—OF THE—

Assiniboine River,

MANITOBA.

REPORTS

—OF—

J. T. FANNING, C. E.,

CHIEF ENGINEER OF THE ST. ANTHONY FALLS WATER POWER CO. MINNEAPOLIS,

CONSULTING ENGINEER.

—AND—

H. N. RUTTAN, C. E.,

CITY ENGINEER OF THE CITY OF WINNIPEG

WINNIPEG:
THE STOVEL COMPANY, PRINTERS.
1893.

WATER POWER AND NAVIGATION

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NOTE.—The date of this report is prior to the extreme low water of 1889-90. The computations for power are based upon the information then available. H. N. RUTTAN.

REPORT

OF THE

Assiniboine River Water Power

IN

WINNIPEG, MANITOBA.

To the Special Committee of Aldermen of the Council of the City of Winnipeg, on the Assiniboine Water Power.

GENTLEMEN.—In response to your request, I have made an examination of that part of the Assiniboine River within and near the City of Winnipeg, and also of portions of its more remote watershed toward its head-waters, and have the honor to report herein on the feasibility of creating a large water power on this stream, within the City of Winnipeg.

I have the thorough surveys and maps of the river, covering the area between Headingly and the junction of the Assiniboine River with the Red River of the North, made under the direction of Mr. H. N. Ruttan, City Engineer, together with the varied information received in consultation with your Committee and with the citizens of Winnipeg, to aid me in the study of the project.

LOW WATER FLOW.

The uncertain factor to be carefully considered in estimating the capacity of a water power on a stream not already used for power, is the volume of the ORDINARY LOW WATER flow of the stream. By the term 'ordinary low water,' we refer to the quantity of water per second that the users of the power can depend upon at least nine months, and approximately eleven months in each year of average condition of flow of the stream, for use on such fall as is available.

MINIMUM FLOW.

The MINIMUM flow must be considered with equal care, as its rate determines the minimum power of the stream. The minimum rate, for power purposes as herein considered, though not the abolute minimum, may be defined as the mean rate of flow of the month of lowest flow during a severe drought. This minimum is on some streams a rate lower than the absolute minimum in the year when the flow is equal to the average flow.

FLOOD FLOW.

The maximum rate of flow during the time of greatest flood must be learned with all possible accuracy. It is for this absolute rate that the dam is to be proportioned in weight, height, length and profile, that it may be enabled to withstand and control the force of the greatest flood, and to pass that flood without undue injury to lands bordering on the permanent flowage, and without injury to its own foundations by undercutting eddies induced by the energy of the swift falling flood flowing from the crest.

WATER-SHEDS.

From the area of the water-shed and the rates of rainfall upon this area, we have to estimate the three above named important factors of flow unless we have actual measurements of the rate of the stream, continued through a long series of years and covering the extremes of minimum and maximum flow.

Measurement for a short time, such as Major Ruttan has made on the Assiniboine River, are of exceeding value, but may not have reached the extremes.

The relatively low volumes of flow of the Assiniboine River, both in flood and drought, would surprise a manufacturer from any of the principal American water-powers, if he were unfamiliar with the meteorological conditions of the prairie stream.

For instance, I may mention the Merrimac River, in New Hampshire, the most conspicuous power stream of America, as an example of a hill country stream, reduced in a flood, and augmented in drought by aid of a large lake storage. The maximum flood flow of the Merrimac at its largest powers, is about 21 cubic feet per second for each square mile of its drainage area, or water-shed, and its minimum flow is about .3 cubic ft. per square mile.

Many smaller Atlantic slope streams that are used for power have an extreme flood flow exceeding 50 cubic feet per second per square mile of drainage area.

The upper Mississippi River, above St. Anthony Falls, may be cited as a conbined prairie and hill stream. Its maximum flood flow is about 3 cubic feet per second per square mile of drain area, and I have, near the close of a severe cold winter, measured its maximum flow as low as .1 cubic foot per second per square mile. This minimum is, however, the lowest record of which I have knowledge. The Assiniboine may be classed as a true prairie stream, located in a region of light rainfall, of great evaporation all the year, and its tributaries and headwateas are subject to such thickness of ice covering in the winter as materially affects their flow. Its water-shed is, however, large and its minimum flow is equal to the volume that reaches most of those waterpowers that are already noted for their magnitude.

RAINFALL.

I estimate the annual rainfall of the lower section of the water-shed at twenty inches, including snow measured as equivilent rainfall, and the annual rainfall of large portions of the upper water-shed as fifteen inches, and the mean annual rainfall of the entire water-shed as eighteen inches.

