NEWFOUNDLAND & LABRADOR POWER COMMISSION
ENGINEERING DEPARTMENT
SYSTEMS PLANNING DIVISION

# TEN MILE LAKE

# HYDRO POWER DEVELOPMENT

## ESTIMATE OF AVAILABLE POWER AND COST

24 June 1968

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## INTRODUCTION

Ten Mile Lake is located about two (2) miles inland from Brig Bay on the North West coast of the Island of Newfoundland and Labrador. Brig Bay is approximately ninety-three (93) miles South of St. Anthony.

The areas of the surface of the lake and the drainage area of the lake are approximately nineteen (19) and one hundred (100) square miles, respectively. The drainage area may possibly be increased to one hundred and thirty-seven (137) square miles.

Flowing from Ten Mile Lake is the Ste. Genevieve River, which is supposedly the best scheduled salmon river in this area. A short distance North of the Ste. Genevieve River is the West River, also a scheduled river, the flow of which could be diverted into Ten Mile Lake to increase the drainage area by thirty-seven (37) square miles. In this report it was assumed that the entire flow of these rivers could be utilized for power development.

The area around Ten Mile Lake is thickly wooded and the nature of the soil and rock conditions could only be assumed, for purposes of this report.

The head and flow available for hydro power is dependent on the extent of development, for which three schemes are proposed:-

 



SCHEME 1 Operate on the original elevation of the lake, with no storage.

SCHEME 2 Raise the lake elevation by five (5) feet and operate on the storage plus the original elevation.

SCHEME 3 Increase the drainage area from one hundred (100) square miles to one hundred and thirty-seven (137) square miles and raise the original lake elevation by five (5) feet.

Estimates of runoff are based on a mass curve of runoff which was plotted using figures obtained from the annual publication "Atlantic Drainage", for the Torrent River, and adjusted for the Ste. Genevieve River.

Estimates of available power were obtained using the approximate formula:

$$\frac{\text{Flow in c.f.s.} \times \text{Head in feet}}{10}$$

which gives the horsepower obtained from a wheel realizing eighty-eight (88) percent of the theoretical power.

The calculated power is that power available at the powerhouse. Figures for available power and the associated cost are given in the summary sheet in Appendix A.

A topographical map of Ten Mile Lake and its drainage area as well as the drainage area of the possible extension can be found in Appendix B. Also shown on this map are the sites of the proposed structures.

In Appendix B is a drawing of Ten Mile Lake and the possible extension showing the work involved and the area included under each echeme.

DESCRIPTION OF DEVELOPMENTS

Three (3) schemes are proposed for the development of Ten Mile Lake as a source of hydro power.

SCHEME 1: This scheme would involve the construction of a powerhouse and related equipment, approximately 9960 feet of wood stave pipeline and related equipment, an intake at the end of a 2300 feet long power canal, a deep channel across the neck of land between the two sections of the lake and a bridge to replace the existing one at this site, and a concrete spillway at the Ste. Genevieve River outlet from the lake. Provision may be necessary in this spillway to maintain a flow in the river or to permit salmon to enter the lake. With this Scheme, a dependable flow of 283,5 c.f.s. could be developed but the available head would depend on the number and size of wood stave pipelines and also the cross section of the power canal. The head loss for various combinations of pipe diameters and power canal cross sections, and the resulting available head are given in the summary sheet in Appendix A under the heading of the appropriate scheme number. The available power that could be developed for the corresponding available head and the cost of that power per kilowatt-hour, are also given in the summary sheet. The unit costs for all schemes are given in the section on unit costs.

SCHEME 2: This scheme would involve raising the lake elevation by five (5) feet and thus giving the development a live storage capacity of

2.655 b.c.f. This Scheme would have the same structures as Scheme 1, except that the pipeline and power canal would have to accommodate a higher dependable flow, and a higher spillway would be necessary at the Ste. Genevieve River outlet as well as an earth dyke, or possibly a concrete dam. This dyke would be a low structure on fairly level ground. Also, the elevation of the road, where it crosses the neck of land between the two (2) sections of the lake, would have to be raised for a distance of about three hundred (300) feet.

This scheme could yield a dependable flow of 409.5 c.f.s. that could be developed over a head which depends on the number and diameter of pipelines and the cross section of the power canal, as in Scheme 1. For available power and costs, see the summary sheet.

SCHEME 3: Scheme 3 would be the same as Scheme 2 except that the drainage area and the dependable flow are increased.

