and the other at the top of the slope along the actual HVDC line route would be adequate.

5) If an anemometer site must be dropped, possibly Sunnyside would be most dispensible, followed by Hawkes Bay. Yankee Point (Savage Cove) is required for the Straits Crossing Salt Contamination Program.

<u>II ICE:</u>

The present state of knowledge of ice in the system area is as follows:

<u>A. Glaze Ice From Freezing Rain:</u>

1. <u>The distribution of glaze from freezing rain is</u> fairly well known (PIM observations of CMP - 4 years, 30 stations).

2. <u>The severity of glaze</u>: The extreme value estimates for standard return periods have been done by MRI for the HVDC line and by WECAN for the St. John's area and for the Cat Arm coastal area (TL-247). Estimates for the

Cat Arm distribution area (12.5 kV line) will be available shortly. The EVA's for the basic AES observing stations have also been done (MRI-73, FR-1131 and MRI-77, FR-1501).

B Cloud Glaze Ice:

1. The distribution of cloud glaze ice is imperfectly known. The Cat Arm study by WECAN (Final Report on TL247, (Draft), Oct. 15, 1981) using the data from Sites 5, 6, 8, 11, 11a, and 12 of the CMP, has concluded that the extremely heavy ice along the upper slopes of the east coast escarpment is cloud glaze. It, undoubtedly, occurs widely elsewhere in the province (e.g. Sites 4, 4a, etc.). A current study for the 12.5 kV distribution system will present the known data on this, but a more complete knowledge of this condition should remain an important goal of the CMP.

Cloud glaze intensity depends on wind speed, cloud drop sizes, and the cooling power of the air(i.e. the "wet growth" condition). While quite adequate estimates of the general winds can be made, as described above, the cloud glaze occurs where speed-up and other topographic effects on wind are predominant. Also, there are no observational data available on cloud drop sizes in Newfoundland. The drop sizes can be determined by various research-type instruments, the simplest being to expose a series of cylinders of various sizes to the storm wind. The different cylinders then accrete different amounts of ice which can be interpreted in terms of different drop sizes, if the wind speed is known or can be estimated.

It is recommended that this problem of more precise data on droplet sizes be tackled at the Cat Arm Development and at 4-Mile Pond-Holyrood. This is a major problem in the ice accretion theory. The results will be directly applicable to any Lake Michel-Daniel's Harbour extension, to the Long Range crossing, to the Labrador upslope, and to the Highlands of St. John, so that any solution will be of wide application.

C. Cloud Rime:

The distribution and severity of cloud rime ice is fairly well known from the MRI HVDC estimates, and the CMP Test Tower observations. The MRI estimates are conservative, and it would be desirable to obtain more precise data so that, if possible, some reduction or refinement in the estimates might be made. The CMP has produced observational evidence on rime severity, its local distribution, and on the marked effect of slight topographic shelter in reducing the icing loadings.

It is recommended that (1) the Test Tower program should be maintained, possibly on a more limited area. The program could be restricted to those towers in the Long Range Crossing area (i.e. suspend visits to the Highlands of St. John and the Labrador Up-slope areas). However, until the design for the HVDC line is finalized it would be very useful to have full data from the sites already installed.

The Cat Arm sites should be maintained, and be transferred to the Cat Arm Development. These changes would considerably reduce the helicopter expense which is a major budget item.

2. The Test Span program should be discussed with the SNC design engineers. Subject to their needs, it is tentatively recommended that either the program be terminated, or that two spans be transferred to one of the more exposed Test Tower sites in the Long Range crossing along the HVDC line route.

Two Test Spans, one fully exposed and the other in slight topographic shelter along the line route at the same general site would be ideal. The fully exposed span should then accumulate sufficient ice to provide loadings which could test the effectiveness of the loading cells.

III SALT CONTAMINATION PROGRAM:

Measurements under this program are taken by the washdown of non-energized insulator strings installed at the thirteen (13) locations listed in Table A-1, Appendix A. The installation and details are given in the Report for Year 2, 1978-79, Appendix VI.

The 13 sampling sites are all at low elevations near the sea coast, except for two new sites, 12a, and 11a, at elevations of about 700 feet above m.s.l. in the Cat Arm Development area).

The findings have been that salt contamination drops off rapidly with distance inland from the sea, so that it is not a serious concern more than a mile inland.

However, recent observations from the two new test sites on the Labrador side of the Strait of Belle Isle Crossing cast some doubt on the decay rate with distance inland previously found. Here, a new site about a mile inland has recorded higher salt levels than the station right at the coast. This information was recently brought to WECAN's attention and the following possible explanation has been offered:

Figure 1 shows diagramatically the two test stations during a period of on-shore wind flow. Station "A" near the sea is only about 50 feet above sea level and so is well below the base of the stratus cloud which regularly moves on-shore during easterly and southerly storms.

Station B is at an elevation of about 250 feet. This station could therefore be in the cloud when the stratus ceiling is below that level. The air flowing up into the cloud base from the sea contains "cloud nuclei" consisting of tiny brine droplets (approx. 0.5 to 1 micron in diameter). Particles as small

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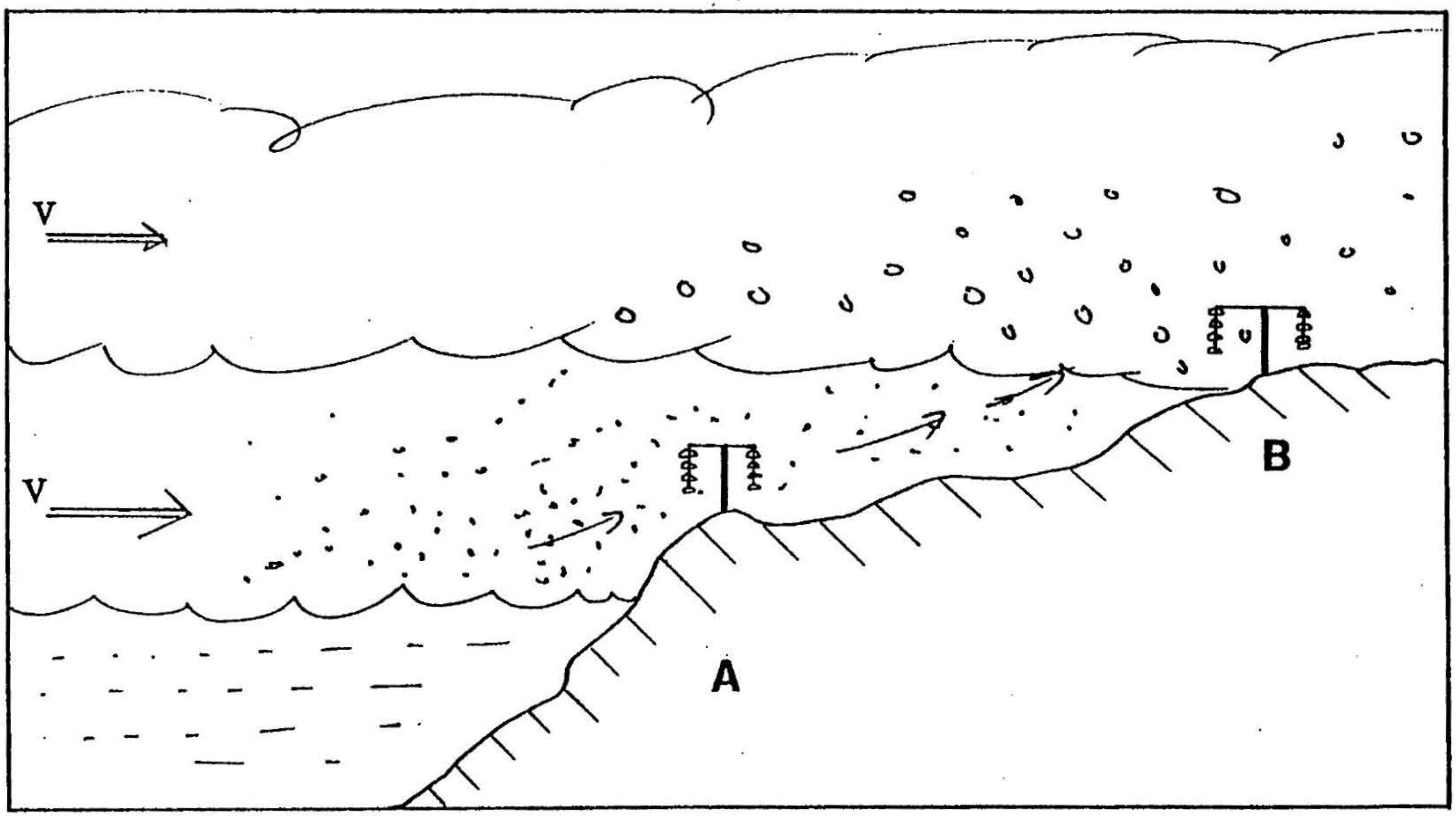