I judge that the distribution of the precipitations through the months of the year may be similar to that shown in the following tables of rainfall at Breckenridge and Moorhead in the State of Minnesota.

MONTHLY PRECIPITATIONS AT BRECKENRIDGE AND MOORHEAD.

	Breckenridge.		Moorhead.					
	1879	1880	1881	1882	1883	1884	1885	1886
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
Jan. . .	.05	.01	.60	1.34	1.19	.55	.02	.94
Feb . .	.40	.00	2.13	.80	.74	1.32	.08	.78
March.	.25	1.49	.62	2.83	.38	1.03	.31	.14
April .	1.04	2.23	.77	1.69	1.65	1.23	3.43	5.49
May . .	5.42	5.84	2.80	5.32	3.59	1.75	2.27	2.51
June .	2.86	7.90	5.59	5.43	2.32	1.84	7.92	3.71
July . .	3.78	2.52	1.97	4.92	4.57	7.32	3.34	5.40
Aug . .	2.04	3 67	5.89	2.50	3.16	6.17	1.47	1.32
Sept . .	2.36	.68	4.75	1.23	2.51	2.49	2.20	1.31
Oct. . .	.79	1.78	2.75	4.04	3.22	3.70	.68	. . . . .
Nov . .	.29	.73	1.41	2.54	.16	.34	.64	. . . . .
Dec . .	.66	. . . . .	.20	1.37	1.47	.76	.32	. . . . .
Ann'l	19.94	26.85	29.48	34.01	24.96	28.50	22.68	. . . . .

ANNUAL RAINFALLS.

	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	AVERAGE ANNUAL RAINFALL.
	In	In	In	In	In	In	In	In	In	In	In	In	
St. Paul, Minn.	36	31	24	29	23	32	30	39	23	27	. .	. .	29.76
Duluth, "	36	27	32	34	28	45	38	38	38	23	35	20	34.01
Moorhead, "	28	20	18	29	36	20	. .	29	34	25	28	23	26.36
St.Vincent, "	13	. .	26	22	34	19	. .	16	22	18	22	16	20.90
Bismark, N. D.	. .	27	31	18	20	23	20	16	21	16	23	. .	21.50
Buford, "	. .	. .	. .	. .	. .	20	23	14	13	11	7	. .	14.67

A careful measurement of the water-shed of the Assiniboine River on a good map of the central Provinces of Canada,gives the total area as 58352 square miles.

CHARACTERISTICS OF WATER-SHEDS.

Comparing the meteorological characteristics of this great water-shed with those of the water-shed of the Red River of the North, south of the National boundary and with those of other prairie streams whose data are at hand, I estimate the extreme flood flow of the Assiniboine as a little in excess of 1 . cubic foot per second per square mile, or a total volume of about 60,000 cubic feet per second, and the ordinary low water flow as about . 044 cubic feet per second per square mile, or 2568 . cubic feet per second, and the extreme minimum flow as about one-half this last named volume.

In the following table appears some statistics of well-known streams that will illustrate the relative characteristics and power capacities of hill and prairie streams, and appended thereto the estimated data for the Assiniboine River.

DATA OF FLOW OF STREAMS.

In cubic feet per second, per square mile of drainage area.

STREAM.	LOCALITY.	Drainage Area.	Annual Rainfall.	Maximum flow in cubic ft. per sec.	Minimum flow in cubic ft. per sec.	Ordinary flow in cubic feet per second.
		Sq. Mls.	Ins.			
Sudbury....	Framingham, Mass...	78	44	41.385	.036	.353
Croton	Croton Dam, N.Y....	339	48	74.867	.178	1.109
Merrimack .	Lawrence, Mass......	4,599	43	20.874	.300	.600
Connecticut.	Hartford, Conn......	10,154	44	20.235	.513	......
Deleware ..	Lambertville, N.J....	6,820	44	51.320	.290	......
Potomac....	Great Falls, Md......	11,476	42	15.249	.093	......
Kanawha ..	Charleston, Va., Pool.	8,900	44	13.291	.123	......
Missouri....	St. Charles, Mo......	527,000	19	0.816	.028	......
Minnesota .	Ft. Snelling, Minn...	16,027	28	3.7436	.050	.156
Mississippi .	Minneapolis, Minn...	19,585	27	3.0636	.100	.250
Red River..	National Boundary...	39,577	21	....	.030	.074
Assiniboine .	Winnipeg, Manitoba..	58,352	18	1.0283	.022	.044

CROSS-SECTION MEASURES.

