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REPORTS

UPON THE

WATER AVAILABLE

FROM THE

HUMBER WATER-SHED

With Profiles of the Humber Valley and Cross-Sections of Dams

AT

BABY'S POINT AND WESTON.

TORONTO:
THE CARSWELL CO., LIMITED.
1900.

HUMBER RIVER WATER POWER.

City Engineer's Office,
Toronto, October 29th, 1900.

E. A. Macdonald, Esq., Mayor, and Members of the City Council:

Gentlemen,—Referring to the following extract from Report No. 16 of the Board of Control, adopted in Council on April 30th, 1900:

"The Board beg to recommend that the Committee on Works be requested to direct the City Engineer to prepare a report on the available water of the Humber River watershed, and the power available therefrom, and also to report the approximate cost of developing the same."

I beg to submit the enclosed report, prepared by Mr. C. B. Smith, Assistant Engineer of this Department, to which report is attached cross sections of the proposed dams to be constructed at Baby's Point and Weston. I also enclose two reports prepared by Mr. Willis Chipman, which are referred to by Mr. Smith, as well as a profile of the Humber Valley, and a copy of a report prepared by Mr. Kivas Tully, upon borings made in this district some years ago, under his direction.

Yours respectfully,

C. H. Rust,
City Engineer.

Mr. C. H. Rust, City Engineer. October 20th, 1900.

Humber River Water Power.

Dear Sir,—Referring to the following extract from Report No. 16 of the Board of Control adopted in Council.

"The Board beg to recommend that the Committee on Works be requested to direct the City Engineer to prepare a report on the available water of the Humber River water shed, and the power available therefrom, and also to report the approximate cost of developing the same."

I beg to report as follows:—

I have had presented to me various cross sections for dam sites at Baby's Point and Weston, and such profiles and plans as enable me to make a reasonably close estimate of the cost of construction of these two dams, and have also had the report of Mr. Willis Chipman, C. E., on the available water of the Humber River watershed. The sites of these two dams have been visited, and the drill holes that have been put down by Mr. Sharp at these two dam sites, examined. This has enabled me to determine somewhat closely the probable depth to which the foundation of these two dams would have to be carried. My estimate on this water power development is as follows:

(*a*) Baby's Point Dam water power. (Known as the "first" section.) The cost of a Rubble concrete dam faced with Ashlar, 925 ft. long at top, 510 ft. long at bottom and 134 ft. high including tailrace (see Chipman's report of Reservoir Area) $1,060,200

Cost of installing an hydraulic electric plant of 6,000 H. P. gross (4,800 H. P. net) (see Chipman's report of Available Power), and transmitting the same 7 miles to the centre of the City of Toronto $191,900

Total $1,252,100

Add for engineering and legal expenses and incidentals 15 per cent... 187,900

Total $1,440,000

Equals $300 per 10 hour H. P.

Land damages. unstated.

Reconstruction of railway bridges, unstated.

Reconstruction of highway bridges and roads.

(*b*) Weston Dam (known as the second section).

Cost of constructing Rubble concrete dam, faced with Ashlar, 650 ft. long at top, 430 ft. long at bottom, and 80 ft. high, including tailrace, and the necessary valve house, valves, pipes, waste weir, headrace, etc., to pass the water through this dam in order to utilize it at Baby's Point Dam only, $360,000.

This dam could either be used in this way as a feeder to the Baby's Point power house during dry periods, or as a special power or both. Taking it as a feeder only we have the following estimate based on the assumption that this reservoir is so extensive as to afford complete storage to the Humber River water shed, which may be drawn upon during dry periods. This assumption is made merely from a general view of the Humber River Valley at this point, but this reservoir appears to be fully as extensive as Baby's Point Reservoir would be

(*c*) Baby's Point and Weston's water power combined—

Baby's Point Dam	$1,060,200
Weston Dam	360,000
Total	$1,420,200
The hydraulic electric plant necessary to develop 12,000 gross H.P. (9,600 H.P. net—see Chipman's report of Available Power) including transmitting to the centre of the City of Toronto....	366,600
Total	$1,786,800
Add for engineering and legal expenses, etc., 15%	268,000
Total	$2,054,800

Equals $214 per 10 hour H.P.

Land damages, unstated.

Reconstruction of railway bridges, unstated.

Reconstruction of highway bridges and roads, unstated.

(*d*) In addition to this the Weston Dam has 66 feet total workable head, and while feeding the lower power can work under say an average of 33 feet head during dry seasons. The reservoir capacity has not been measured. There should either be established here a small plant of say 1,000 gross H.P. (800 net H.P.) costing say $40,000, or additional smaller reservoirs could be built further up the Humber River so as to conserve the water at points further up the stream and in this way develop 66 feet head at Weston and 140 feet at Baby's Point, or say 205 feet total head. With such supplemental reservoirs, the gross H.P. during three dry seasons should be say 20,500 ten-hour H.P. gross, or say 16,000 ten-hour H.P. net.

The cost of installing the necessary machinery to develop this power and place it on the Toronto market could easily be estimated, but as the information needed for estimating the cost of the necessary supplemental dams and consequential damages is not at hand, this phase cannot be entered upon.

(*e*) Additional water from the Credit River can also be carried to the basin of the Humber near Inglewood, by constructing a dam on the Credit River and an open cut to the watershed of the Humber, but there is not sufficient information at hand to determine whether the cost of this work would be justified by the addition of about 100 square miles of watershed, to that of the Humber River.

(*f*) The opening of a channel from Lake Simcoe, which has 1,200 square miles of drainage area, would render an enormous power available at these two dams, and at other dams which would be built higher up the Humber River.

A rough estimate of the cost of cutting a canal, say 50 feet wide at the bottom, and carrying in it 10 feet depth of water from Lake Simcoe at a speed of say $1\frac{1}{2}$ feet per second, would be 48,000,000 cubic yards at 25 cents per cubic yard, equals $12,000,000. This water would develop under head of 205 feet at these two dams 24,410 gross H. P. for 24 hours, or 19,200 net H. P. for 24 hours.

Yours truly,

(Sgd.) Cecil B. Smith,

Assistant Engineer.

REPORT

UPON THE

WATER AVAILABLE FROM THE HUMBER WATER-SHED

By WILLIS CHIPMAN, C.E.

To the President and Directors of the Georgian Bay Ship Canal and Power Aqueduct Company:

Gentlemen,—I beg to submit the following report upon the water-shed of the River Humber, and the amount of water available for power and other purposes that can be utilized.

River Described.

The River Humber discharges into Lake Ontario about half a mile from the present western limit of the City of Toronto. From the outlet to Bloor Street, a distance of about two miles, there is no rapid or fall to obstruct navigation for light draught vessels, but above Bloor Street the stream is broken with rapids. The distance from the head of the longest branch of the river to the outlet is about thirty-five miles. The high lands at this point have an elevation of about 1,000 feet above Lake Ontario, the fall in the streams being greater in the northern part of the water-shed than in the southern portion.

About two and one-half miles above Weston, and ten miles from Lake Ontario, the west branch of the Humber joins the main river. At Woodbridge, fourteen and one-half miles from the lake, the east branch comes in.

The elevation along the river at different points is approximately as follows:

POINT.	Distance from the Lake.	Elevation above Lake Ontario.
Outlet at Lake Ontario	0 Miles.	0 Feet,
Crest of Dam, Lambton	3 "	59½ "
Crest of Wadsworth Dam, Weston	7 "	151 "
Junction West Humber	9½ "	163(?) "
Town Line, York and Vaughan	13 "	199(?) "
Junction East Humber	14½ "	225(?) "
Main Branch at Kleinburg	17 "	339 "
East Branch at Kleinburg	17 "	361 "
Town Line, Vaughan and King, East Branch	28 "	450 "

Area Water-shed.

The official maps of the Province are so imperfect that no dependence whatever can be placed upon the topographic features as shown thereon.

In determining the area of the Humber water-shed, the following maps and plans were consulted :

Tackaberry's Atlas of the Dominion of Canada.
Miles' Atlas of the County of York.
Unwin and Scott's Map of the County of Peel.
Unwin's Map of the Township of Etobicoke.
Tremaine's Map of the County of York.
Hogg's Map of the County of Simcoe.

The topographic surveys made by us in 1894 and 1895 in the Township of King, Vaughan and York have also been used for more accurately defining the water-shed between the Humber and the Don.

The total area of the water-shed of the Humber is approximately 337 square miles, which area may be sub-divided as follows :

Township of	York	26	square miles.
"	Etobicoke	20	"
"	Vaughan	68	"
"	Gore of Toronto	21	"
"	Albion	83	"
"	Chinguacousy	30	"
"	Caledon	11	"
"	Adjala,	8	"
"	Mono	7	"
"	King	57	"
"	Whitchurch	6	"
	Total	337	"

The drainage area of each of the different branches is about as follows :

West Branch (above Thistleton)	79	square miles.
East branch (above Woodbridge)	81	"
Main Branch (above Woodbridge)	112	"

In the Townships of York and Etobicoke the surface of the country is undulating and rolling.

The greater part of King, the north part of Albion and the parts of Adjala, Mono and Caledon drained by the Humber are hilly, the summits of the hills being from 900 to 1,300 feet above the sea. There are no lakes, large ponds or marshes within the area drained by the river, and nearly all of the land is tillable, although a comparatively small portion is bush land.

Rainfall.