Station "A" is below cloud base and is exposed to brine droplets (radius 0.5 microns)

Station "B" is in cloud and is exposed to much larger cloud droplets (radius 3 - 5 microns) containing the brine droplets.

Figure 1.

as that have a low rate of impaction and collection on the insulator plates. The concentration of salt particles in the air will always be less at Site B than at Site A because of the fallout of particles with distance inland. Consequently, the salt contamination on the insulators should be less.

Under in-cloud conditions at Site B, the salt particles will have entered the cloud base and have become activated by the higher relative humidity and will have become cloud droplets. This means a very large increase in their size from 0.5 microns to about 5 to 10 microns, i.e. an increase of from 10 to 50 times. This will mean a large increase in the collection efficiency of the insulator plates for such large drops. Thus, even though the absolute salt content of the air flowing inland is actually dropping off at the usual rate, the salt collected on the insulator plates could be much greater under in-cloud conditions because more particles are actually collected.

Table 5

Sizes of Brine Droplets and Cloud Drops

Mass of Salt	10^{-14} g	Rel. Size	10^{-13} g	Rel. Size
Radius of Salt Crystal	0.103 μm	1	0.22 μm	1
Radius of Brine drop	0.19 μm	2	0.39 μm	2
Radius of Cloud Drop at Cloud Base	2.0 μm	20	6.2 μm	30

Sites near the sea which have a high frequency of occurrence of in-cloud conditions because of their elevation would be subject to the mechanism just described. Typical cloud base heights over the sea during storms of on-shore flow would be 300 to 500 feet; inland this flow could give in-cloud conditions at sites with elevations as low as 200 to 300 feet.

The above model would indicate that for transmission system structures near the coast which are sensitive to high salt levels, the problem might be eliminated by locating them at elevations which are below the usual cloud base height.

It is recommended that the following steps be taken:

(1) Re-evaluate the data from Years 2 and 3, and for the Cat Arm sites 11a and 12a, from the standpoint of the exposure of the existing sites to in-cloud conditions.

(2) Evaluate the data from the new Strait Crossing test sites as in (1) above.

(3) Make any necessary recommendations for test site re-location or for new installations, so that the magnitude of the in-cloud effect on salt deposition patterns can be established.

IV SALT CORROSION PROGRAM:

This program was carried on from Dec. 1978 to January 1980 (14 months). The results showed a marked drop-off in corrosion index with distance from the sea, and, as these findings confirmed the results of previous studies by Teshmont, the program was terminated. (For details see Report, Year 3, 1979-80, p. 8 and Appendix VI; Report, Year 2, 1978/79, pp 13-14 describing the CLIMAT units installed (Classification of Industrial Marine Atmosphere)).

It is recommended that either this program remain in abeyance until the in-cloud assessment of Salt Contamination be completed, at which time the correlation between salt contamination readings and salt corrosion could be studied to see if there are any implication for corrosion under in-cloud conditions, or, alternatively, that CLIMAT units be installed at the Strait Crossing on the Labrador side to obtain direct corrosion index readings there.

SECTION 4

4.0 SUMMARY OF RECOMMENDATIONS:

I. WIND:

1. Maintain 4-Mile Pond, Holyrood, since it represents a topographic up-slope station which can be correlated with the AES surface wind and rawinsonde observations at St. John's-Torbay on a real time basis to quantify the speed up effects.

2. Maintain Levi's Gulch, Codroy Valley until the downslope problem is satisfactorily solved.

3. Maintain as a second priority Sunnyside, Hawkes Bay (for the Lake Michel-Daniel's Harbour line), but, if necessary, move equipment from them to Cat Arm as being higher priority.

4. Maintain Yankee Point (Savage Cove) so long as the Salt Corrosion/Salt Contamination programs are under way at the Strait Crossing.

5. Consider installation of two new anemometers at the Cat Arm Development.

6. Maintain an annual up-date of wind data, and a complete index of data, studies, and sources at N&LH.

7. Possibly install an anemometer near Parson's Pond during summer months only to confirm the extent of the downslope winds already observed at Levi's Gulch.

II ICE:

8. Maintain PIM installations for 3 to 5 years more, then consider reduction and relocation.

9. Maintain RID at 4-Mile Pond, Holyrood.

10. Terminate other RID's until the USAF evaluation study is available.

11. Relocate two Test Spans to a more exposed site near an

existing Test Tower along the HVDC line route if they can be fully instrumented. Otherwise, maintain them all as passive ice tower sites at present locations.

12. Maintain inspection visits to Long Range Crossing and Labrador sites until the final HVDC line design is set.

13. Equip one or two exposed sites in the Long Range Crossing with vertical pole arrays or cylindrical casings to the test towers to determine average values of storm cloud drop sizes and collect data on the critical diameter for ice growth.

14. Maintain the Cat Arm Test Tower program under the Cat Arm Development.

15. Equip Cat Arm sites with vertical pole arrays at the 2 anemometer sites, as well as at Site 11, and at the proposed microwave tower Site "C".

16. Equip 4-Mile Pond-Holyrood with vertical pole arrays.

17. After the Cat Arm cloud glaze findings are completed (Items 4 and 15), reassess their implications for the Labrador Up-Slope and Highlands of St. John.

18. Maintain, and up-date annually, NL&H files on icing, data, reports, studies and sources.

III. SALT CONTAMINATION:

19. Reassess existing data on salt contamination for evidence f in-cloud enhanced deposition.

20. Based on results of 19, assess the scope and placement of four new sites at the Strait Crossing.

SALT CORROSION:

21. Install CLIMAT units at the two salt contamination sites on r side of the Strait Crossing.

Appendix A

TABLE 1

Summary
of
Climatological Monitoring Program Installations

Program Item	Content	Year 1	Year 2	Year 3	Year 4
A. WIND	Recording Anemometers Bendix Model 120	4 Sunnyside 4-Mile Pond-Holyrood Hawkes Bay Yankee Point	4	4	4 (Moved to Savage Cove)
	AES Cup-type Battery operated				1 Levi's Gulch (1 Yr. 5 in Codroy Valley)
B. ICE					
1) Passive Ice Meter (PIM)	Hydro Quebec type (Ann. Rpt. Yr. 1, p. 56, Fig. 1)	30 (See Ann. Rpt. for locations)	30	30	30
2) Rosemount Ice Detector	(Ann. Rpt. Yr. 1 p. 5, and photo)	3 Yankee Point Sunnyside 4-Mile Pond-Holyrood	3	3	3
3) Test Spans	Single spans, 40 m of 1192.5 MCM ASCR 54/19, 30-feet high Load cells and recorders	-------	------	3 Brian's Pond Inner Pond Parson's Pond	3 Brian's Pond ins rumentation mov to Inner Pond