A check upon the flood estimate given above for the Assiniboine is found in an estimate of the flow though the cross-section, No. xlv., near Headingly, of Major Ruttan's survey.

The extreme flood heights pointed out by residents of the vicinity, and observed during the flood of 1882 by Major Ruttan, gave a cross-section of flood stream equal to 7180 square feet. The fall along the surface of the stream near section xlv, was at the rate of one and one-half feet per mile.

To compute the velocity of flow we have:—

The ratio of inclination, $\underline{i}$; of surface of stream, .0002841.

The cross-section, S; of stream 7180 sq. ft.

The contour C; of stream, 450 lin. ft.

The hydraulic mean depth, $\underline{r} = \frac{S}{C}$; 15.9555.

The coefficient of flow, m; .004.

From which we deduce:—

$v = \sqrt{\frac{2g}{m}} \times \sqrt{ri} = 8.082$ ft. per second, and 7180 sq. ft. section x 8.082 ft. vel. = 58029. cu. ft. per sec.

Applying the formula $v = c\sqrt{ri}$, we find that with an assigned value of $c = 120$, we arrive at almost precisely the same velocity, and this is equivalent to a flood flow of 1.0056 cubic ft. per second per sq. mile.

The rates of ordinay low water flow and the minimum flow are now well established by the measurements of Major Ruttan in the cross-sections of the Assiniboine River within the city limits.

We will assume in our computations:—Flood flow of the Assiniboine River, 60,000 cu. ft per sec.; ordinary low water flow, 2568. cu. ft. per sec.; minimum flow 1284 cu. ft. per sec.

These volumes of maximum and minimum flow are extremes and will be rare,but must be anticipated in the construction of dams, and it is never safe to predict that the next coming season will not be that rare one that presents all the conditions that lead to one or other of the extremes.

SITE OF THE DAM.

A site which is favorable for the construction of the dam and head gates is found near and above the bridge of the Canadian Pacific Railway adjacent to the St. James station, and near the cross-section line XXI, indicated on the map. If the railway bridge was not already in position a site below the bridge would be preferred, and after conference with the railway authorities and agreements as to flowage, may still be preferred. In either case the canal and mill sites will extend along the river below the railway.

LOCKS.

Locks for navigation purposes may be located at the southerly end of the main dam or at the foot of the power canal.

THE FLOW LINE.

I am of the opinion that the line of permanent flowage at ordinary low water should be established at the altitude + 90. shown by the contour line marked 90. on Major Ruttan's map of the power site.

FALL.

The level of water in the power canal or head race may be assumed at the same level, + 90., as suggested above for flowage and the summer level of water in the respective tail races assumed at altitude + 66.

The available fall, at times of low water, will be approximately (99 – 66 =) 24 feet.

There is but slight fall in the river at low water within one mile below a point fifteen hundred feet below the railroad bridge, but the lands on both sides of the river, and especially on the north bank, are favorable for the extension of the canal and mill sites to a distance two or three thousand feet below the railway bridge if the uses of the power shall make such an extension desirable.

MILL SITES.

Both banks of the river below the bridge are admirably adapted in topography and material for the construction of the canal and tail races and for the location of numerous mills and store-houses and for residences of superintendents and employees.

TRANSPORTATION.

Excellent railway facilities are already at hand for this site and excellent water transportation is possible from the agricultural and timber regions up the river and bordering the great lakes and streams to the north-west of Winnipeg and for transportation of manufactured products down the stream toward near and distant markets.

POWER.

The estimate above given of 2568 cubic feet of water per second as the ordinary summer flow of the Assiniboine River and the available low water fall, 24 feet, give factors for computing the gross power as follows :

$$\frac{2568 \text{ cu. ft.} \times 62\tfrac{1}{3} \text{ lbs.} \times 24 \text{ ft. fall}}{550 \text{ foot lbs.}} = 6986. \text{ Horse Pow's.}$$

The estimated minimum flow, anticipated at rare intervals, late in winter, gives by similar computation 3492 H. P.

The minimum flow at times of low water in years of average flow may be estimated at 5,000 horse power, gross, or 4,000 horse power, net, as reduced to the standard of indicated power of steam engines, and available for 24 hours use each day.