The elevation of Ten Mile Lake would be raised by five (5) feet, requiring the same structures as Scheme 2 except that the size of the pipeline and the power canal will be different, to accommodate a higher dependable flow. In addition, an earth dyke or concrete dam at the West River outlet of the lake just North of Ten Mile Lake, and a canal between the lakes would be necessary to divert the flow of the West River into Ten Mile Lake, thereby increasing the drainage area of Ten Mile Lake to one hundred and thirty-seven (137) square miles and the dependable flow to 516.8 c.f.s.

From the information available, the elevations of the West River Lake and Ten Mile Lake are two hundred (200) feet and one hundred and eighty (180) feet respectively, making this diversion feasibile. The diversion canal would be approximately 1750 feet long.

The dyke or dam on the West River would be a low structure unless the elevation of the West River Lake was to be raised. A control gate would be necessary on the diversion canal, at its higher end.

The unit costs are shown in the section on unit costs and the available power and resulting cost per kilowatt-hour are given in the summary sheet for various combinations of pipeline sizes and power canal cross sections.

In general, the land along the Western side of Ten Mile Lake is low lying. Photographs numbered 1, 2, 3, and 4 (see Appendix B) show the lowest lying land along this shore. If the lake elevation is to be raised more than five (5) feet, it might be necessary to construct more and considerably longer dams along this side of the lake at the sites of the above photographs. The land along the other sides of the lake is relatively high and as photograph number 6 (Appendix B) shows, there is a high hill near the road at the foot of the lake, which might be a source of earth fill. Photograph number 5 (Appendix B) shows the shoreline at the far end of the lake from the road, at the point of the proposed diversion canal and photographs numbered 7 and 8 (Appendix B) show the existing channel and bridge between the two sections of the lake.

The points at which the photographs were taken and also the directions in which they were taken are shown on the topographic map in Appendix B.

In Appendix A a graph with kilowatts of available power as ordinate and the velocity of water in the pipeline as abscissa. This graph was plotted using figures from the summary sheet. The values for velocity were calculated using the formula:

$$Q = VA$$

| | | | |
|---|---|---|---|
| in which | Q | = | quantity of flow in pipeline |
| | V | = | velocity of water in pipeline |
| | A | = | cross sectional area of pipeline |

As can be seen on the graph for any given diameter of pipeline, the higher the velocity, the greater the rate of decrease in power that can be produced. This is particularly noticeable in the smaller diameter pipelines. This is because the head loss in the pipeline varies as the square of the velocity. The velocity in any diameter pipeline can be such that maximum power is produced.

From this graph, estimates of available power, quantity of flow in a pipeline, or the diameter of a pipeline can be obtained if any two (2) of these three (3) items are known.

 



<u>EXAMPLE:</u> If the velocity of water in an 8 feet diameter pipeline is 10 feet per second,

$$Q = 503 \text{ c.f.s.}$$

and the power that can be developed using this pipeline is 5375 KW.

# UNIT COSTS

## UNIT COSTS - SCHEME 1

| ITEM | UNIT COST | |
|---|---|---|
| Powerhouse | $1,000,000. | |
| Deepen channel and replace bridge | 10,500. | |
| Spillway | 17,500. | |
| SUB TOTAL | | $1,028,000. |
| **EXAMPLE:** | | |
| 1-6 ft diameter wood stave pipeline | 896,400. | |
| 7.5 ft deep power canal | 243,300. | |
| Intake for 6 ft diameter pipe | 120,000. | |
| 6 ft diameter steel penstock | 19,200. | |
| Surge Tank | 179,280. | |
| SUB TOTAL | | 1,458,180. |
| TOTAL | | $2,486,180. |

### ANNUAL COST

| | |
|---|---|
| Annual first cost at 9% for 40 years | 231,360. |
| Annual labour cost | 18,500. |
| Annual operating cost | 10,000. |
| Depreciation charge at 2.5% | 62,150. |
| ANNUAL COST | $322,010. |

 



## UNIT COSTS - SCHEME 2

| ITEM | UNIT COST | |
|---|---|---|
| Powerhouse | $1,000,000. | |
| Deepen channel and replace bridge | 10,500. | |
| Dam and spillway | 33,000. | |
| SUB TOTAL | | $1,043.500 |
| **EXAMPLE** | | |
| 1-6 ft diameter wood stave pipeline | 896,400. | |
| 7.5 ft deep power canal | 290,050. | |
| Intake for 6 ft diameter pipe | 120,000. | |
| 6 ft diameter steel penstock | 19,200. | |
| Surge Tank | 179,280. | |
| SUB TOTAL | | $1,504,930. |
| TOTAL | | $2,548,430. |
| **ANNUAL COST** | | |
| Annual first cost at 9% for 40 years | | $237,160. |
| Annual labour cost | | 18,500. |
| Annual operating cost | | 10,000. |
| Depreciation charge at 2.5% | | 63,710. |
| ANNUAL COST | | $329,370. |