Table 1 cont'd

Program Item	Content	Year 1	Year 2	Year 3	Year 4
4) Test Tower Sites	30-foot, guyed lattice steel towers	10 1, 2, 2a, 3, 4, 4a, 5, 6, 7, 8	15 1, 2, 2a, 2b, 3, 4, 4a, 5, 6, 7, 8, 9, 10, 11, 12	22 1, 2, 2a, 2b, 2c, 3, 4, 4a, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 PW-1, -2, -3, -4	18 2, 2a, 2b, 2c, 2d, 2e, 3, 4, 4a, PW-1, -2, -3, -4, 9, 10, 13, 14, 15.
C. SALT CONTAMINATION	Insulator string Washings	------	13 Pt. Amoure(1) L'Anse au Loup (1) Yankee Pt (1) Roddickton Rd (2) Zinc Mine area (5) Sally's Cove (1) CNT Xmitter Rd at Green Pt. (2)	13	Terminated (Note: 2 new sites to be constructed at each end of Str. Belle Isle Crossing termination points)
D. SALT CORROSION	Alcan CLIMAT units	-----	6 Yankee Point (1) Daniel's Harbour (1) Zinc Mine Rd. (3) Sunnyside (1)	6	Terminated

Table 2

Maximum Ice on Test Towers
(1977-80)

Zone	Site	Nov	Dec	Jan	Feb	Mar	Apr	Maximum Diam.	Maximum Weight
1. Sheffield	1	.5"G	1"R	B	2.5"G	6"G	B	6" Glaze	9.8 lbs/ft
2. Long Range Crossing	2	1.5"R	18"R	9"R	18"R	2.5"R	2"G	18" Rime	43.6 lbs/ft
	2a	B	.5"R	.25"R	3"G	B	Tr.R	3"Glaze	
	2b	Tr G	6"R	6"R	18"R	8"R	B	18" Rime	43.6 lbs/ft
	2c	B	B	1.3"R	B	B	B	1.3" Rime	
	9	B	.3"R	7"GR	3"G	2.5"G	B	7" Gl + R	
	10	B	B	B	B	B	B	----	
	13	B	B	B	B	B	B	-----	
	14	-	-	1.5"R	9"R	3"G	-	9" Rime	
3. Labrador Up-slope	4	6GR	4.5GR	8G	10G	12G	16G	16" Glaze	77.2 lbs/ft
	4a	Tr G	.5G	.8G	4.8G	.8G	6R	6" Rime	
	PW-1	-	-	.8G	B	B	B	0.8" Glaze	
	PW-2	-	-	1.5G	1.8G	B	B	1.8" Glaze	
	PW-3	-	-	B	B	B	B	Nil	
	PW-4	_	_	B	1.3G	B	B	1.3" Glaze	
4. Cat Arm-Lake Michel	5	B	.5R	1G	12G	6G	B	12 "Glaze	42.9 lbs/ft
	6	B	2.5R	4R	12G	2G	B	12" Glaze	42.9 lbs/ft
	8	B	B	1G	5.5G	2G	B	5.5" Glaze	
	11	B	1.5R	1.5G	12G	8G	B	12" Glaze	42 9 lbs/ft
	12	B	.5R	-	8G	B	B	8" Glaze	
5. Highlands of St. John	3	.3R	3.3R	2GR	7G	5R	-	7" Glaze	
	7	B	4.5GR	7R	4R	1G	-	7" Rime	