The following extract from a paper by Desmond Fitzgerald, Esq., M. Am. Soc. C. E., printed in the transactions of the Am. Soc. C. E., September, 1892, is a fitting introduction to this subject:

"There is hardly any phenomenon about which so many misstatements are commonly made as that of the rainfall. Either 'the cutting down of the forests is fast diminishing the annual precipitation,' or else the latter is 'increasing rapidly from turning up of the ground,' and other causes. 'There are no longer such snow storms as we used to have.' 'The rains come now altogether in the spring.' 'Freshets and droughts come alike from great changes in the rainfall.' These and a multitude of other fallacies are constantly met with. As a matter of fact, the annual rainfall is such a varying quantity that it is extremely difficult to lay down general laws in regard to certain of its phases, even with the aid of a good rainfall table.

"Again, the observations themselves are frequently inaccurate, as can sometimes be told at a glance. The earlier results were generally too small, because the gauges were placed too high and less care was exercised to measure all the small showers and the snow. Too often the tables issued from official sources, and stamped with the approval of the Government, are open to this criticism. The periods also are generally too short to build safe theories upon and, lastly, self-interest connected with important commercial enterprises leads to false statements."

Rainfall observations have been taken at the Toronto Meteorological Observatory from 1843 to the present time, except from August, 1844, to March, 1845, inclusive. The recorded rainfall in 1843 is given as 50.175 inches, the heaviest on record. As the two following years are not available, and this is so high, it would be safer to eliminate it from the averages.

The observed rainfall at the Toronto Observatory has been as follows:

Table I.

Average of	8	years,	1846	to	1854	inclusive	............34.16	inches.
"	10	"	1855	"	1864	"	............34.88	"
"	10	"	1865	"	1874	"	............33.66	"
"	10	"	1875	"	1884	"	............31.53	"
"	10	"	1885	"	1894	"	............31.92	"
"	54	"	1841	"	1894	"	............34.61	"
"	23	"	1872	"	1894	"	............32.77	"
"	5	"	1890	"	1894	"	............33.60	"

The rainfall in the above tables includes the melting snow.

Rain observations have been taken at some few points north, east and west of the Humber water-shed, sufficient to demonstrate that the annual precipitation differs but little from that of Toronto, the amount at Toronto being slightly less than at points to the north and north-west.

It is generally supposed that the deforesting of our country has contributed more than any other factor towards the gradual drying up of our streams, during the summer months especially. Farm drainage is no doubt another important factor. I am of opinion, however, that such streams as the Don, the Humber, the Thames, the Sable, the Sydenham, the Rideau, and many others in the older parts of this Province carry as large a proportion of the rainfall from their water-sheds to-day as they did twenty years ago; that the removal of the forest areas has reached its maximum limit; and that therefore the flow of these streams will remain a constant ratio to the precipitation.

Although it is generally conceded that the annual rainfall is decreasing from the effects of deforesting, this question has not been settled entirely in favor of this theory.

I am of the opinion that the quantity of water required by growing grains, grasses, roots, etc., per acre is greater than that required by forest land, during the summer months, and that therefore a much larger proportion of the rainfall and the moisture in the air is absorbed now than formerly.

It is not probable, however, that the area of the forest land within the limits of the Humber water-shed will decrease during the future.

The rainfall varies from 50 inches to 24 inches, the following being the heaviest and lightest recorded :

TABLE II.

1843	50.175 inches	1874	24.344 inches.
1878	48.490 "	1882	24.837 "
1870	46.188 "	1872	25.338 "
1855	41.550 "	1877	25.615 "
1852	40.895 "	1887	25.758 "
1857	40.585 "	1888	26.279 "
1859	39.764 "	1848	26.805 "
1893	39.715 "	1881	26.898 "
1869	39.642 "	1860	27.9[illegible]4 "
1866	39.419 "	1856	28.055 "

During the last ten years the annual rainfall has been less on the average than during the total period since 1843, but slightly greater than during the period of 1871 to 1880.

If each dry year were followed by a wet year it would be safe to take the average, but this is not the case. Since 1843 the precipitation in consecutive dry years has been as follows :

TABLE III.

Two years,		1881, 1882,	average	25.87	inches.
"	"	1887, 1888,	"	26.02	"
"	"	1874, 1875,	"	27.04	"
"	"	1873, 1874,	"	27.98	"
"	"	1872, 1873,	"	28.47	"
"	"	1888, 1889,	"	28.74	"
Three	"	1872, 1874,	"	27.09	"
"	"	1887, 1889,	"	27.75	"
"	"	1873, 1875,	"	28.56	"
"	"	1881, 1883,	"	28.61	"
"	"	1874, 1876,	"	28.82	"
Four	"	1872, 1875,	"	27.76	"
Five	"	1872, 1876,	"	28.38	"
Six	"	1872, 1877,	"	28.17	"
Seven	"	1871, 1877,	"	28.82	"
Eight	"	1870, 1877,	"	30.99	"
Nine	"	1871, 1879,	"	30 81	"
Ten	"	1871, 1880,	"	31.49	"

From the foregoing table it is evident that it would not be safe to use the average annual rainfall for the last 54 years in estimating the available yield of water from any given water-shed.

The flow by months, and the average for 10-years and for 54 years, is given in Table IV.

TABLE IV.

Precipitation observed at Toronto Observatory.

	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	Average last 10 Years.	Average 54 Years.	1874
January	2.79	5.52	3.20	1.93	3.46	3.36	3.13	1.55	2.99	1.67	2.97	2.89	4.04
February	1.82	3.08	4 28	1.68	2.37	3.48	2.65	2.27	3.62	2.27	2.75	2.65	3.06
March	1.22	3.00	1.51	2.80	0.99	1.48	3.03	0.77	2.04	1.32	1.82	2.70	1.65
April	3.05	2.96	1.61	1.37	1.59	2.11	2.31	1.26	4.90	1.33	2.25	2.47	2.34
May	2.25	2.44	0.81	0.85	3.14	2.62	0.52	3.48	3.86	9.36	2.93	2.94	1.49
June	4.19	1.92	2.65	3.99	3.55	4.87	3.05	5.81	1.83	1.08	3.29	2.95	1.80
July	2.10	2.45	0.66	0.86	3.26	4.11	2.16	2.50	2.27	1.61	2.20	3.00	3.35
August	3.92	2.63	2.00	2.91	0.43	3.02	4.83	3.99	5.75	0 38	2.99	2.92	0.38
September	3.62	3.83	1 20	3.29	2.08	1.85	1.70	3.12	1.25	5.48	2.74	3.25	1.55
October	3.73	2.59	1.63	2.67	1.89	4.94	1.70	1.35	3.62	2.35	2.65	2.39	1.42
November	2.15	2.65	2.80	3.10	3.56	4.59	3.56	2.17	2.99	0.61	2.72	3.15	2.11
December	1.98	2.01	3.41	0.83	4.90	1.94	2.88	1.24	4.60	2.41	2.62	3.31	1.16
Year	32.92	35.08	25.76	26.28	31.22	37.37	31.52	29.51	39.72	29.87	31.92	34.61	24.34
								Monthly average,			2.66	2.88	2.03

From Table IV. it will be seen that the monthly rainfall varied from 5.75 in August, 1893, to 0.66 in July, 1887, during the last 10 years. The lowest recorded monthly rainfall observed during the last 54 years was 0.38 in August, 1874.

During the last 10 years there has been a greater variation in the monthly averages than during the period of 54 years, the difference in the first place between extremes being 3.29-1.82, or 1.47 or 55 per cent. of the average, while in the latter the difference is only 3.31-2.47, or 0.84 or only 29 per cent. of the monthly average.

This may be accidental. The driest months in the 10 year period are, in order, March, July, and April, while in the longer period they are April, February and March.

Flow of Stream.

The flow of a stream equals the rainfall, less evaporation and absorption.

There is no method of deducing the percentage of the rainfall that is represented by the evaporation or the absorption except by actually measuring the flow of the stream during the period covered by the observations of the rainfall.

this Province no gaugings of this kind have been made of the flow of the riv... and streams, and the volume of flow as deduced from the rainfall must therefore be considered as approximate only. Such observations have, however, been made upon the St. Lawrence, the rivers connecting the great Lakes, and upon many rivers and streams in the United States, more particularly in the New England States, the results of which may be safely applied to the Humber. The rainfall, "run-off," etc., on several water-sheds are as follows:

Table V.

Observed flow of some rivers in the Unit.d States.

RIVER.	Area, Water-Shed. Sq. Miles	Average Rain. Inches.	Average Flow or Run-off. Inches.	Percentage of Rainfall.	C. Ft. per sec. per Sq. Mile of Basin.
St. Lawrence at Odgensburg, N.Y.	272.025	29.78	14.96	50.2	1.102 Cooley.
St. Lawrence at Odgensburg, N.Y.	270.075	31.29	15.07	48.1	1.110 Crossman
Connecticut, Conn	10.234	44.69	25.25	56.5	1.831
Sudbury, Mass	76	45.80	22.67	49.5	1 669
Croton, N.Y	337	45.08	22.36	49.6	1.648
Madison, Montana	2.000	20.00	13.00	65.0	).958
Rio Grande, Tex	1.40	30.70	12.84	41.9	).946

The gaugings for St. Lawrence are from reports of engineers, U.S.A., those for the other rivers from a paper by C. C. Babb, Jun., Am. Soc. C. E., (Transactions May, 1893), reports and papers by Messrs. L. E. Cooley, R. E. McMath, Geo. Y. Wisner, Chas. Crossman, L. Y. Scherme horn and others, have been consulted in preparing the above table.