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## UNIT COSTS - SCHEME 3

| ITEM | UNIT COST | |
|---|---|---|
| Powerhouse | $1,000,000. | |
| Deepen channel and replace bridge | 10,500. | |
| Dam and spillway | 33,000. | |
| 5 ft deep diversion canal | 90,770. | |
| Diversion dam | 17,200. | |
| SUB TOTAL | | $1,151,470. |
| EXAMPLE | | |
| 1-6 ft diameter wood stave pipeline | 896,400. | |
| 7.5 ft deep power canal | 332,700. | |
| Intake for 6 ft diameter pipe | 120,000. | |
| 6 ft. diameter steel penstock | 19,200. | |
| Surge tank | 179,280. | |
| SUB TOTAL | | $1,547,580. |
| TOTAL | | $2,699,050. |
| ANNUAL COST | | |
| Annual first cost at 9% for 40 years | | 251,170. |
| Annual labour cost | | 18,500. |
| Annual operating cost | | 10,000. |
| Depreciation charge at 2.5% | | 67,480. |
| ANNUAL COST | | $347,150. |



## CONCLUSION

Referring to the summary sheet in Appendix A, the maximum power that a development of Ten Mile Lake would yield is 6,215 kilowatts.

A major part of the cost of the Ten Mile Lake development is in the power canal and the pipeline to the powerhouse. Calculations have shown that for a given flow of water in the power canal, a deep and narrow canal is more economical than a shallow and wide canal. Also, a pipeline with a large diameter, although it would cost more initially than a pipeline with a small diameter, would have less head loss and therefore result in the production of more power and cheaper power.

With respect to the amount of power produced, and the cost involved, it would seem most practical to use one pipeline with a large diameter, preferably eight (8) feet diameter, and a power canal which is deep and narrow. An eight (8) feet diameter pipeline is the most economical diameter of the three considered for all three schemes and a power canal designed for 516.8 c.f.s. would not cost very much more than a canal designed for a smaller flow and it would avoid a possible shutdown of the powerhouse and increased costs if a small canal was to be enlarged at a later date.