Appendix B

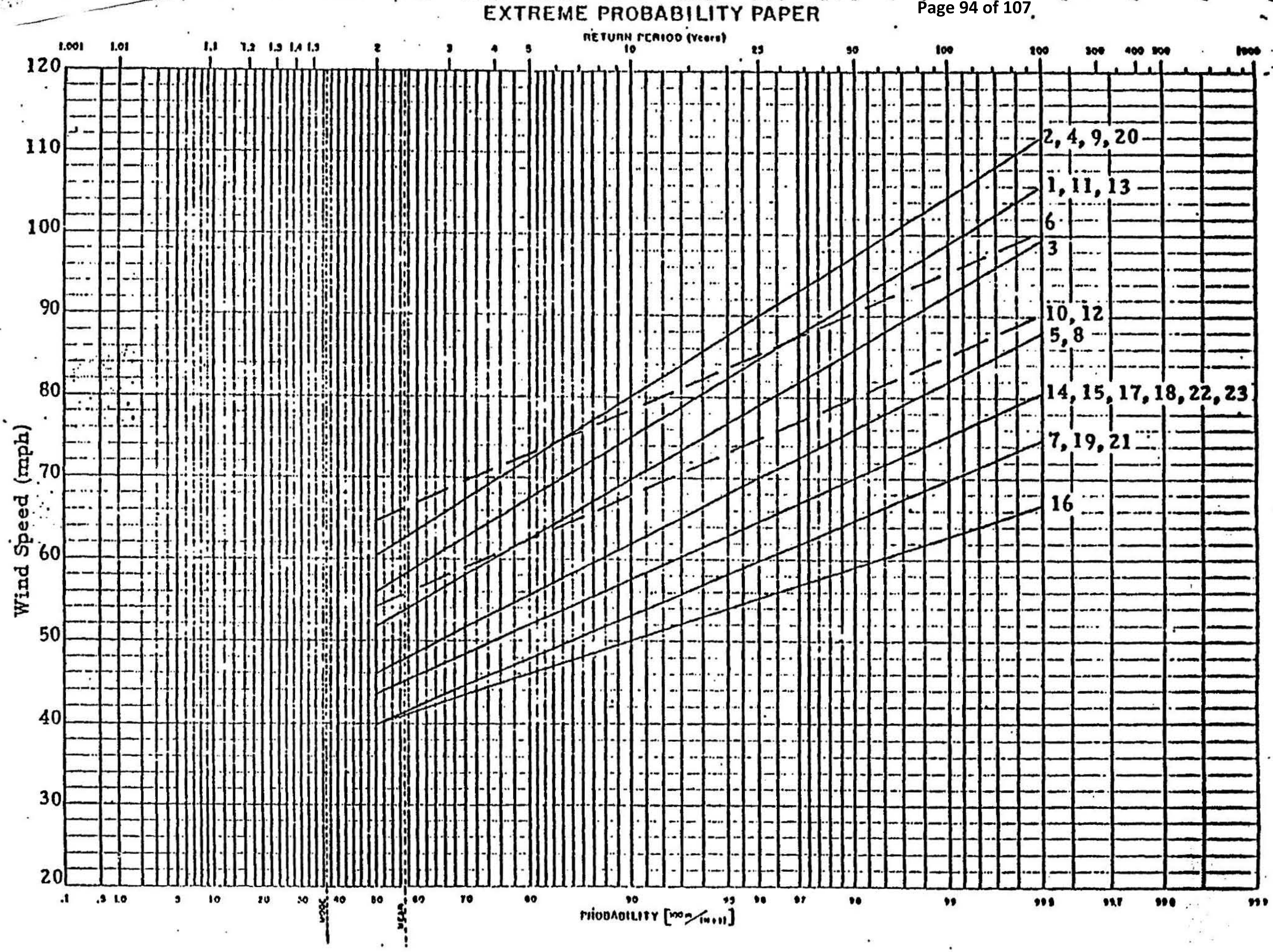


Fig. 29. MAXIMUM WIND SPEED PROBABILITIES BY LINE SEGMENT

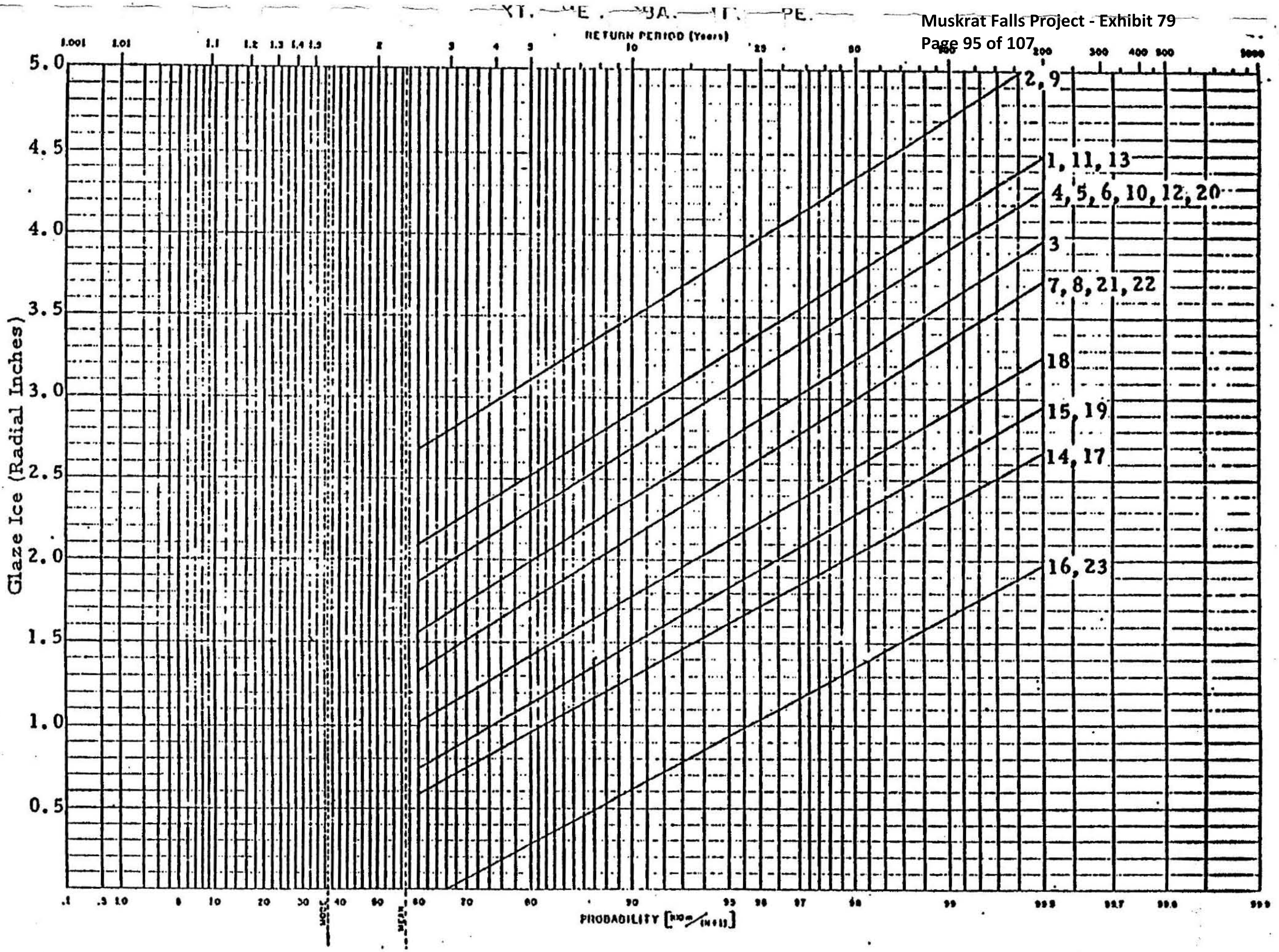


Fig. 30. MAXIMUM GLAZE ICING PROBABILITIES BY LINE SEGMENT

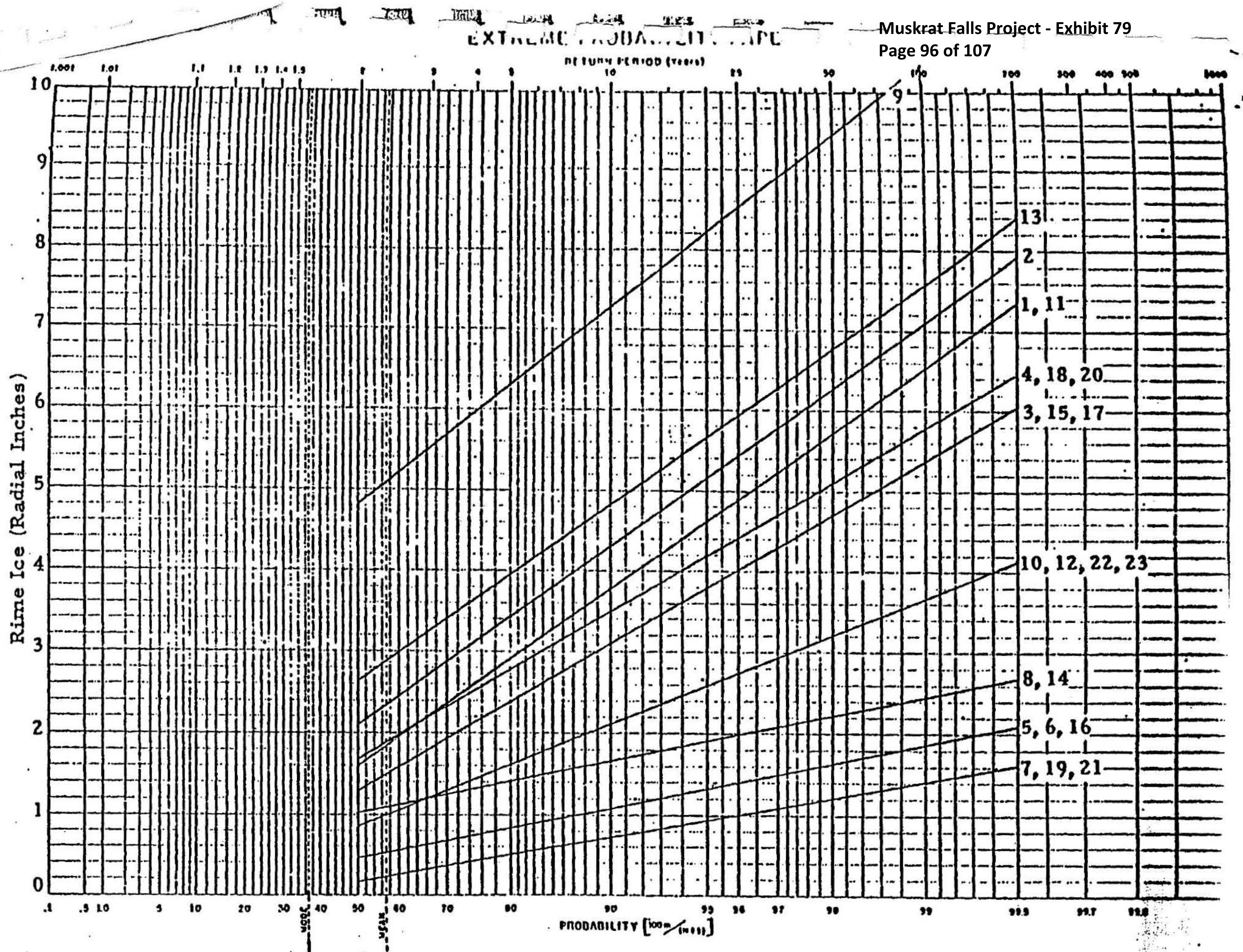


Fig. 31. MAXIMUM RIME ICING PROBABILITIES BY LINE SEGMENT

TABLE VI-1: 10-YEAR RETURN PERIOD VALUES

Seg. No.		Maximum Winds			Maximum Ice Loads						Combined Wind and Ice Loads				
					Glaze		Rime		Wet Snow			Glaze		Rime	
		Wind Dir.	Wind Speed (mph)	Max. Gusts (mph)	Rad. In	lb/ft	Rad. In	lb/ft (0.9)	Rad. In	lb/ft (0.5)	Wind Speed (mph)	Rad. In	lb/ft (0.9)	Rad. In	lb/ft (0.9)
1	Holyrood to Whithouse (< 500 ft)	W	75	91	2.9	17.4	3.8	15.0	0.8	1.5	40	2.2	11.3	2.4	7.2
2	Whitbourne to 10 miles west of Clarenville (< 500 ft)	W	80	97	3.5	23.6	4.3	18.4	0.8	1.5	43	2.8	16.5	2.8	9.1
3	10 miles west of Clarenville to Grand Falls (≤ 800 ft)	WSW	70	86	2.4	12.9	3.1	10.8	1.2	2.6	36	1.7	7.7	1.7	4.3
20	Grand Falls to north end of Humber Valley	NNE	80	97	2.7	15.5	3.5	13.1	1.7	4.3	43	2.0	9.8	2.1	5.9
8	North end of Humber Valley to top of ridge of Long Range Mountains on north side of Main River ~ 49°50'N (300 ft to 1200 ft)	NNW	62	77	2.2	11.3	1.7	4.3	1.4	3.2	36	1.4	5.8	1.0	2.0
9	Crossing Long Range Mountains (1200 ft to 1800 ft)	E	126	143	3.5	23.6	7.3	46.2	1.7	4.3	67	2.8	16.5	5.8	30.8
10	Along west Coastal Plain (≤ 500 ft)	SW	68	83	2.7	15.5	2.3	5.9	0.9	1.8	36	2.0	9.8	1.3	2.9
10a	East side of High Lands of St. John (500-1700 ft)	SW	80	97	2.7	15.5	4.3	18.4	1.7	4.3	44	2.0	9.8	2.8	9.1