It will be observed that the rainfall on the water-sheds of the Rio Grande and of the St. Lawrence are about the same as the average on that of the Humber water-shed. In estimating the "run-off" from the rainfall, it would be safer to take the percentage given by the flow in the St. Lawrence, 49%, than that of the Rio Grande, owing to similarities in meteorological conditions and in surface geologies of their water-sheds.

Of the total basin of the St. Lawrence (above Ogdensburg), 272,000 square miles, about 95,300 square miles is in the Great Lakes.

From calculations based on observations and experiments, it is known that the evaporation from a water surface is much greater than from land. If, therefore, the Great Lakes were absent from the drainage basin and their sites replaced by land, the run-off of the St. Lawrence would be increased.

At Boston, from 1875 to 1890, the average yearly evaporation was 39.20 inches from a water surface, and on the Great Lakes the observed evaporation is known to be greater than from land surface, and about 60 per cent. of the rainfall.

We can, therefore, safely estimate that the average flow of the River Humber is at least 50 per cent. of the average rainfall, on the basin within its water-shed, or one and two-tenths cubic feet per second for each square mile, or 648,000 imperial gallons per day.

As given on page 5, the area of the basin is 337 square miles, from which it follows that the average flow in the river is about 404 cubic feet per second or 218,160,000 Imperial gallons per day, the average rainfall being taken as 31 inches.

With sufficient storage capacity for the surplus water in years of great precipitation, the above average could be depended on.

The following table shows that the annual "run-off" on the Croton and Sudbury water-sheds does not bear a constant proportion ao the rainfall :

TABLE VI.

Yield in Percentage of Rainfall of the Croton Basin, 337 Square Miles, and the Sudbury Basin, 76 Square Miles.

	Croton.		Sudbury.		
Year.	Rainfall.	Run-off Per Cent.	Rainfall.	Yield Per Cent.	Humber Rainfall.
1870	46.63	48			46.19
1871	48.94	43			32.73
1872	40.74	47	For 16 Years.		25.34
1873	43.87	64			31.61
1874	42.37	63			24.34
1875	43.66	63	45.49	44.9	29.73
1876	40.68	61	49.56	48.2	32.40
1877	46.03	48	44.02	57.9	25.61
1878	54.14	53	57.93	52.6	48.49
1879	46.08	50	41.42	45.3	29.36
1880	38.52	40	38.18	31.9	35.32
1881	46.33	44	44.17	46.5	26.90
1882	55.20	46	39.39	45.9	24.83
1883	43.15	37	32.78	34.1	34.13
1884	53.71	47	47.14	50.4	28.55
1885	45.99	42	43.55	43.4	32.91
1886	47.59	47	46.04	49.5	35.08
1887			42.70	56.7	25.76
1888	For 17 Years.		57.46	62.2	26.28
1889			49.95	58.2	31.22
1890			53.00	50.9	37.37
Averages	45.79	49.5	45.8	49.5	31.72

The above tables have been taken from the report of chief engineer, Walter S. Church, to the Aqueduct Commission of New York City, and the reports of the Water Board, Boston. It will be seen from the table that while the average yield of each has been 49.5 per cent. of the rainfall, the flow has in some years fallen below 40 per cent., 32 per cent. on the Sudbury area, 37 per cent. on the Croton.

The minimum yield of the Sudbury during this period was 11.19 inches in 1883, not quite half the average, and the minimum on the Croton 15.32 inches or 67 per cent. of the average.

The larger the area of the water-shed the less the variation in flow. As the Humber basin is larger than the Croton, we may safely assume that the minimum yearly flow in the river will be about 70 per cent. of the average or 283 cubic feet per second, equal to 152,712,000 Imperial gallons per day.

Storage Required.

Assuming that the daily flow available will average 150,000,000 gallons per day, our next cosideration will be the storage required to equalize the monthly flow.

No gaugings have been made of the Humber for a term of years with which it is impossible to determine the monthly average flow in percentage of the rainfall without which latter data the storage capacity required to make available the minimum yearly flow cannot be calculated. These observations cannot now be made, so the only thing to do is to compare the Humber with the streams where such have been made. The following table gives the average monthly flow of the Connecticut, the Sudbury and the Croton, and the flow in percentage of the rainfall.

Table VII.

Flow by Months in Percentage of Rainfall.

Month.	Connecticut Averages.			Sudbury Averages.			Croton Averages.			Humber Average Rain 10 Years.
	Rain.	Flow.	Per Cent.	Rain.	Flow.	Per Cent.	Rain.	Flow.	Per Cent	
Jan.....	3.27	1.93	59.1	4.18	2.05	49.1	3.65	2.12	58.2	2.97
Feb	3.10	2.04	65.8	4.06	3.18	78.5	3.30	2.47	74 9	2.75
March...	3.94	3.00	76.3	4.58	5.02	110.0	4.36	3.80	89.6	1.82
April	3.26	4.73	145.0	3.32	3.62	109.0	3.64	3.51	96 5	2.25
May	3.17	4.19	132.2	3.20	2.00	62.5	3.28	2.44	74 4	2.93
June	4.00	1.46	36.5	2.98	.87	29.2	3.66	1.06	29.0	3 29
July	4.79	1.02	21.3	3.78	.34	9.0	3.92	.60	15.3	2.20
August ..	4.87	1.06	21.8	4.23	.55	13.0	3.76	1.05	28.0	2.99
Sept	3.04	.89	29.3	3.23	.46	4.2	4.00	.93	23.3	2.74
Oct......	3.93	1.11	28.3	4.41	1.02	23.2	4.00	1.01	25.3	2.65
Nov.....	3.93	1.76	44.8	4.11	1.62	39.4	3.98	1.33	33.4	2.72
Dec......	3.99	2.06	60.7	3.71	1.95	32.7	3.53	2.04	57.8	2 62
Totals...	44.69	25.25	56.5	45.80	22.67	49.5	45.08	22.30	49.6	31.92

In the Connecticut the monthly flow is more uniform that on the other streams owing to its larger basin, especially in the summer season. The Sudbury being the smallest has the least summer flow, falling as low as one third of an inch or nine per cent. of the July rainfall.

Applying the percentage of the Croton to the rainfall on the Humber, we get the following as the monthly flow of the Humber :

TABLE VIII.

Month.	Average for 10 Years Past. 1885-1894.			For 1874.		Average for 3 Dry Years. 1887-1889.	
	Rainfall Inches.	Per-centage.	Flow. Inches.	Rainfall Inches.	Flow. Inches.	Rainfall.	Flow.
January	3.0	58	1.74	4.0	2.32	2.9	1.68
February	2.8	75	2.10	3.0	2.25	2.8	2.10
March...... ..	1.8	90	1.61	1.7	1.53	1.8	1.62
April	2.3	96	2.21	2.3	2.21	1.5	1.44
May.........	2.9	75	2.17	1.5	1.12	1.6	1.20
June	3.3	29	.96	1.8	.52	3.4	.98
July.....	2.2	15	.33	3.3	.49	1.6	.24
August	3.0	28	.84	0.4	.11	1.7	.47
September	2.7	23	.62	1.6	.37	2.2	.51
October......	2.6	25	.65	1.4	.35	2.0	.50
November	2.7	33	.89	2.1	.69	3.1	1.02
December	2.6	58	1.51	1.2	.70	3.1	1.80
Total..	31.9	....	15.63	24.3	12.66	27.7	13.56
Monthly Av'ge.	2.66	49	1.30	2.03	1.05	2.31	1.13

One inch of "run-off" from one square mile represents 14,520,000 gallons, or 2,323,200 cubic feet, from which the average daily run off would be about 540,000 gallons per day for the three dry consecutive years, 1887-1889, and for the dry year 1874, only 504,000, say 500,000 Imperial gallons to each square mile, that is, 168,500,000 gallons per day from the Humber water-shed. This differs but 10% from the amount given elsewhere on this page.

In round numbers the minimum run off by months will be as follows, assuming one inch gives $14\frac{1}{2}$ millions of gallons.

TABLE IX.

Monthly Run Off in Millions of Gallons Per Square Mile.

	Inches.	Million Gallons.	Surplus.
January	1.7	24.65	6.75
February	2.0	29.00	16.40
March	1.6	23.20	30.40
April	2.0	29.00	38.60
May	1.2	17.40	52.60
June	.6	8.70	54.40
July	.2	2.90	47.10
August	.2	2.90	35.00
September	.3	4.35	22.90
October	.5	7.25	12.25
November	.8	11.60	4.50
December	1.5	21.75	1.20
	12.6	182.70	......
Average	1.05	15.22	......

If it be required to utilize one-half million of gallons per day from each square mile of water-shed, or say 15,000,000 per month, storage would be required for the surplus over the average in the six wet months.

Assume reservoir empty on December 1st, the surplus at first of each month thereafter would be as in the fourth column in above Table IX.

The storage in this case required would thus be 54,400,000 of gallons per square mile of water-shed, say 54,500,000 per square mile. The total storage required on the Humber basin would therefore be 54,500,000 x 337 = 18,366,500,000 of gallons. This being an incomprehensible number, it can be better expressed by stating that it corresponds with a pond having five square miles of surface with a uniform depth of about 21 feet.