Adjoining the water-shed of the Assiniboine River, on the north are the water-sheds of Lakes Manitoba and Winnipegosis. Major Ruttan's surveys show that Lake Manitoba lies fourteen feet higher than low water in the Assiniboine River near Baie St. Paul and that the waters of these two lakes can readily be canalled into the Assiniboine. Manitoba Lake lies but seventeen miles from the river, and Long Lake, which intervenes, would form a portion of the conducting canal. Lakes Manitoba and Winnipegosis have a combined water-shed of 31900 square miles. These lakes have a combined water area of 4500. square miles, equal to more than six-tenths of the area of Lake Ontario, and offer most favorable conditions of storage of water. The Assiniboine flow might readily be re-enforced therefrom so as to increase its ordinary flow and theoretical power from 6985 h. p. as above estimated to 10,000 h. p. gross or 8000 net h. p.

Adjoining the water-sheds of these two lakes, on the north is the water-shed of the Saskatchewan River. I am informed that the flow of this river can be diverted into Lake Winnipegosis and thence by Lake Manitoba to the Assiniboine River. Above this point of possible diversion, the Saskatchewan River has a water-shed of 152,250 square miles.

These combined sources of water supply with combined water-sheds of 242,592 square miles, give ready facility for increasing the proposed Winnipeg water power to an amount exceeding the great powers of Manchester, Lowell or Lawrence, on the Merrimac River in New England.

FLOWAGE.

We have assumed the level of permanent flowage at low water to be at altitude + 90., shown by a contour line on the map. This is very near the level of the top of the present river banks in the vicinity of the site chosen for the dam, and as the average slope of the river and prairie is about two feet to the mile, altitude 90. cuts lower and lower on the banks as it is traced up the stream. Adjacent to the tops of the present banks are low terraces at altitudes averaging about + 95. In the vicinity of the site of the dam, and from the top of the terrace the prairie gradually rises on each side of the river. As the dam is to be constructed, primarily for a water power, and it is proposed that navigation will be subserved by locks at one end of the dam, it is important that the permanent construction shall be built up as near to the level + 90., of permanent flowage as the proper passage of the flood waters will permit.

It is reported that heretofore the highest flood levels on the Assiniboine River, from the fork with the Red River up to the proposed site of the dam, have been due to the backing up of the Red River flood. The flood level at section 22, near the site of the dam, was during the flood of 1882 at + 90.05 and during the great flood of 1850, + 98.55. This flood of 1850 in the Red River submerged a portion of the city, and now suggests that the first floors of our mills should not be below altitude +100.

The average flood flow is estimated as not exceeding 30,000 cubic feet per second, with occasional floods of 50,000 cubic feet per second and very rare extreme floods of 60,000 cubic feet per second.

Assuming that a flood of 40,000 cubic feet per second ought not to rise above the level of contour +95. and that a depth of 7.5 feet of water on the overfall or "roll-way" of the dam will pass 66⅔ cubic feet of water per second for each foot of length, then we compute a length of overfall as $\frac{40,000.}{66.667}$ cu. ft. = 600 ft. This gives (+ 95 – 7.5 =) + 87.5 as the permissable altitude of the permanent portion of the dam. With the same length of overfall, 50,000 cubic feet of water flowing per second would give a depth of water on the overfall of about 8.75 feet and the flood level +96.25, and 60,000 cubic feet per second flowing would give a depth of about 10. feet on the crest, and flood level +97.5.

The altitude + 87.5 for the permanent crest of the dam appears advisable for attaining the maximum effect of the low flow of the river, and apparently will not lead to the submergence of a large area of land outside of the river bank, even at the time of extreme flood.

FLUSH BOARDS.

As the proposed level of the permanent crest (+ 87.5) is about 2.5 feet below the proposed level of permanent flowage (+ 90.) the two and one-half feet can readily be controlled by removable flush boards placed to maintain the full flowage in droughts, and removed to permit the passage of the floods. On the hill streams of the Atlantic coast, subject to sudden floods, such flush boards are usually of cheap character, and so arranged that if not removed before the arrival of the high water they are carried away by the force of the current, being in this respect automatic in action, and cheaply replaced when again needed. In some cases the flushing portion of the dam is made of a series of gates or wickets, to be operated by machinery, but this system finds most frequent application where the primary use of the dam is to form slack pools for navigation purposes. Also the flushing portion of the dam is sometimes composed of scantling "needles," adjusted by hand or machinery. This last system finds most frequent application on power dams in streams whose flow is well regulated by relatively large lake storage. Mechanically operated flush apparatus requires either a temporary or permanent bridge or trestle along the crest of the dam.

FOUNDATIONS OF THE DAM.