11	51°N to Strait of Belle Island (≤ 500 ft)	NNE	75	91	2.9	17.4	3.8	15.0	2.2	6.3	40	2.2	11.3	2.4	7.2

TABLE VI-1: 10-YEAR RETURN PERIOD VALUES (Continued)

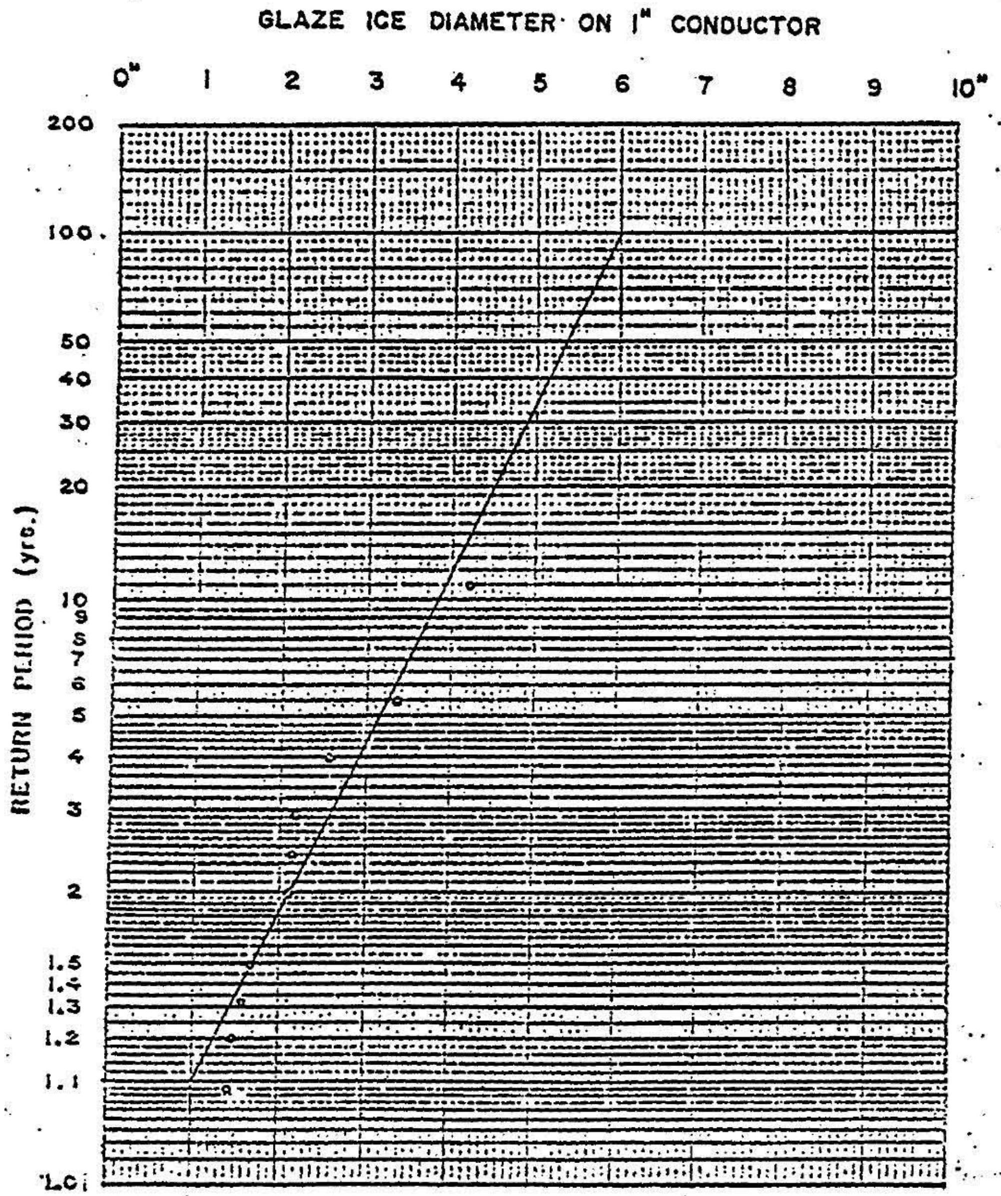
Seg. No.		Maximum Winds: Wind Dir.	Maximum Winds: Wind Speed (mph)	Maximum Winds: Max. Gusts (mph)	Maximum Ice Loads: Glaze Rad.	Maximum Ice Loads: Glaze In lb/ft	Maximum Ice Loads: Rime Rad.	Maximum Ice Loads: Rime In lb/ft (0.9)	Maximum Ice Loads: Wet Snow Rad.	Maximum Ice Loads: Wet Snow In lb/ft (0.5)	Combined Wind and Ice Loads: Wind Speed (mph)	Combined Wind and Ice Loads: Glaze Rad.	Combined Wind and Ice Loads: Glaze In lb/ft (0.9)	Combined Wind and Ice Loads: Rime Rad.	Combined Wind and Ice Loads: Rime In lb/ft (0.9)
12	Strait of Belle Isle to 30 miles inland from coast near corner of Quebec (≤ 500 ft)	NNW	75	91	2.7	15.5	2.1	5.9	2.2	6.3	40	2.0	9.8	1.3	2.9
13	Same area (500-1500 ft)	NNW	90	108	2.9	17.4	4.8	22.2	3.1	10.8	44	2.2	11.3	3.4	12.5
14	30 miles inland to 58°40'W (1000 to 1400 ft)	NNW	62	77	1.3	5.3	1.7	4.3	1.4	3.2	36	0.6	1.9	1.0	2.0
15	58°40'W to 60°05'W (≥ 1500 ft)	NNW	62	77	1.5	6.4	3.1	10.8	1.7	4.3	36	0.8	2.7	1.7	4.3
16	60°05'W to 60°30'W (≤ 1300 ft and protected from north)	W	53	66	0.6	1.9	1.1	2.3	1.2	2.6	32	0.5	1.5	0.7	1.3
17	60°30'W to Gull Lake Valley (≥ 1400 ft)	NW	68	83	1.3	5.2	3.1	10.8	1.4	3.2	36	0.6	1.9	1.7	4.3
23	Gull Lake to Churchill Falls (500-1600 ft)	NNW	68	83	0.6	1.5	2.1	5.1	0.8	1.3	36	0.5	1.2	1.3	2.5