By substituting the dry year 1874, it will be found that a storage of 60,000,000 gallons per square mile would be required.

The following table from Mr. Fitzgerald's paper (Trans. Am. Soc. C.C., Sept. 1892), gives the storage capacity required to sustain a constant daily draft from one square mile containing various percentages of water surface, based on Sudbury River water-shed. This is for a term of 16 years: the gallons are United States gallons and must therefore be decreased by one-sixth to reduce to Imperial gallons.

TABLE X.

Constant Daily Draft.	0 Per Cent.	2 Per Cent.	4 Per Cent.
200,000	8,797,000	9,937,000	12,802,000
250,000	17,997,000	20,637,000	23,502,000
300,000	28,473,000	31,337,000	34,202,000
350,000	39,173,000	42,037,000	44,902,000
400,000	51,303,000	52,788,000	55,602,000
450,000	63,553,000	65,038,000	66,525,000
500,000	75,803,000	77,288,000	79 105,000
550,000	88,053,000	89,877,000	92,905,000
600,000	100,651,000	103,677,000	106,705,000
650,000	114,451,000	121,577,000	132,154,000

The above storage would tide over the deficiency of the dry years, 1875 to 1890 inclusive, and is not intended for one minimum year.

In my calculations I have assumed that the minimum flow would be the available flow, and that the storage capacity would not be sufficient to tide over the deficiency of a series of dry years, such as occurred between 1877 and 1880.

The total amount that can be made available from the Humber basin is 650,000 imperial gallons per day per square mile of water-shed, by constructing reservoirs to store the surplus water in wet years. To make available the total average flow, the storage capacity required would be about 70,000,000 of gallons for each square mile of basin, that is 23,590,000,000 of gallons, or a reservoir 27 feet in depth and five square miles in area.

The proportion of the average flow of the river that can be made available for power puposes depends upon the capacity of the storage reservoirs.

SUMMARY.

Area of basin of Humber....	337	sq. miles.
Average rainfall last ten years..............	31.9	inches.
Minimum rainfall (1874).......................	24.3	"
Average rainfall for 2 consecutive dry years.....	25.8	"
" " " 3 " "	27.1	"
" "run off" 50 per cent. of rainfall 10 years................	15.9	"
" " per sec. per square mile......................	1.2	c. feet.
" " " " " 3 dry years............	1.0	"
" " per day " "	650,000	gallons.
Minimum " " " " (1874)..............	450,000	"
" " " " " (3 years)......... ..	500,000	"

The above data are I believe correct, and I hope they may be useful to your Company.

Yours very truly,

WILLIS CHIPMAN, C.E.

Toronto, September 3rd, 1895.

REPORT UPON THE CAPACITY OF THE PROPOSED LAMBTON RESERVOIR.

To the President and Directors of the Georgian Bay Ship Canal and Power Aqueduct Co.:

GENTLEMEN—On September 9th I presented to you my report upon the water available from the Humber water-shed, this report being dated September 3rd, 1895.

Owing to delays in completing the surveys and plans, the computed areas of the land covered by the proposed Lambton reservoir were not given to me by the Companys's surveyors until Saturday 21st September.

The site of the proposed dam is at Baby's Point, almost midway between Bloor Street and the Village of Lambton.

The areas flooded at different elevations as computed by G. B. Abrey, Esq., C. E., with his plainmeter, from plans made from actual t pographic surveys, are as follows:

TABLE A.

Elevation Above Lake Ontario.	Areas Flooded, in Acres.	Differences, in Acres.	Mean Areas Between Elevations Given.	
			Acres.	Square Miles.
140 feet.	1,772	240	1,652	2.58
130 "	1,532	186	1,439	2. 5
120 "	1,346	217	1,237	1.93
110 "	1,129	....	......	...

640 acres, 1 square mile.

A reservoir of one acre in area and ten feet in depth will contain 435,600 cubic feet, representing 2,722,500 Imperial gallons.

The total area of the Humber basin being 337 square miles, the storage capacity of the reservoir between the elevations given will therefore be as follows:

TABLE B.

Between Elevations.	Capacity in Imperial Gallons.	Gallons Per Sq. Mile.
140 and 130	4,497.570,000	13,345.000
130 and 120	3,917,677.500	11,625,000
120 and 110	3,367,732,500	9.993,000
140 and 120	8,415,247,500	24,971,000
140 and 110	11,782,979,000	34,964,000

The surface of the reservoir has an area of less than one per cent. of that of the water-shed of the Humber, but other ponds and the river itself may increase this somewhat, but certainly to not more than two per cent.

By referring to table X in my first report it will be seen that this storage capacity will give above 216,000 gallons per day, constant draft, the reservoir to be lowered not more than ten feet during the year, or a constant draft of about 270,000 gallons per day from each square mile if lowered twenty feet, or 317,000 gallons per day per square mile if lowered thirty feet.

This may be shown better in tabular form, as follows :

TABLE C.

Elevations.	Constant Draft in Imperial Gallons Per Day.	
	Per Square Mile.	From Total Water-shed.
140 to 130	216,000 gallons.	72,800,000 gallons.
140 to 120	270,000 "	90,990,000 "
140 to 110	317,000 "	106,830,000 "

From the former report the average daily "run off" from the Humber water-shed was determined to be approximately as follows, per square mile :

For dry year 1874..........................504,000 Imperial gallons.
For dry years 1887, 1888, 1889..............540,000 " "
For average for future......................650,000 " "

The proposed reservoir would, therefore, be of sufficient size to conserve about one half of the mean annual flow of the river if lowered thirty feet, 43 per cent if lowered twenty feet, and 32 per cent. if lowered ten feet.

Assuming that the reservoir can be lowered twenty feet, 140 to 120 during the season, the daily draft possible would be one-half the mean daily flow of the river during the three consecutive dry years, 1887, 1888, 1889. With additional reservoirs of a combined capacity equal to this reservoir, the total flow of the river for those years would be utilized. Those auxiliary reservoirs could of course, be entirely emptied.

The Theoretical horse-power produced by 90,990,000 Imperial gallons of water falling 130 feet is 2,489, or about 2,000 horse-power available for power purposes.

Table D.

Power available with average head of 130 feet, first during three extreme dry years; second during average years:

Horse Power Required.	Three Dry Years.		Average Years.		
	Reservoir No. 1 Only.	Double This Storage.	Reservoir No. 1 Only.	Double This Storage.	Complete Storage Capacity.
Constant....	2,000 H.P...	4,000 H.P..	Same as before in summer months.		5,500 H.P..
12hrs. per day	4,000 " ..	8,000 " ..			11,000 " ..
10 "	4,800 " ..	9,600 " ..			13,200 " ..
8 "	6,000 " ..	12,000 " ..			16,500 " ..

The last column gives the total horse-power that can be obtained at or near Baby's Point from the River Humber with storage capacity sufficient to maintain the mean daily flow, the fall available being taken as 130 feet.

At the lower ends of each of the other storage reservoirs power would be available, but the amount can only be calculated after these reservoirs have been located and designed.

WILLIS CHIPMAN, C.E.

Toronto, 14th October, 1895.

Huron and Ontario Ship Canal Company.

Engineer's Office,
Toronto, Nov. 22nd 1865.

To F. C. Capreol, Esq., President and Managing Director, Huron and Ontario Ship Canal Company, Toronto.

Sir:—The boring in the "ridges" on the line of the deep cut having been completed, I have the honor to state the results for the information of the Directors and others who have taken an active interest in the progress of their great public work. Borings were made at the following points in the Township of King:

No. 1.	Lot 4	in the	7th	Concession,	40	feet in depth.
" 2.	" 9	"	7th	"	122	" "
" 3.	" 16	"	8th	"	102	" "
" 4.	" 22	"	8th	"	120	" "
" 5.	" 29	"	8th	"	40	" "

Also, between Lots 5 and 6 in the 7th Con., 60 feet in depth.