Borings have been made in the bed of the river at several of the surveyed cross-sections, but the sub strata have been most fully studied at cross-section XXII, which is about twelve hundred feet above the railroad bridge. Here the bed of the river averages (+87.5—19=68.5) 19 feet below the proposed crest line of permanent dam. The bed of the river is a stratum of coarse gravel and small boulders about four and one-half feet thick, and this rests upon a layer of hard-pan about eight feet thick, and the hard-pan rests upon limestone rock.

This bed rock apparently underlies all the river in the vicinity, and will make a good foundation, capable of carrying the weight of the dam, and can be made tight where the dam rests, so that there will be no danger of percolation of water underneath the dam.

PROFILE OF THE DAM.

The crest of the dam, with flash-boards off, will be thirty-two and one-half feet above the bed rock, and about twenty feet above the low water level of the water immediately below the dam.

When the flood is pouring over the crest its waters will act with great force in front of the down stream toe of the dam. The gravel and hard-pan will soon be removed, and the profile of the dam and its method of construction must be such as to pass the water down to the pool below the dam with the least eroding force, or a deep pool will in time be cut in the limestone along the line where the shock is most severe.

The erosion will be lessened by forming the lower face of the dam into a series of steps, or making it a long incline, as illustrated in the accompanying outline sketch. The sketch suggests a structure of timber crib work filled with stones and puddled solid full in the interstices between the stones with fine gravel and sand, so as to maintain the timbers within the dam always in a state of saturation with water and protected from the air.

CANAL..

Assuming that the power may in time be developed to the extent of ten thousand horse powers, then with a fall of 24 feet there will be required at least 3676. 5 cubic feet of water per second flowing in the canal. If it has a mean rate of flow of five feet per second, then the slope of water surface in the canal will still be less than the slope of the river opposite the canal. The canal should have at least ten feet depth below the under side of the thickest ice. We have then $\frac{3676.5}{5 \times 10}=73.55$ feet as the least mean width of the canal above the mill site nearest the dam and head gates. It is probable that a canal with sides sloping up to within three feet of the standard level of the water surface and then finished with revetment walls to the tops of the banks will be advisable.

ICE.

The users of mill powers on the hill streams in high latitudes have sometimes to contend with anchor ice or "frazil" at intervals durimg the winter. Anchor ice is formed in water when its temperature is rapidly falling and has reached the point of crystalization. In this condition a slight agitation converts it into needles of ice of nearly the same specific gravity as water. The needles are tossed about in the currents and stick to rocks or other projections in the stream and stick together in spongy masses and gather on the racks and gate-jambs of water-power appendages. The condition that produces another ice may occur late in Autumn, when a sudden fall of temperature of the air chills the water, but the effect is counteracted on smooth streams as soon as a sheet of ice covers the water and protects it from the sudden chill. On rapid flowing streams there may in winter be frequent formations of anchor ice where the water is open and agitated in the stony rapids.

On the Assiniboine River there will be smooth water for nearly twelve miles above the dam which will be soon covered with ice at the setting in of winter.

Considering the length of this pond and its conditions favoring smooth flow, we are led to the opinion that trouble from anchor ice at this power will much less frequent than the majority of water powers in New England.

COST OF CONSTRUCTION.

An approximate estimate of the cost of construction of the dam, head gates, canal, waste weir, feeder gates and canal bridges is as follows:

Dam, 600 feet of filled crib-work	$186,000
Abutment masonary and side walls	46,000
Head gates and masonry	37,000
Canal, 1500 ft. length and feeder gates	65,000
Bridges over canal	28,000
Grading	1,600
Contingencies and superintendence 10 per cent.	36,260
	$399,860

A closer statement of cost can be prepared when the site of the works has been more fully contoured, the precise location of structures selected and the detail drawings are complete, so that accurate bills of quantities may be used in the estimate.

The cost of the water power construction, exclusive of lands, and locks for navigation purposes, will be substantially four hundred thousand dollars, and this includes head gates and canal of a capacity of ten thousand gross horse powers, at an approximate cost for original construction of $40.00 per horse power.

RENTAL VALUES.

Recent rentals of water power by the St. Anthony Falls Water Power Co. at Minneapolis, have been at the rate of $20.00 per gross horse power per annum, exclusive of land rentals. Earlier rental rates have gradually increased from $6.67 and $7.50 in the early days of the manufacturing at St. Anthony, as the demand for power increased, to the present rate. The advance of rental rates at other large powers have similarly increased from the times when low rates were offered as an inducement to promote new enterprises and mill building, to the times when the demand for power was greater than the low water power of the respective streams.

Ten dollars per annum per horse power will be a very low rate for the earliest rentals of water power in Winnipeg, as compared with any other power that can compete with it for manufacturing purposes, and the rental rates may undoubtedly be increased in time to $25.00 or $30.00 per annum.