TABLE VI-3: 50-YEAR RETURN PERIOD VALUES

Seg. No.		Maximum Winds			Maximum Ice Loads						Combined Wind and Ice Loads				
		Wind Dir.	Wind Speed (mph)	Max. Gusts (mph)	Glaze		Rime		Wet Snow		Wind Speed (mph)	Glaze		Rime	
					Rad.	In lb/ft	Rad.	In lb/ft ((0.9))	Rad.	In lb/ft (0.5)		Rad.	In lb/ft (0.9)	Rad.	In lb/ft (0.5)
1	Holyrood to Whitbourne (< 500 ft)	W	93	110	3.8	27.0	5.7	29.9	1.2	2.6	48	2.8	16.5	3.4	12.5
2	Whitbourne to 10 miles west of Clarenville (< 500 ft)	W	98	116	4.4	34.5	6.2	34.6	1.2	2.6	51	3.4	22.5	3.9	15.7
3	10 miles west of Clarenville to Grand Falls (≤ 800 ft)	WSW	88	106	3.3	21.4	4.7	21.4	1.8	4.7	44	2.3	12.1	2.4	7.2
20	Grand Falls to north end of Humber Valley	NNE	98	116	3.6	24.7	5.1	24.6	2.3	6.7	51	2.6	14.7	2.8	9.3
8	North end of Humber Valley to top of ridge of Long Range Mountains on north side of Main River ~ 49°50'N (300 ft to 1200 ft)	NNW	76	92	3.1	19.4	2.2	6.3	2.0	5.4	44	2.0	9.8	1.2	2.6
9	Crossing Long Range Mountains (1200 ft to 1800 ft)	E	140	157	4.4	34.5	9.5	74.4	2.3	6.7	87	3.4	22.5	6.8	40.7
10	Along west Coastal Plain (≤ 500 ft)	SW	80	97	3.6	24.7	3.2	11.3	1.5	3.6	44	2.6	14.7	1.8	4.7
10a	East side of High Lands of St. John (500-1700 ft)	SW	98	116	3.6	24.7	6.2	34.6	2.3	6.7	51	2.6	14.7	3.9	15.7
11	51°N to Strait of Belle Isle (≤ 500 ft)	NNE	93	110	3.8	27.0	5.7	29.9	2.7	8.6	48	2.8	16.5	3.4	12.5

TABLE VI-3: 50-YEAR RETURN PERIOD VALUES (Continued)

Seg. No.		Maximum Winds			Maximum Ice Loads						Combined Wind and Ice Loads				
					Glaze		Rime		Wet Snow			Glaze		Rime	
		Wind Dir.	Wind Speed (mph)	Max. Gusts (mph)	Rad. in	lb/ft	Rad. in	lb/ft (0.9)	Rad. in	lb/ft (0.5)	Wind Speed (mph)	Rad. in	lb/ft (0.9)	Rad. in	lb/ft (0.5)
12	Strait of Belle Isle to 30 miles inland from coast near corner of Quebec (< 500 ft)	NNW	93	110	3.6	24.7	3.2	11.3	2.7	8.6	48	2.6	14.7	1.8	4.7
13	Same area (500-1500 ft)	NNW	100	118	3.8	27.0	6.7	39.7	3.8	15.0	51	2.8	16.5	4.4	19.2
14	30 miles inland to 58°40'W (1000 ft to 1400 ft)	NNW	76	92	2.1	10.5	2.2	6.3	2.0	5.4	44	1.0	3.7	1.2	2.6
15	58°40'W to 60°05'W (≥ 1500 ft)	NNW	76	92	2.3	12.1	4.3	18.4	2.3	6.7	44	1.2	4.7	2.0	5.4
16	60°05'W to 60°30'W (≤ 1300 ft and protected from north)	W	65	80	1.4	5.8	1.6	3.9	1.8	4.7	40	0.5	1.5	1.0	2.0
17	60°30'W to Gull Lake Valley (≥ 1400 ft)	NW	80	97	2.1	10.5	4.7	21.4	2.0	5.4	44	1.0	3.7	2.4	7.2
23	Gull Lake to Churchill Falls (500-1600 ft)	NNW	80	97	1.4	5.0	3.2	10.2	1.2	2.2	44	0.5	1.2	1.8	4.0



	Weather Engineering Corporation	
	Extreme Value Analysis Glaze Ice TORBAY, NEWFOUNDLAND	
Fig. 4	Drawn By: R.M.	Approved By: B.P.
	Date: FEBRUARY 72	Dwg. No. 72/49

TABLE 1

GLAZE LOADINGS
Extreme Value Analysis
Torbay

Return Period (T) (yrs.)	Total Glaze Diameter on 1" Conductor
25	4.7
50	5.3
75	5.7
100	6.0

TABLE 2

AVERAGE MONTHLY WIND SPEEDS
For Icing Directions Only
mph

	Gander	Grand Bank	Cape Race	Torbay
Jan.				
North East	11.3	15.5	19.8	11.3
East	14.2	14.1	15.4	11.9
Feb.				
North East	12.9	15.7	24.5	18.5
East	15.7	16.9	17.0	13.9
Mar.				
North East	13.9	14.8	21.1	11.6
East	13.6	13.4	13.1	8.0