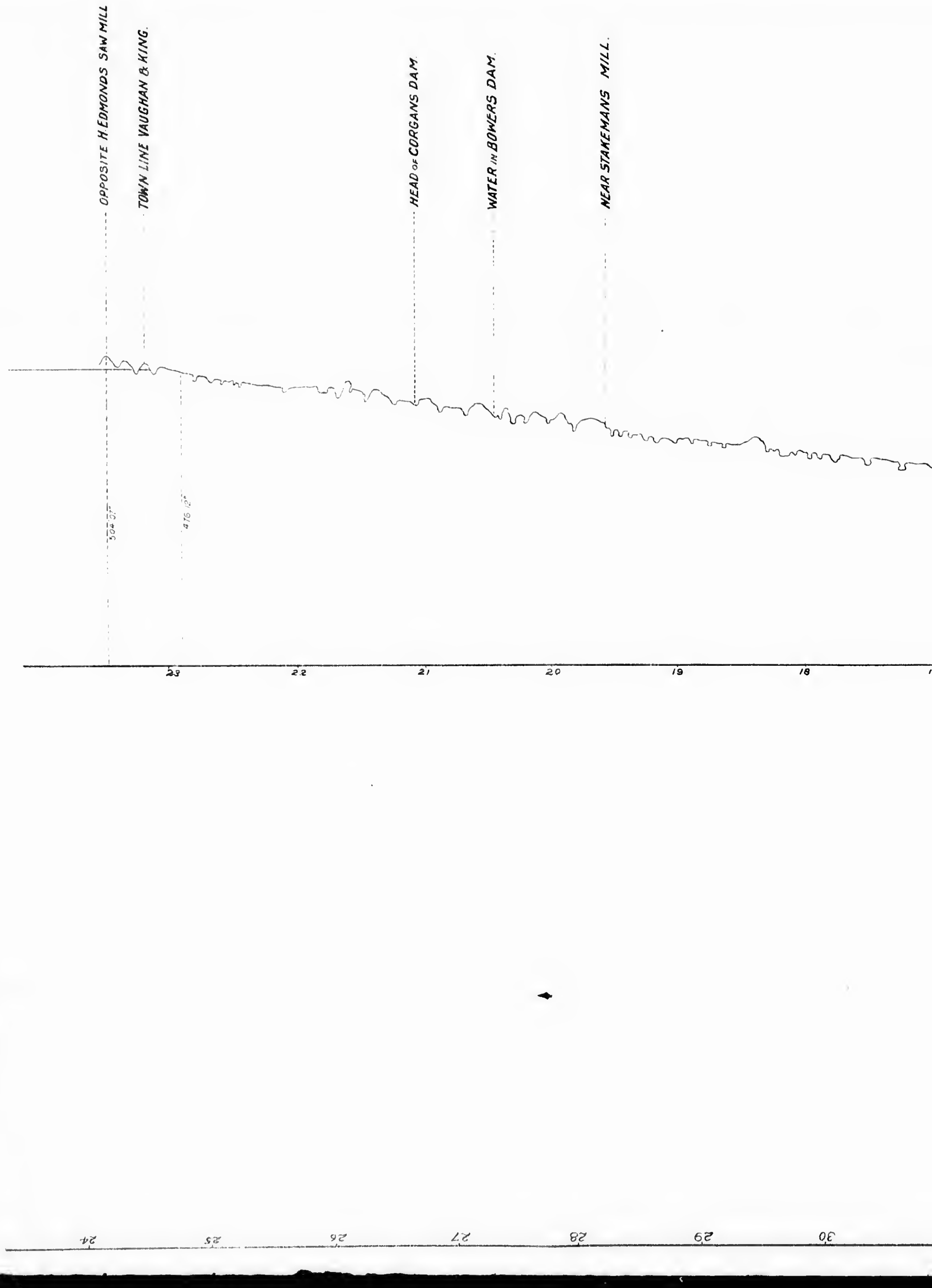
In every instance, except No. 3, the borings were made to the bottom of the proposed canal. No. 3 was not bored to the bottom, the indications being the same as in the borings on either side. I herewith forward a section of the deep cut, showing the position of the above borings, with the particulars of the strata passed through at each side. The borings were made with a hollow augur, two inches in diameter, and about four feet long, the augur being forced down and filled, was taken up and cleared out, the result being noted at the time. In this manner the material bored through was accurately ascertained. The material comprising the various strata may generally be described as: surface soil, two feet in depth, next, blue clay, mixed with sand beds and gravel, twelve inches in depth, 16 feet from the surface; next, clay and fine gravel with boulders, gray plastic, and indurated clays at the lower portion of the borings. This corresponds with Sir Charles Lyell's opinion and description of the "drift" in North America which was quoted in my report on the canal in 1858; the particulars of which can be consulted in the Manual of Geology, page 135, and which concluded as follows; "The order of superposition will be, first and uppermost, sand, loam, and gravel, occasionally fosiliferous; secondly, an unstratified and unfosiliferous mass, for the most part of much older date than the preceding, with angular erratics or with boulders interspersed; and thirdly, beneath the whole, a surface of polished and furrowed rock." In no instance was there any indication of rock, so that the whole of the deep cut will be through strata as above described, and which from its toughness, can be excavated with slopes one to one, instead of one and a half to one, thereby effecting a considerable saving 'n the cost. The best example of the material to be excavated, and which will be familiar to many of the Directors, is that of the blue clay which forms the bank in front of the City, and from which the western portion of the Esplanade was filled some years ago. From the information now before me, my former opinion as to the practicability of this deep cutting has been fully cofirmed and strengthened, and ought to be convincing to any unprejudiced mind, and I have no hesitation in repeating that the whole question is one of expense, which the enormous and rapidly increasing trade of the west would not only justify but urgently demands.

I have the honor to remain

Your obedient servant,

KIVAS TULLY,

Chief Engineer.



OPPOSITE H EDMONDS SAW MILL
TOWN LINE VAUGHAN & KING.
HEAD OF CORGANS DAM.
WATER IN BOWERS DAM.
NEAR STAKEMANS MILL.
504.07
476.12
23
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21
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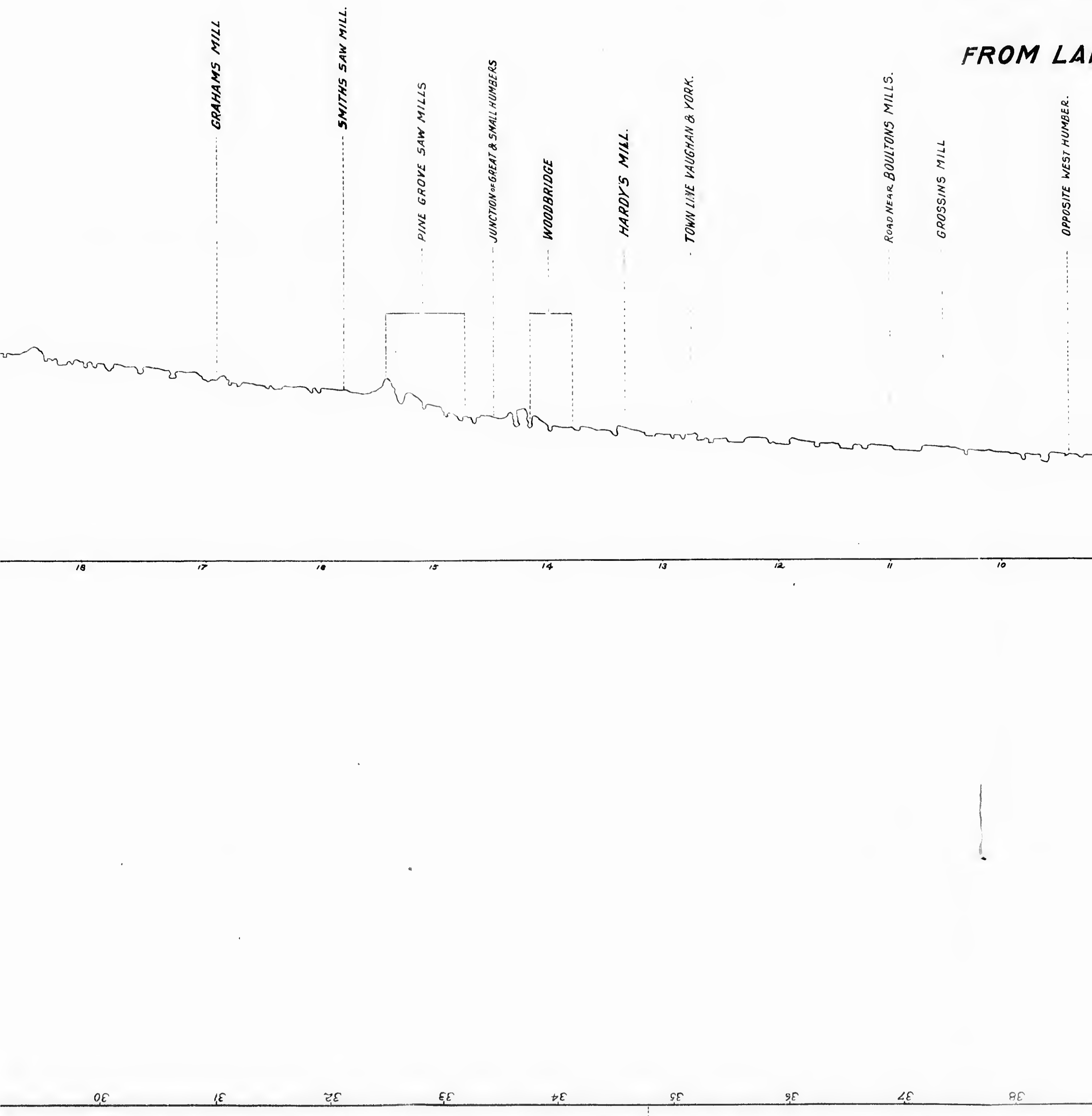
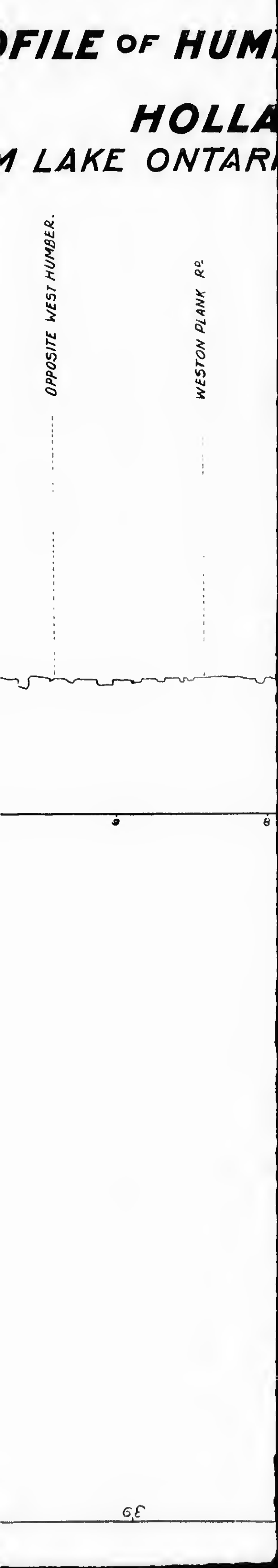
PROFIL