At the present rates for good fuels, steam power must cost, for twenty-four hour runs, in Winnipeg, approximately $90.00 per net horse power per annum, an average of about twenty-nine cents per day for each 310 working days.

Thus it is seen that the average cost of original construction of one horse power of water power is but one half the annual cost of operating and maintaining one horse power of a steam plant, and when the water power is substantially constructed its annual cost of operation and maintenance is very small compared with any power having its origin in fuel.

Assuming the cost of construction of the water power of 10,000 h. p. capacity at $400,000, the rentals of power at the following respective average rates per horse power per annum, wili pay interest on the investment, in addition to the maintenance expenses, at the per cents indicated.

Rental of	2,500 h.p.	at average,	$10.00,	returns	5	per cent.
"	5,000	"	"	11.00,	"	12	"
"	7,500	"	"	12.00,	"	18	"
"	10,000	"	"	15.00,	"	36	"

FEASIBILITY.

The measurements and maps of Maj. Ruttan, together with the facts and estimates herein presented, leave no doubt respecting the feasibility as an engineering project, of the construction of a large and permanent water power on the Assiniboine River in the City of Winnipeg. As a financial scheme it may be in a measure dependent on the disposition of the citizens of Winnipeg, and the expression of their will by powers granted and instructions given to the City Council to promote the scheme. Geographical position and transportation facilities have favored the development of the city as a trade centre, and will in a greater degree favor it as a manufacturing centre if it provides ample facilities for setting machinery in motion by a cheap power.

Estimating the wheat crop of the present season as twenty million bushels. we find that this wheat, exclusive of the seed wheat, if brought to Winnipeg would give in its conversion into flour, constant employment for a year to this power of the Assiniboine River.

When the Assiniboine is re-enforced by aid of a canal from Lake Manitoba, the shores and water-shed of the lake will offer vast quantities of spruce and poplar for grinding into pulp and the manufacture of paper.

The increasing agricultural development of the Central Canadian Provinces and mineral development in the mountains will call for the manufacture of large quantities of machinery, implements and woolen goods. A water power of low annual rental is the potent infiuence that only can secure this work in the face of active outside competition.

The inducements for Winnipeg to make itself a manufacturing centre seem very great, and as an exceptionally favorable opportunity is presented through the development of its great water power. I can conceive of no way in which the city can with more certainity and profit enhance its own growth, permanent revenues from taxation and general prosperity than by promoting, directly or indirectly, this Assiniboine water-power project, until its ten thousand horse powers shall be fully loaded with busy machinery.

Very respectfully submitted,

J. T. FANNING, C. E.

MINNEAPOLIS, Minnesota,
June 18, 1889.

NOTE.—Report of 5th July, 1888, revised and amended to date.

Water Power and Navigation

OF THE

ASSINIBOINE RIVER.

OFFICE OF THE CITY ENGINEER,
WINNIPEG, Man., 20th Jan., 1893.

To His Worship the Mayor, and the Council of the City of Winnipeg.

GENTLEMEN,—The undersigned has the honor to submit the following report of progress on the surveys and examinations of the Assiniboine River, made in accordance with instructions contained in resolution of Council, passed on the 6th February, 1888, as follows:

"That after having heard the joint delegation of the "Board of Trade and citizens, with reference to the im- "provement of the navigation of the Assiniboine River "and the utilization of a vast water power within the city "limits, and as it is necessary that action should be taken "at once in the way of preliminary surveys, this Council "would recommend that the Finance Committee provide "a sum not more than $2,000 to be spent in the most "benefical manner under the supervision of the City "Engineer."

The objects of the survey, as stated in the above resolution, were:

1st. To obtain information in reference to the improvement of navigation;

2nd. To obtain imformation in reference to the utilization of water power of the Assiniboine within the city limits.

With the above objects in view the survey was commenced on the 11th of February, 1888.

The work done in connection with the survey consisted of the following :

(1) About 20 miles of transit lines on both sides of the river between Winnipeg and Headingly.

(2) Traverses of lateral valleys and streams.

(3) Lines of checked levels on transit and traverse lines.

(4) 45 cross-sections of the Assiniboine River extending between the traverse lines on the banks.

(5) Cross sections of streams and lateral valleys and cross-sections for use in plotting contour lines.

(6) Borings were made at points indicated on plan.

(7) A picket line, 17 miles in length, was run between the Assiniboine River at Baie St. Paul and Lake Manitoba, upon which a line of checked levels was taken.