7.1 Location of Anemometers

7.2 Location of Test Sites & Test Spans

7.3 Location of Salt Contamination Sites

7.4 Contamination Structure

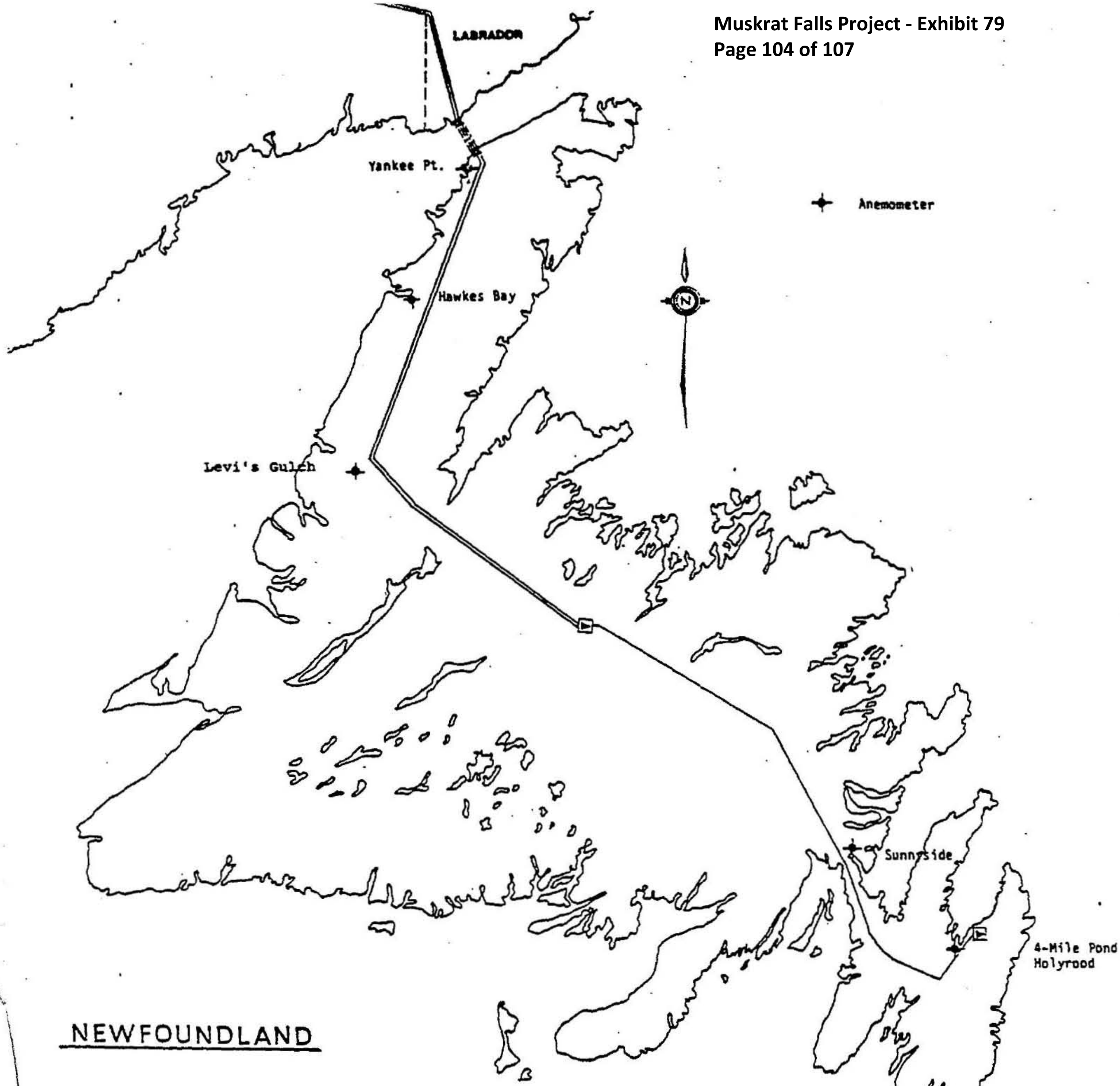
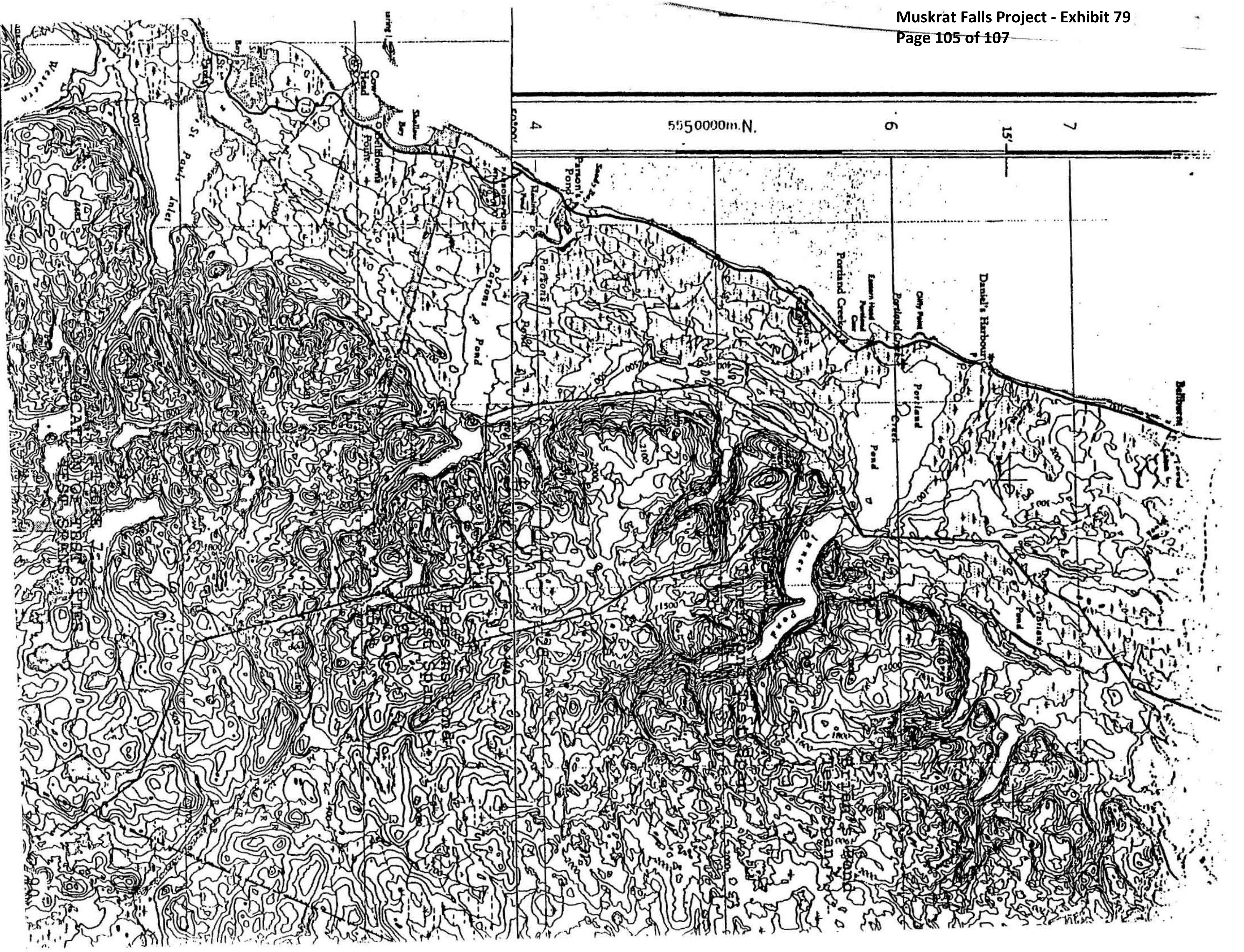
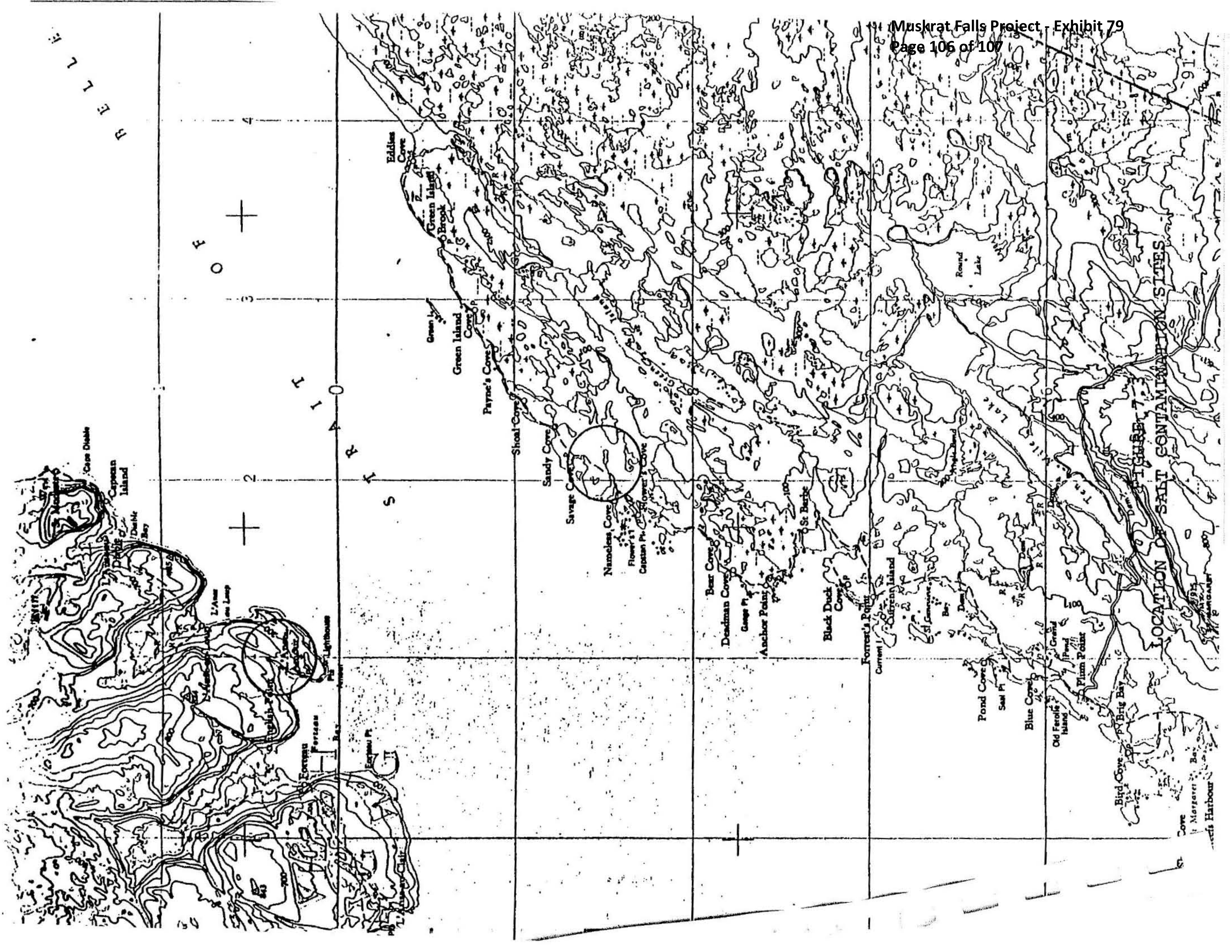