FROM LA



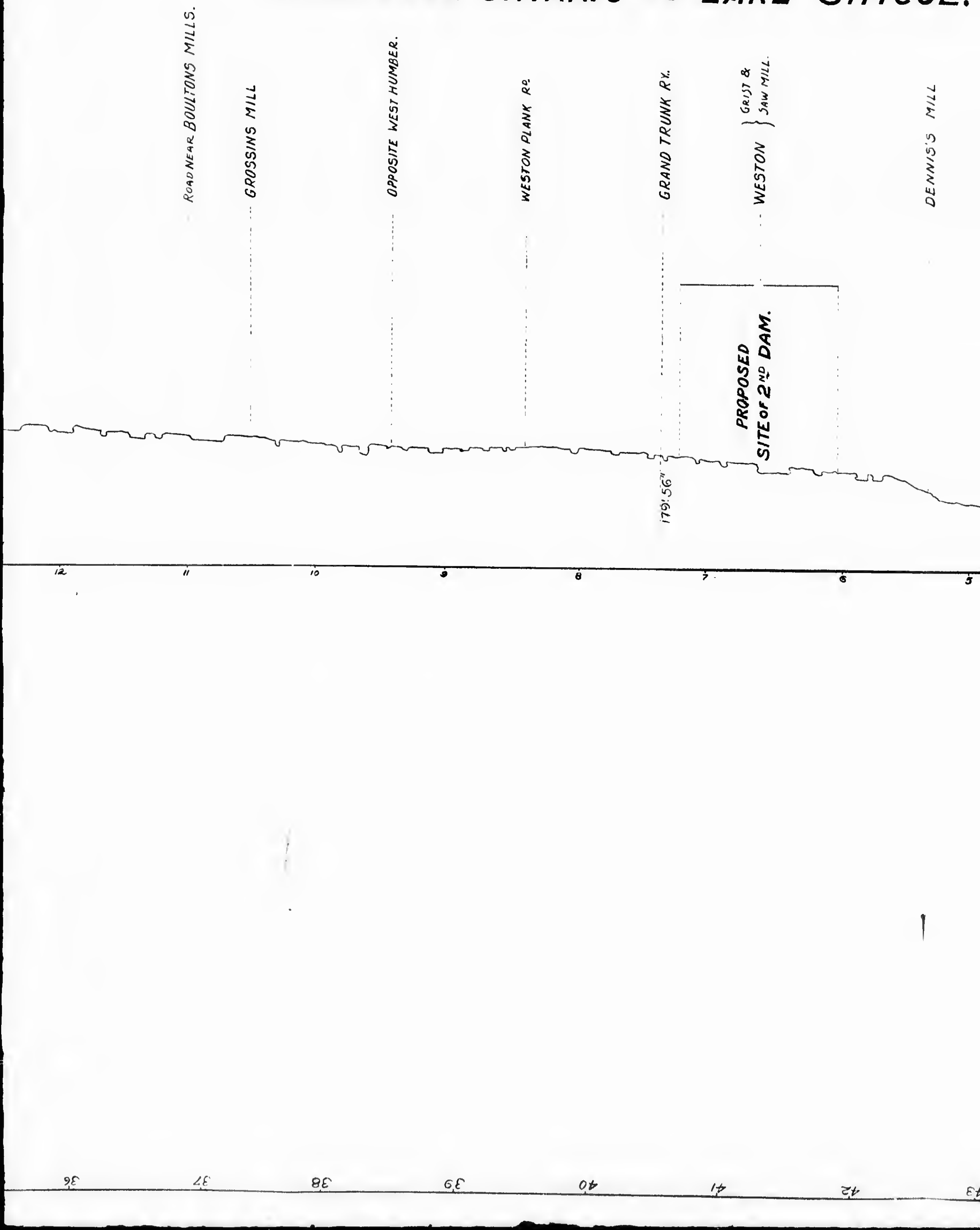


PROFILE OF HUMBER RIVER VALLEY

AND

HOLLAND RIVER,

FROM LAKE ONTARIO TO LAKE SIMCOE.