# APPENDIX A

# SUMMARY SHEET FOR TEN MILE LAKE HYDRO DEVELOPEMENT

| SCHEME | DRAINAGE AREA (SQ. MI.) | DEPENDABLE FLOW (C.F.S.) | NUMBER & DIAMETER OF PIPELINE | HEAD LOSS IN PIPELINE (FT.) | DEPTH OF WATER IN POWER CANAL (FT.) | HEAD LOSS IN POWER CANAL (FT.) | AVAILABLE HEAD MIN. | AVAILABLE HEAD MAX. | AVAILABLE POWER H.P. | AVAILABLE POWER KW. | INITIAL COST $ | ANNUAL COST $ | COST PER KW-HR. AT 0.60 CAPACITY FACTOR ¢ | COST PER KW-HR. AT 1.0 CAPACITY FACTOR ¢ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 100 | 283.5 | 1-4' | 293.00 | 7.5 | 1.4 | — | — | — | — | — | — | — | — |
| | | | | | 5.0 | 1.5 | — | — | — | — | — | — | — | — |
| | | | | | 3.5 | 1.8 | — | — | — | — | — | — | — | — |
| | | | 2-4' | 74.3 | 7.5 | 1.4 | 87.8 | 94.3 | 2580 | 1,923 | 2,659,810 | 342,520 | 3.38 | 2.03 |
| | | | | | 5.0 | 1.5 | 87.7 | 94.2 | 2580 | 1,923 | 2,699,910 | 347,250 | 3.43 | 2.06 |
| | | | | | 3.5 | 1.8 | 87.4 | 93.9 | 2570 | 1917 | 2,743,410 | 352,390 | 3.49 | 2.09 |
| | | | 1-6' | 36.3 | 7.5 | 1.4 | 125.8 | 132.3 | 3660 | 2727 | 2,486,180 | 322,010 | 2.24 | 1.35 |
| | | | | | 5.0 | 1.5 | 125.7 | 132.2 | 3660 | 2727 | 2,526,280 | 326,760 | 2.28 | 1.37 |
| | | | | | 3.5 | 1.8 | 125.4 | 131.9 | 3650 | 2721 | 2,569,780 | 331,880 | 2.32 | 1.39 |
| | | | 2-6' | 9.3 | 7.5 | 1.4 | 152.8 | 159.3 | 4430 | 3305 | 3,581,060 | 451,280 | 2.60 | 1.56 |
| | | | | | 5.0 | 1.5 | 152.7 | 159.2 | 4425 | 3300 | 3,621,160 | 456,820 | 2.63 | 1.58 |
| | | | | | 3.5 | 1.8 | 152.4 | 158.9 | 4415 | 3290 | 3,664,660 | 461,150 | 2.67 | 1.60 |
| | | | 1-8' | 8.1 | 7.5 | 1.4 | 154.0 | 160.5 | 4465 | 3327 | 3,241,050 | 411,140 | 2.35 | 1.41 |
| | | | | | 5.0 | 1.5 | 153.9 | 160.4 | 4460 | 3325 | 3,281,150 | 415,870 | 2.38 | 1.43 |
| | | | | | 3.5 | 1.8 | 153.6 | 160.1 | 4450 | 3320 | 3,324,650 | 421,010 | 2.41 | 1.45 |
| | | | 2-8' | 2.1 | 7.5 | 1.4 | 160.0 | 166.5 | 4635 | 3455 | 5,070,800 | 513,070 | 2.82 | 1.69 |
| | | | | | 5.0 | 1.5 | 159.9 | 166.4 | 4630 | 3453 | 5,110,900 | 516,900 | 2.84 | 1.70 |
| | | | | | 3.5 | 1.8 | 159.6 | 166.1 | 4,620 | 3445 | 5,154,400 | 521,060 | 2.87 | 1.72 |
| 2 | 100 | 409.5 | 1-4' | 608.0 | 10.0 | 1.1 | — | — | — | — | — | — | — | |
| | | | | | 7.5 | 1.1 | — | — | — | — | — | — | — | |
| | | | | | 5.0 | 1.2 | — | — | — | — | — | — | — | |
| | | | 2-4' | 153.9 | 10.0 | 1.1 | 8.5 | 20.0 | 585 | 436 | 2,697,010 | 346,910 | 15.13 | 9.08 |
| | | | | | 7.5 | 1.1 | 8.5 | 20.0 | 585 | 436 | 2,722,060 | 349,860 | 15.26 | 9.15 |
| | | | | | 5.0 | 1.2 | 8.4 | 19.9 | 582 | 434 | 2,782,710 | 357,030 | 15.65 | 9.38 |
| | | | 1-6' | 75.4 | 10.0 | 1.1 | 87.0 | 98.5 | 3800 | 2835 | 2,523,380 | 326,410 | 2.19 | 1.31 |
| | | | | | 7.5 | 1.1 | 87.0 | 98.5 | 3800 | 2835 | 2,548,430 | 329,370 | 2.21 | 1.33 |
| | | | | | 5.0 | 1.2 | 86.9 | 98.4 | 3790 | 2827 | 2,609,080 | 336,580 | 2.26 | 1.36 |
| | | | 2-6' | 19.0 | 10.0 | 1.1 | 143.4 | 154.9 | 6110 | 4560 | 3,618,260 | 455,680 | 1.90 | 1.14 |
| | | | | | 7.5 | 1.1 | 143.4 | 154.9 | 6110 | 4560 | 3,643,310 | 458,630 | 1.91 | 1.15 |
| | | | | | 5.0 | 1.2 | 143.3 | 154.8 | 6110 | 4560 | 3,703,960 | 465,790 | 1.94 | 1.16 |
| | | | 1-8' | 16.8 | 10.0 | 1.1 | 145.6 | 157.1 | 6200 | 4623 | 3,278,250 | 415,590 | 1.71 | 1.03 |
| | | | | | 7.5 | 1.1 | 145.6 | 157.1 | 6200 | 4623 | 3,303,300 | 418,490 | 1.72 | 1.03 |
| | | | | | 5.0 | 1.2 | 145.5 | 157.0 | 6200 | 4623 | 3,363,950 | 425,650 | 1.75 | 1.05 |
| | | | 2-8' | 4.3 | 10.0 | 1.1 | 158.1 | 169.6 | 6710 | 5000 | 5,108,000 | 631,550 | 2.40 | 1.44 |
| | | | | | 7.5 | 1.1 | 158.1 | 169.6 | 6710 | 5000 | 5,133,050 | 634,510 | 2.41 | 1.45 |
| | | | | | 5.0 | 1.2 | 158.0 | 169.5 | 6700 | 4,990 | 5,193,700 | 641,670 | 2.44 | 1.46 |
| 3 | 137 | 516.8 | 1-6' | 120.5 | 10.0 | 0.9 | 42.1 | 53.6 | 2475 | 1846 | 2,658,900 | 342,410 | 3.52 | 2.11 |
| | | | | | 7.5 | 1.0 | 42.0 | 53.5 | 2470 | 1842 | 2,699,050 | 347,150 | 3.58 | 2.15 |
| | | | 2-6' | 30.3 | 10.0 | 0.9 | 132.3 | 143.8 | 7140 | 5325 | 3,753,780 | 471,670 | 1.68 | 1.01 |
| | | | | | 7.5 | 1.0 | 132.2 | 143.7 | 7140 | 5325 | 3,793,930 | 476,410 | 1.70 | 1.02 |
| | | | 1-8' | 26.7 | 10.0 | 0.9 | 135.9 | 147.4 | 7320 | 5460 | 3,413,770 | 431,530 | 1.50 | 0.90 |
| | | | | | 7.5 | 1.0 | 135.8 | 147.3 | 7320 | 5460 | 3,453,920 | 436,270 | 1.52 | 0.91 |
| | | | 2-8' | 6.8 | 10.0 | 0.9 | 155.8 | 167.3 | 8330 | 6215 | 5,228,020 | 645,720 | 1.97 | 1.18 |
| | | | | | 7.5 | 1.0 | 155.7 | 167.2 | 8325 | 6210 | 5,268,170 | 650,460 | 1.99 | 1.19 |