FIGURE 7.1

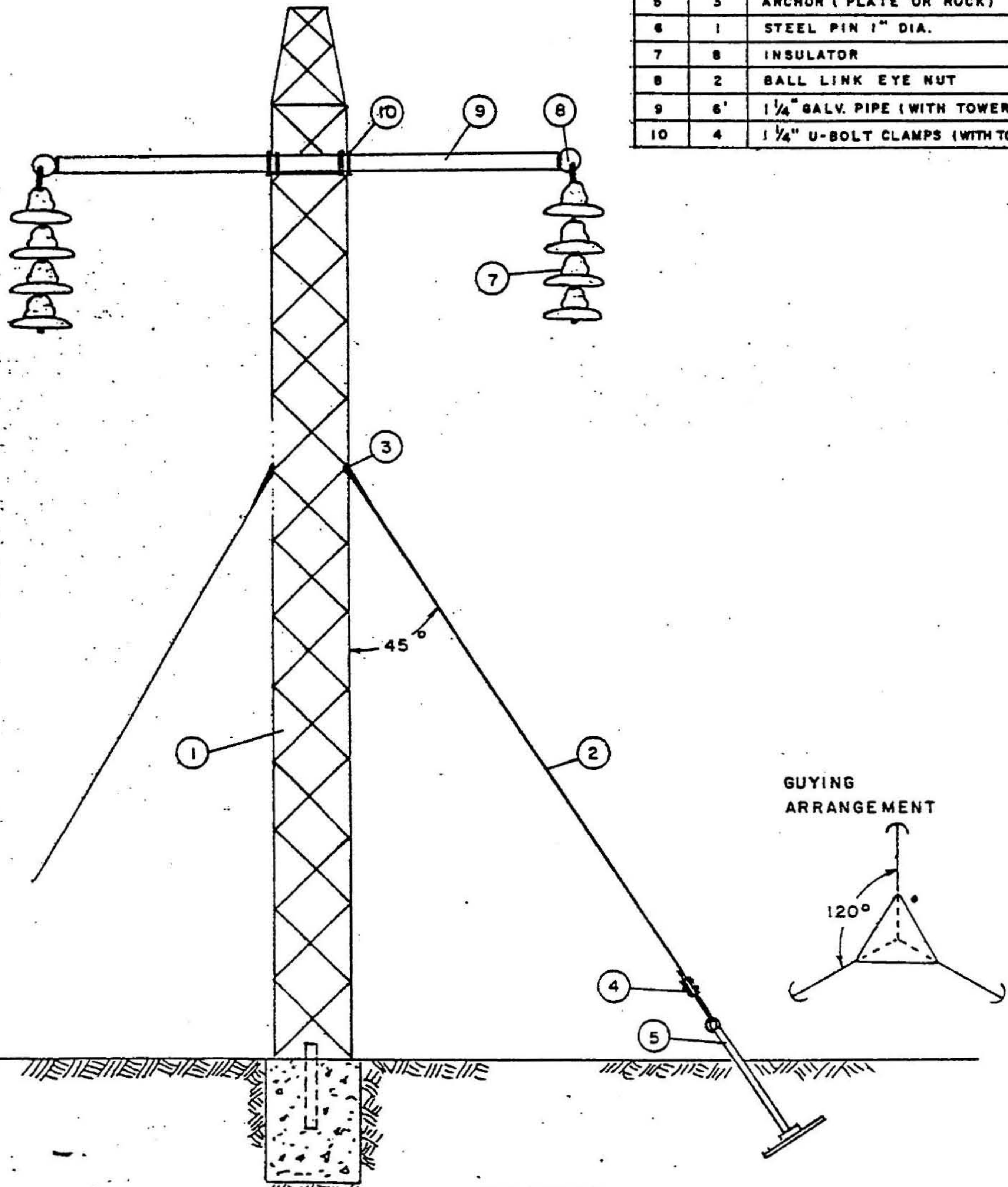
LOCATION OF ANEMOMETERS


5550000m.N.
Parsons Pond
Portland Creek
Portland Creek Pond
Daniel's Harbour
St Paul's Inlet
Cow Head
Shallow Bay


LOCATION OF SALT CONTAMINATION SITES
STRAIT OF BELLE
Eddies Cove
Green Island Brook
Green Island Cove
Payne's Cove
Shoal Cove
Sandy Cove
Savage Cove
Flower's Cove
Nameless Cove
St Barbe
Bear Cove
Deadman Cove
Anchor Point
Black Duck Cove
Forrest's Point
Current Island
Pond Cove
Blue Cove
Old Ferolle Island
Plum Point
Brig Bay
Bird Cove
Round Lake
Ten Mile Lake
Capstan Island
Cape Diable
Forteau
Forteau Bay
Lighthouse

BILL OF MATERIAL

Item No	Quan.	Description
1	1	28' DME 3 TOWER C/W BASE
2	AS REQD	3/8" GUY WIRE
3	3	PREFORMED GUY GRIP 3/8"
4	3	3-BOLT CLAMP
5	3	ANCHOR (PLATE OR ROCK)
6	1	STEEL PIN 1" DIA.
7	8	INSULATOR
8	2	BALL LINK EYE NUT
9	6'	1 1/4" GALV. PIPE (WITH TOWER)
10	4	1 1/4" U-BOLT CLAMPS (WITH TOWER)



CONTAMINATION STRUCTURE

FIGURE 7.4