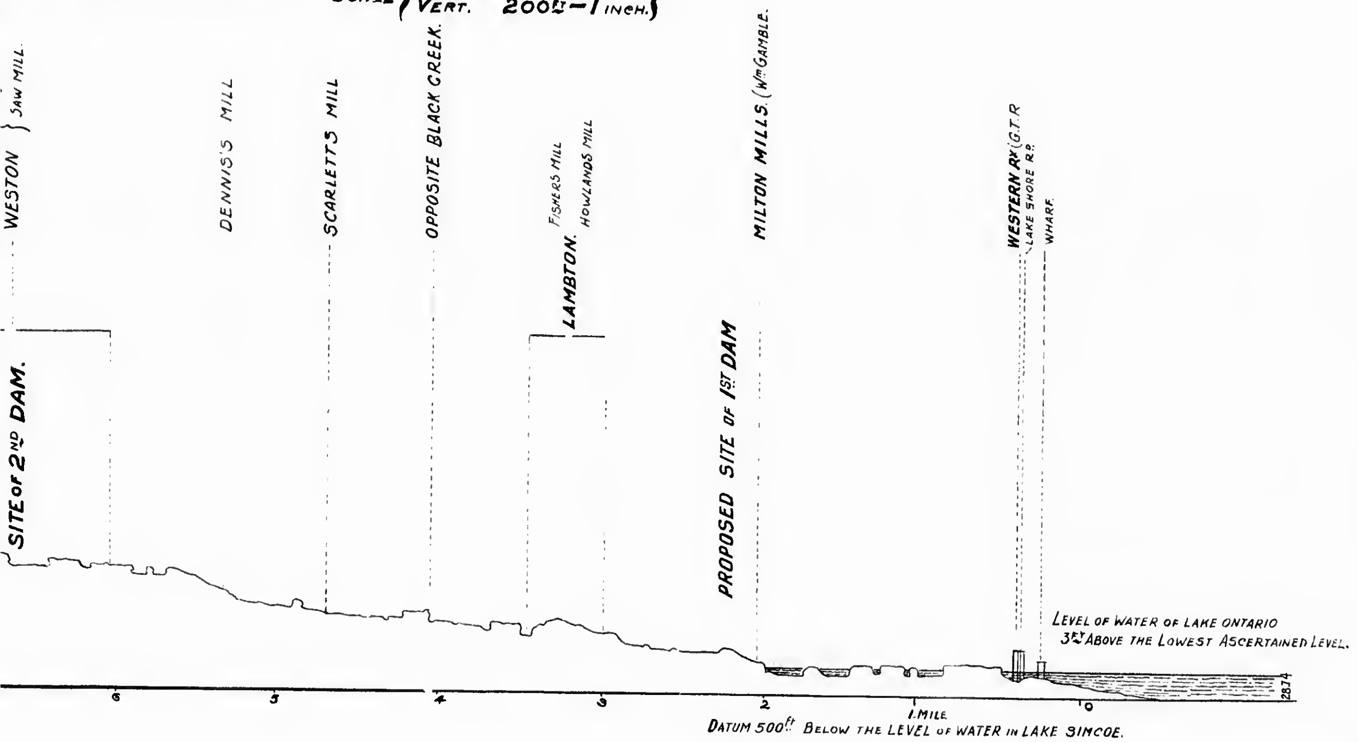


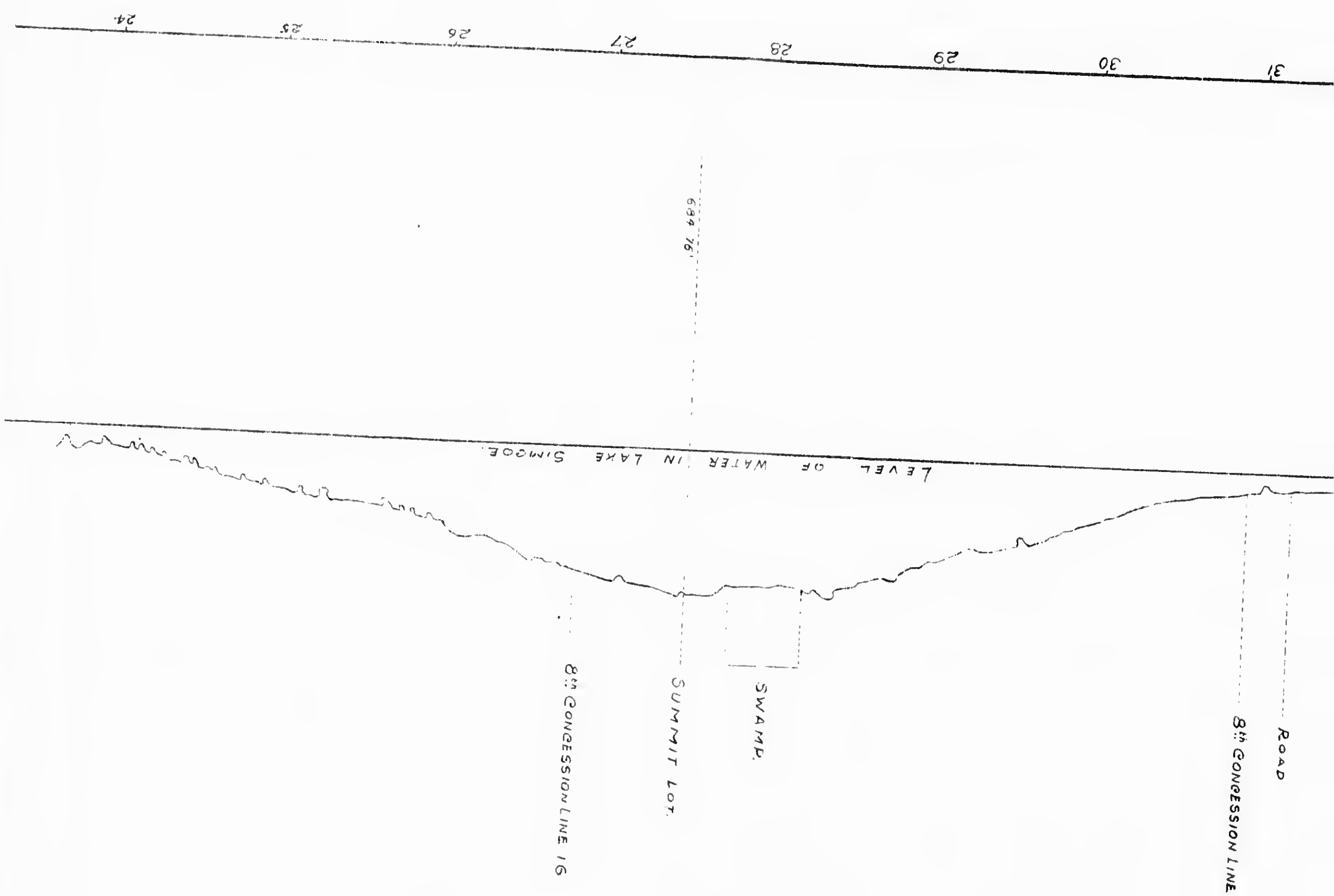
...VER VALLEY

...VER,

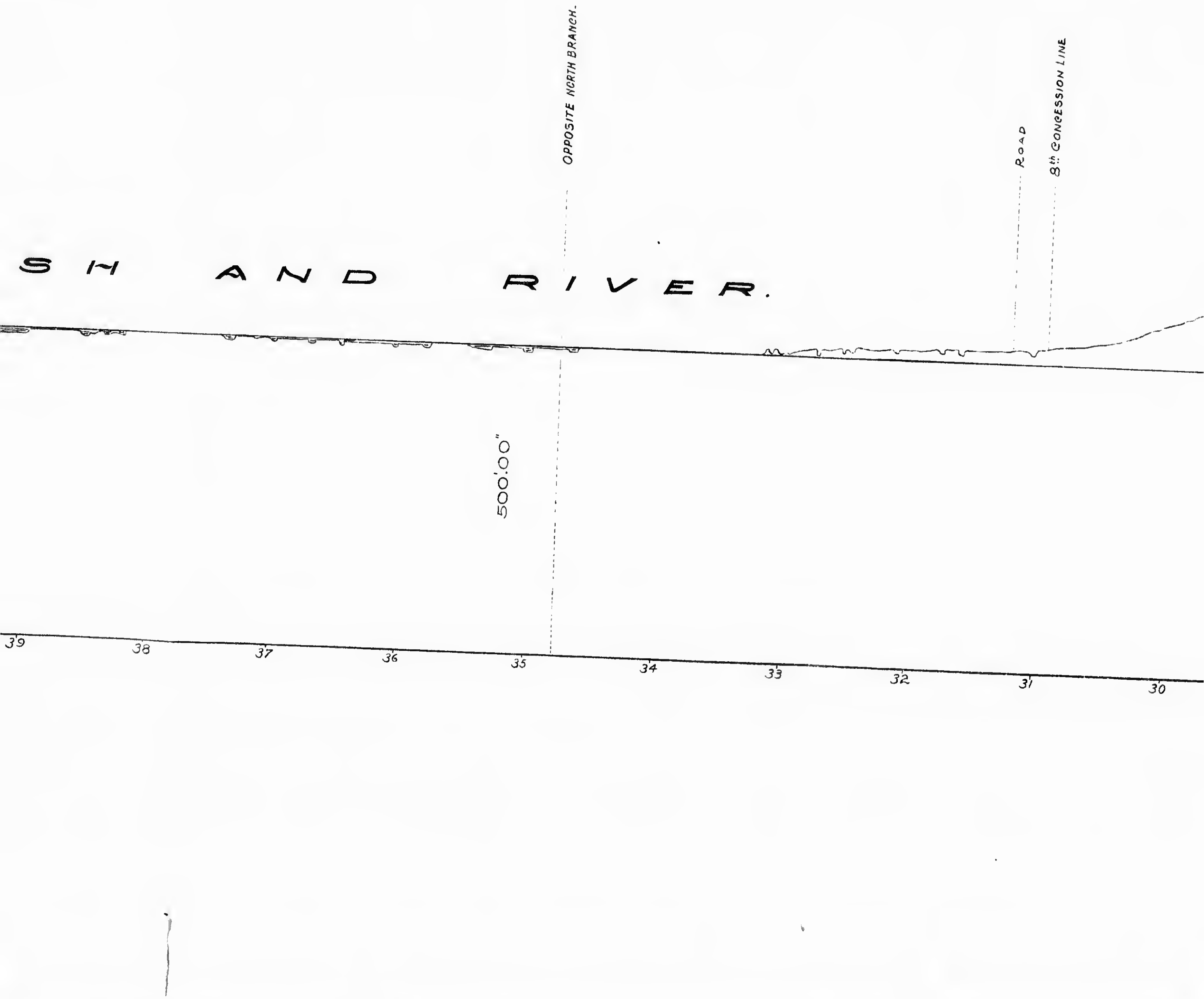
...KE SIMCOE.

SCALE { HOR. 5000 FT — 1 INCH. VERT. 200 FT — 1 INCH. }





24
25
26
27
28
29
30
31
684.76'
LEVEL OF WATER IN LAKE SIMCOE.
8th CONCESSION LINE 16
SUMMIT LOT.
SWAMP.
8th CONCESSION LINE
ROAD



OPPOSITE NORTH BRANCH.
ROAD
8th CONCESSION LINE
SH AND RIVER.
500.00"
39
38
37
36
35
34
33
32
31
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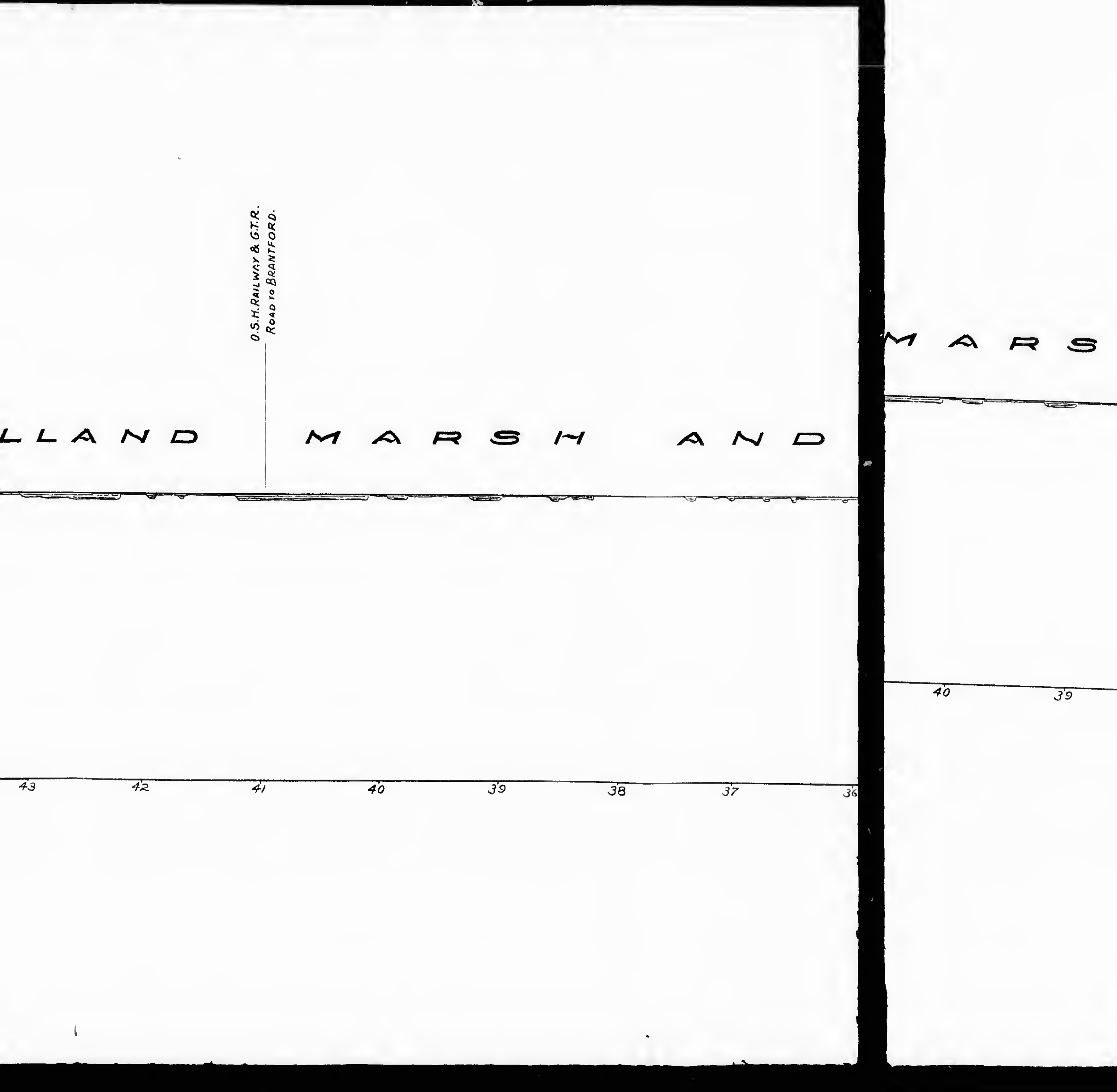