## NOTES

1. SCHEME 2 IS SIMILAR TO SCHEME 1 EXCEPT THAT SCHEME 2 INCLUDES AN EARTH DYKE OR EARTH FILLED DAM ON THE STE GENEVIEVE RIVER, & TEN MILE LAKE IS RAISED 5 FEET

2. SCHEME 3 IS SIMILAR TO SCHEME 2 EXCEPT THAT SCHEME 2 IS EXTENDED TO INCLUDE AN ADDITIONAL 37 SQ MI. DRAINAGE AREA.

3. THE FIGURES LISTED UNDER "DEPENDABLE FLOW" ARE BASED ON RECORDS OF THE PUBLICATION "ATLANTIC DRAINAGE" FOR WHICH A MASS CURVE OF RUNOFF WAS MADE. THESE FLOWS ARE OBTAINED BY STOPPING THE FLOW IN THE STE GENEVIEVE RIVER FOR SCHEMES 1 & 2 AND IN BOTH THE STE GENEVIEVE & WEST RIVERS FOR SCHEME 3.
   NO ALLOWANCE WAS MADE FOR MAINTAINING FLOW IN EITHER OF THESE RIVERS, WHICH COULD POSSIBLY MEAN A REDUCTION IN "DEPENDABLE FLOW."

4. THE HEAD LOSS IN THE PIPELINE WAS CALCULATED BY MEANS OF THE EQUATION
   $$h_f = f \frac{L}{D} \frac{V^2}{2g}$$ (SEE CALCULATIONS)
   THE HEAD LOSS IN THE POWER CANAL WAS CALCULATED BY MEANS OF THE MANNING EQUATION
   $$V = \frac{1.50}{n} R^{2/3} S^{1/2}$$ (SEE CALCULATIONS).

5. THE MINIMUM HEAD IS THAT OBTAINED AT MAXIMUM DRAWDOWN AND CONSIDERING HEAD LOSSES IN THE CANAL AND PIPELINE
   THE MAXIMUM HEAD IS THAT OBTAINED WITH NO DRAWDOWN AND CONSIDERING HEAD LOSSES IN THE CANAL AND PIPELINE