(8) Office work as per detailed list of plans, etc.

The transit lines were marked by iron stakes at all angles and at both ends of the cross-sections, and by wooden stakes every 100 feet.

Bench marks were established frequently and on the most permanent points which could be obtained.

The field work, with the exception of the observations of height of water and gauging, was completed on the 20th March, 1888.

The following is a general statement of the information which has been obtained from the data furnished by the surveys :

The rise in the river bed between Winnipeg (Armstrong's Point) and Headingly, a distance of 12 miles, is 26 feet, the rise in general level of the country being about the same.

The depth of the river bed below the prairie level is from 30 to 40 feet.

From the upper end of Armstrong's Point to cross-section 21, a distance of one and one-half miles, the rise in the river bed is eight (8) feet.

The banks are composed chiefly of clay and sand. The bed of the river is in places covered by stones and boulders.

With the exception of Sturgeon Creek, there are no lateral valleys of any consequence between Winnipeg and Headingly.

It is thought that in the vicinity of cross-section 21 will be found the most suitable and economical place for the proposed dam. The river at this point is wide, enabling a long crest of dam to be obtained for the discharge of flood water; and being at the head of the rise of 8 feet referred to above, the height of dam required will be less than below that point.

The following are the elevations referred to the datum assumed for the levels in connection with the survey.

Bed of river, Armstrong's Point	60.00
" " cross-section 22	68.24
" " Headingly	86.00
General prairie level, section 22	98.00
Flood level of 1882, " "	91.00
" " 1850, " "	98.55

(The flood levels were pointed out by residents.)

Flood level of 1882, section 34	91.60
" " 1882, Headingly	106.10

At the latter point the flood of 1882 was observed by the undersigned, and it was well within the river banks. The high water shown on the lower cross-sections was occasioned by back water from the Red River, to which stream the flooding was due.

It has been assumed for the purposes of this report that the level of water in the upper level for water power will be maintained at an elevation of 90.00.

At an elevation of 90.00 for water in the upper reach the approximate quantity of land which will be overflowed beyond ordinary high water mark is only 100 acres. Contour lines at elevations of 90.00 and 95.00 are shown on the plan.

VOLUME OF DISCHARGE OF THE ASSINIBOINE RIVER.

The gaugings used in computing the discharge were taken at cross-sections 5 and 7 and 21 and 22.

The observations for velocity were taken by wooden discs, 4 in. in diameter, $\frac{3}{8}$ in. thick.

At the points of observation parallel cross-sections were staked out, and the time of the passage of the discs between them was noted.

While it would have been more satisfactory to have taken the observations with a current meter, the above described method is sufficiently accurate for present purposes.

The bed of the river consisting of boulders, there was a considerable quantity of water passing down which could not be taken into account, but which could be intercepted by a dam and would be in addition to the quantity above stated.

The river commenced to rise on the 1st April, 1888, and continued to rise till the 3rd May, at which time the elevation at cross-section 17 was 70.9.

A disturbance in the water levels occurred between the 23rd and 30th April owing to the break up of the ice. The water level on the lower cross-sections was also affected by back-water from the Red River, so that for purposes of comparison the elevations in the upper cross sections will be found most satisfactory.

On the 13th of May the elevation of water at section 22 was 71.3. The mean area of sections 21 and 22 was 1534, and the mean serface velocity between those sections was 3.82 feet per second.

The discharge was therefore

$$1534 \times 3.82 \times .85$$
$$= 4980.15 \text{ c. ft. per second.}$$
$$= 298809 \text{ c. ft. per minute}$$

From the tables of surface elevations and velocities and the information given on cross-sections, the discharge at other dates included in the observations may be calculated.

The lowest recorded discharge of the Assiniboine was on 16th Sept., 1889, at which date the estimated flow was about 670 cubic ft. per second.

The fall of water level in the Assiniboine was gradual from 1882 to 1889, since 1889 the river has been gradually rising and at the date of this report the minimum volume of discharge is 730 cubic feet per second.

During the extreme low water it was found impossible to procure satisfactory observations of velocity at original cross-section. Three new sections were taken opposite stations 20, 21 and 22 of south bank traverse. The velocity at that station was found to be 1 foot per second and the areas respectively 661,782 and 834 square feet.

HORSE POWER OF THE ASSINIBOINE RIVER.

For the purpose of estimating the minimum horse power which the Assiniboine River will afford in the City of Winnipeg, the upper level is assumed as 90.00 and the lower level at 64.75, a fall of 25.25 feet.

The minimun constant flow of the river on 16th of Sept., 1889, was 670 cubic ft. per second.