O.S.H.RAILWAY & G.T.R.
ROAD TO BRANTFORD.
LLAND
MARSH AND
MARS
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42
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36
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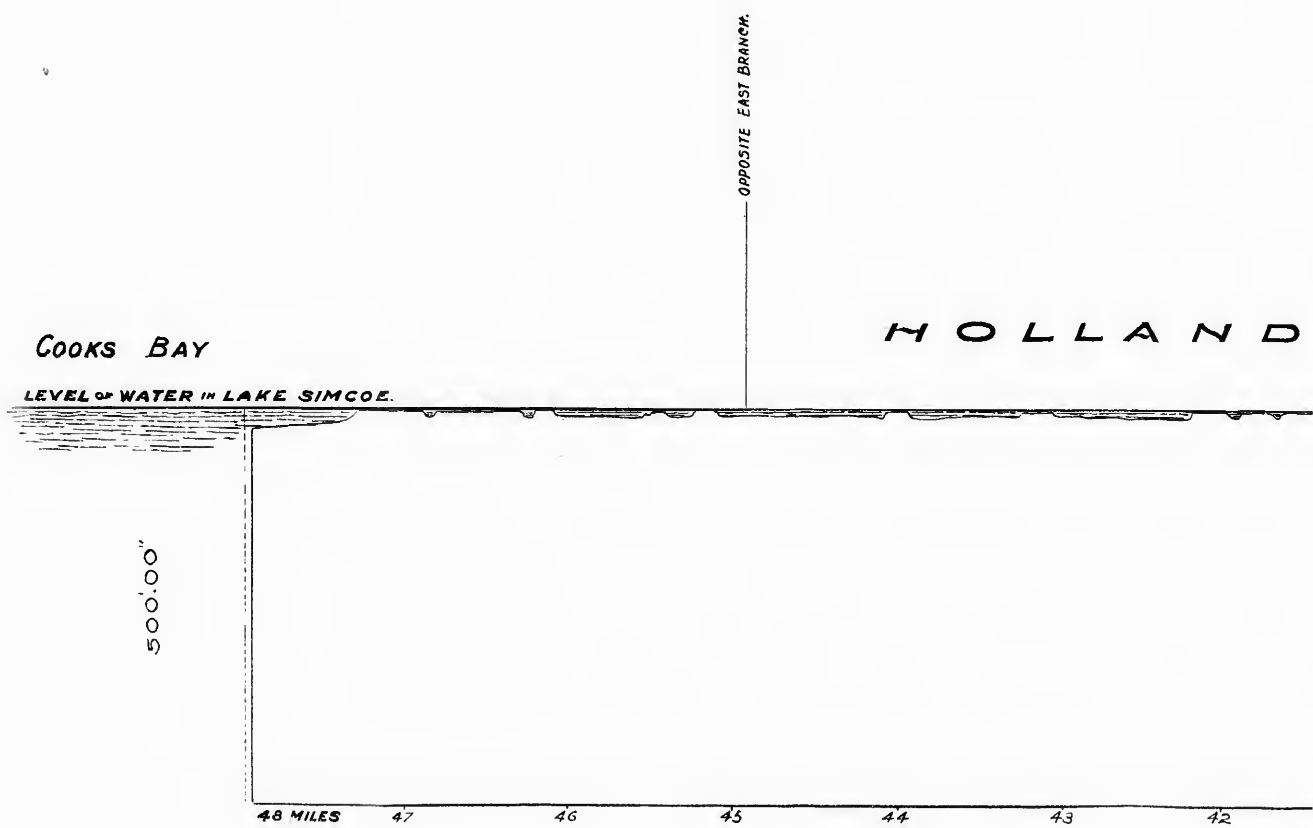
39



COOKS BAY
LEVEL OF WATER IN LAKE SIMCOE.
OPPOSITE EAST BRANCH.
HOLLAND
500.00'
48 MILES
47
46
45
44
43
42

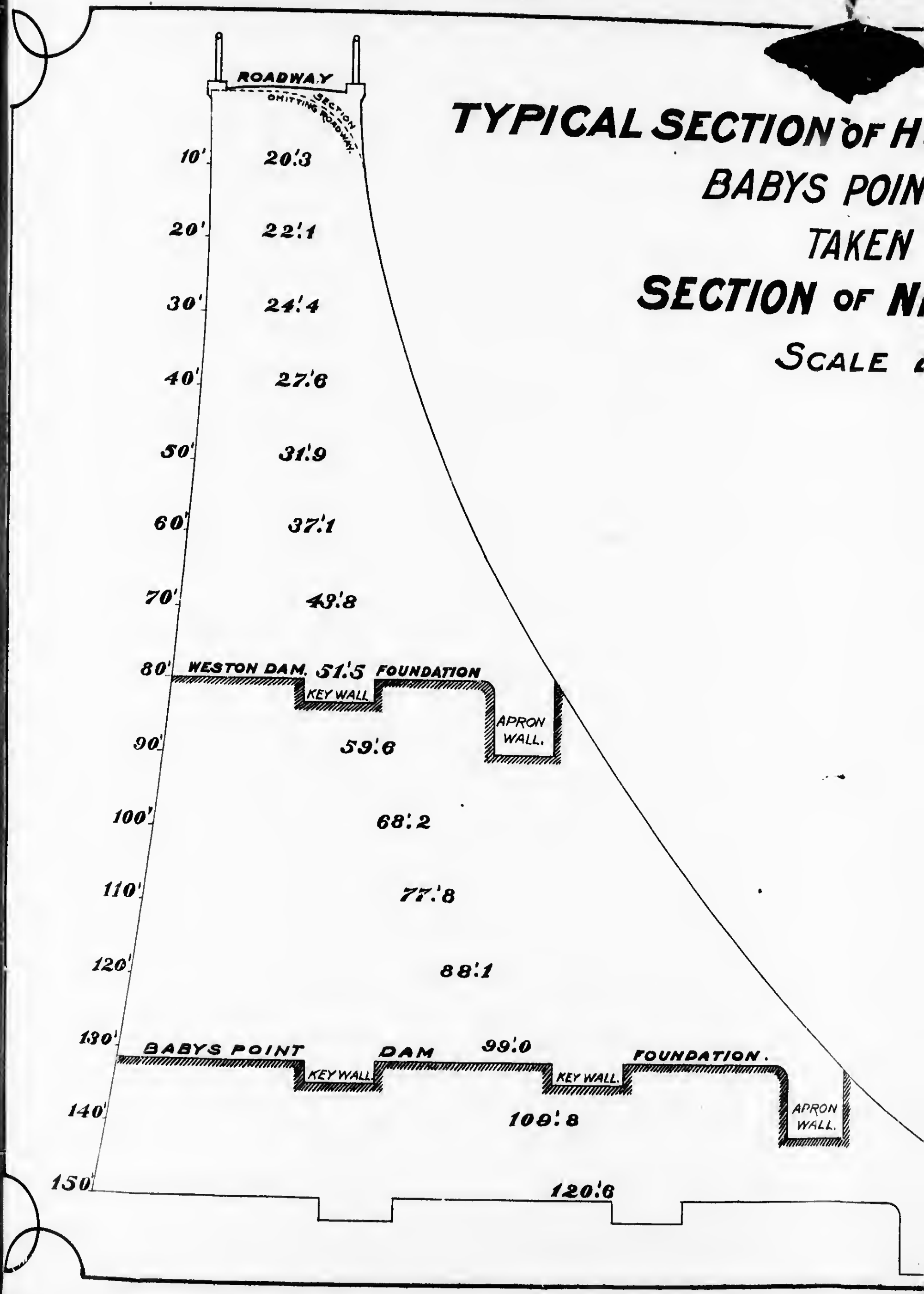
TYPICAL SECTION OF H

BABYS POIN

TAKEN

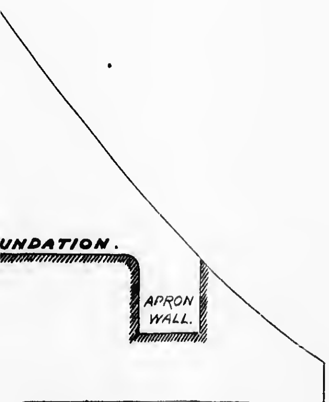
SECTION OF N

SCALE



SECTION OF HUMBER WATER POWER DAMS
BABYS POINT AND WESTON.
TAKEN FROM~
SECTION OF NEW CROTON DAM.

SCALE 20 FT. — 1 INCH.



C. H. Rust
City Engineer
Nov 2, 1900