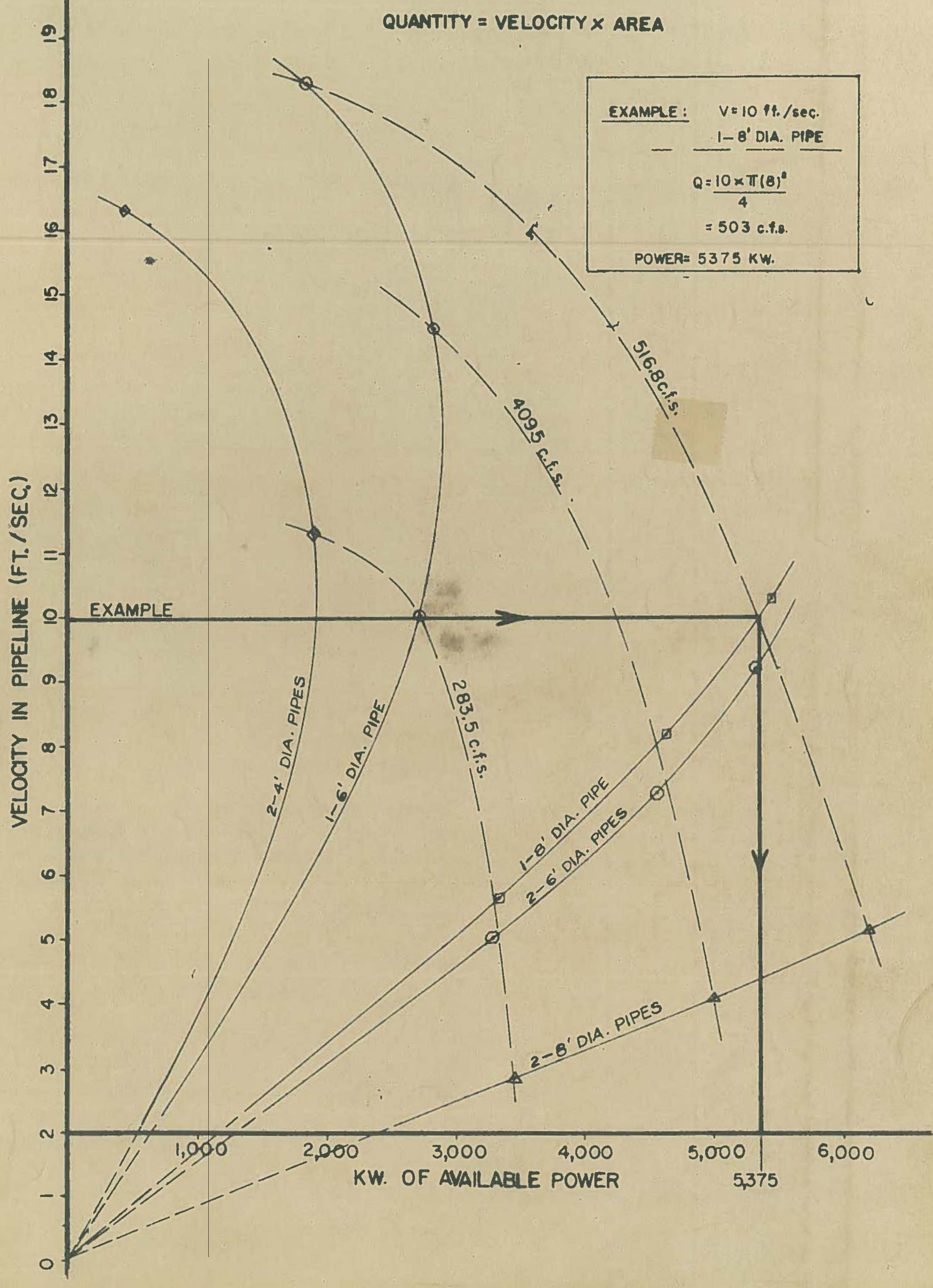
6. THE "AVAILABLE POWER" WAS CALCULATED USING THE AVERAGE HEAD AND THE "DEPENDABLE FLOW", BY USING THE APPROXIMATE EQUATION
   $$\frac{\text{FLOW} \times \text{HEAD}}{10} = \text{NET HP}$$
   (WHICH IS 88% OF THEORETICAL POWER)
   $$\text{KW.} = \text{HP} \times 0.746$$

7. ANNUAL COST WAS CALCULATED FROM INITIAL COST BY GIVING THE DEVELOPMENT A LIFE OF 40 YEARS AT AN INTEREST RATE OF 9%.
   THE ANNUAL COST INCLUDES DEPRECIATION ON A STRAIGHT LINE BASIS.

8. $$\text{COST PER KW.-HR.} = \frac{\text{ANNUAL COST}}{\text{KW.-HR. PER YEAR}}$$
   KW.-HR. PER YEAR = KW. × 8760 × CAPACITY FACTOR

9. DEPENDABLE FLOW :-
   SCHEME 1 — 283.5 C.F.S. = FLOW OF STE. GENEVIEVE RIVER + FLOW FROM 6½' DRAWDOWN FROM ORIGINAL LAKE ELEVATION OVER A PERIOD OF 8 MONTHS.
   SCHEME 2 — 409.5 C.F.S. = FLOW OF STE. GENEVIEVE RIVER + FLOW FROM 5' LIVE STORAGE + FLOW FROM 6½' DRAWDOWN FROM ORIGINAL LAKE ELEVATION OVER 8 MONTHS.
   SCHEME 3 — 516.8 C.F.S. = FLOW OF STE. GENEVIEVE RIVER + FLOW FROM 5' LIVE STORAGE + FLOW FROM 6½' DRAWDOWN FROM ORIGINAL LAKE ELEVATION + FLOW FROM DIVERSION.

# VELOCITY VS. KW. OF AVAILABLE POWER



# APPENDIX B

MAY · 68
TEN MILE LAKE 1.

SEE MAP FOR LOCATION

MAY · 68
TEN MILE LAKE 2.

SEE MAP FOR LOCATION

MAY · 68
TEN MILE LAKE 3.

SEE MAP FOR LOCATION

MAY · 68
TEN MILE LAKE 4.

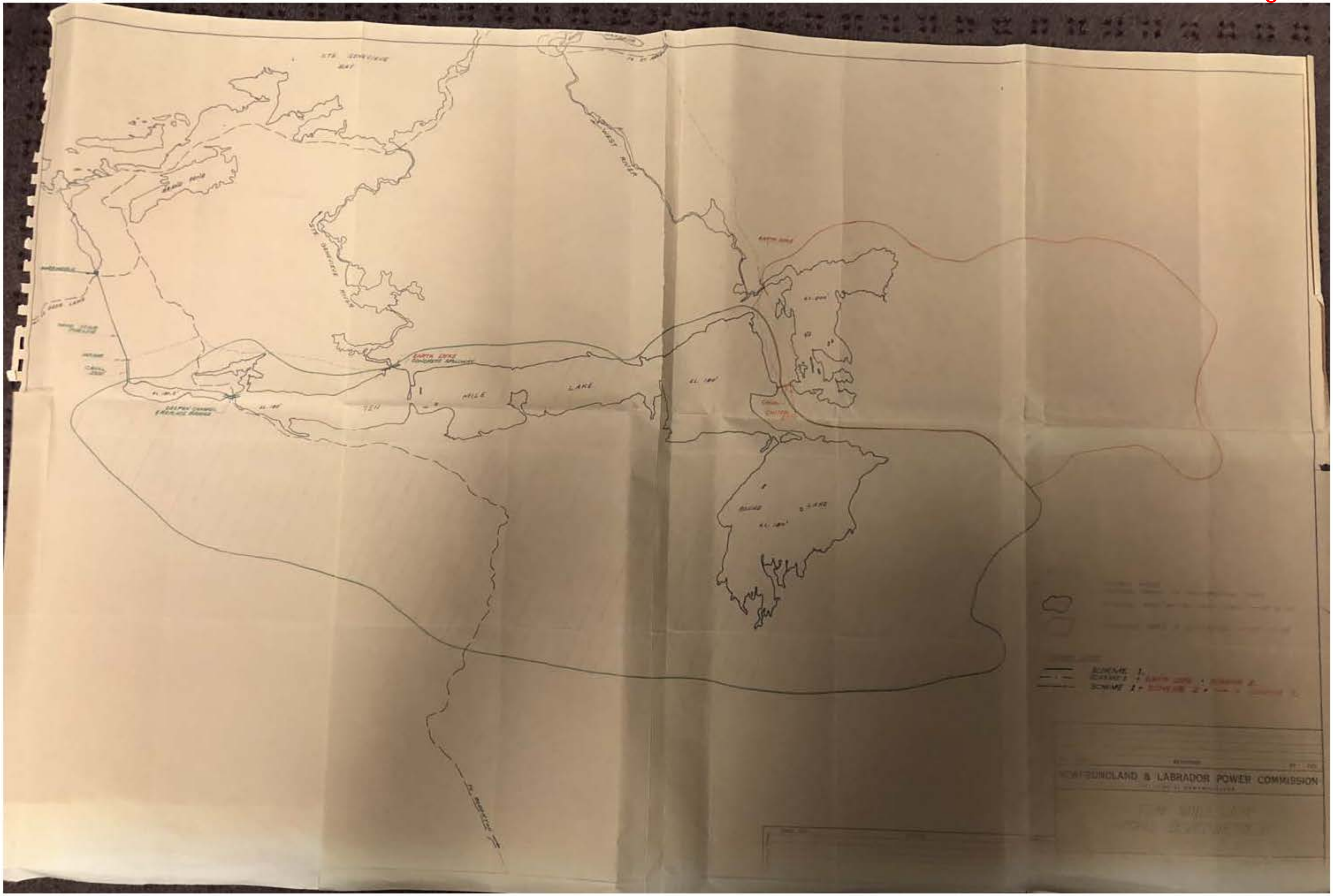
SEE MAP FOR LOCATION

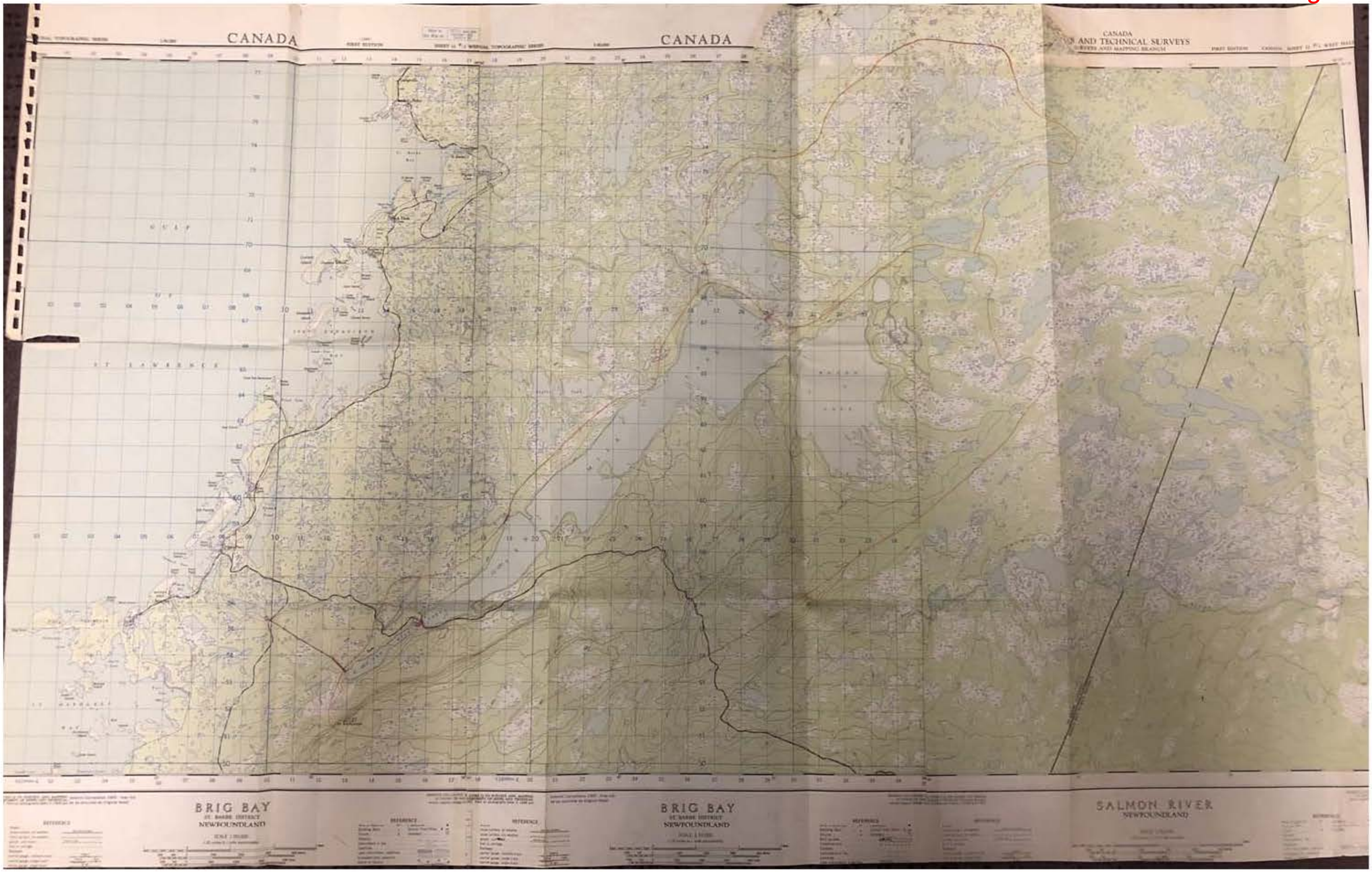

5.
MAY 68
TEN MILE LAKE
SEE MAP FOR LOCATION


MAY 68
TEN MILE LAKE
6.
SEE MAP FOR LOCATION


MAY 68
TEN MILE LAKE
7.
SEE MAP FOR LOCATION


8.
MAY 68
TEN MILE LAKE
SEE MAP FOR LOCATION.


TEN MILE LAKE
WEST RIVER
NEWFOUNDLAND & LABRADOR POWER COMMISSION


CANADA
CANADA
CANADA
AND TECHNICAL SURVEYS
GULF
ST LAWRENCE
BRIG BAY
ST BARBE DISTRICT
NEWFOUNDLAND
BRIG BAY
ST BARBE DISTRICT
NEWFOUNDLAND
SALMON RIVER
NEWFOUNDLAND