The area of the surface of the reservoir above the dam at an elevation of 90.00, is approximately 26,000,000 sq. ft.

Assuming the average time of using the water power to be 14 hours per day, and that water is allowed to accumulate in the reservoir for the remaining ten hours. The total quantity available for use during the day would be:

The regular flow of 24 hours = 57,888,000 c. f.; or cubic ft. per second for 14 hours = 1148.

The working head would be reduced by using the water in the reservoir faster than it is supplied, an average of half a foot or to 24.75 feet.

The gross horse power for 14 working hours per day would be:

$$\frac{1148 \times 62.33 \times 24.75}{550} = 3219 \text{ H.P.}$$

This is at the lowest point reached by the river, since any record of observations has been kept, or in the memory of any one living here.

At the date of this report the flow is 1251 cubic ft. per second for 14 hours, and the gross horse power for the same time, 3491.

By referring to the elevations of cross-sections it will be seen that the highest water during spring freshet was as follows:

CROSS-SECTION 22.

1888, 26 April, elevation 79.3, for few hours only from ice run.
1889, " " 70.0, normal.
1890, 16 " " 70.11, normal.

The working line being 90.00, the head was reduced for a few hours on 26 April, 1888, to 10.7 ft.

During exceptional flood years such as 1882, when the water level was 91.05 or a foot above the proposed upper level, the power would be reduced to nothing. Such extreme high water only last for a few hours, and is due to ice runs or back water from the Red River. Such floods have occurred only once in fifteen years.

CANAL FROM LAKE MANITOBA TO THE ASSINIBOINE RIVER AT BAIE ST. PAUL.

From the sketch plan and profile of the country between Lake Manitoba and the Assiniboine it will be seen that low water in Lake Manitoba is 14.05 feet higher than low water in the Assiniboine at Baie St. Paul, and that the distance between the lake and river is by the traverse line 17 miles.

The ridge shown at station 540 can be avoided by keeping a short distance to the west, and it would be necessary to extend the canal works further into the lake than the end of the survey line as shown on plan, so that the total length of the canal would be about 18 miles.

The valley of Long Lake shown on plan is a natural canal, and with a small expenditure might be used for about one-third the distance between the lake and the river.

A canal, to deliver 150,000 cubic feet of water per minute, at a velocity of two and one-half (2.5) feet per second, would require a water area of one thousand square feet, a mean hydraulic depth of seven and five-tenths (7.5), and an inclination of .00012.

The surveys show that the above conditions can be fulfilled without any unusual difficulty or expenditure.

The soil throughout consists of clay, sand and gravel. Good building stone can be procured on Lake Manitoba.

The construction of this canal would increase the power at lowest stage of water from 3219 to about 15000 H. P. for 14 hours per day.

THE NAVIGATION OF THE ASSINIBOINE RIVER.

The Assiniboine River has not been navigated for the past nine or ten years, since the construction of the Canadian Pacific Railway, and for the last three years the summer level of the water has been too low to admit of navigation by the ordinary river steamers.

The difference in level between Lakes Winnipeg and Manitoba, according to published maps and reports, has been stated at forty-one (41) feet.

The Red River at Winnipeg is about 16 feet higher than Lake Winnipeg.

The surveys just completed show that the difference of level between Lakes Winnipeg and Manitoba is 100 feet, and that the Assiniboine at Long Lake is seventy (70) feet higher than at Winnipeg, over one-third of this rise occurring in the first ten miles above Winnipeg.

The fall of the Assiniboine has hitherto been supposed to be much less than it really is, and the maintenance of navigation will be more difficult and expensive than was expected.

The construction of the water power dam would give slack water navigation between it and Headingly.

Above Headingly there appears to be no doubt that at low water, very heavy expenditure in the construction of dams and locks would be necessary to ensure navigation from the water of the Assiniboine alone, but as the navigation of the Assiniboine would not be of much benefit without its connection with Lake Manitoba by a canal, which will also be required to supply water for power at Winnipeg, it is expected that the additional water from the canal will obviate the necessity for any works except, perhaps, a few wing-dams, between Headingly and Baie St. Paul. This portion of the river was not included in the survey, which shows generally that while the river is not so favorable for navigation as was expected, the water power will be greater and more easily made available, and that the canal necessary for increased water power will probably ensure complete navigation.

By referring to the water elevations it will be seen that at no time for the last four years has the River been navigable for boats drawing 3 ft. of water, and while the River was a little higher before the records were kept, it has not been navigated since 1882.

The Assiniboine is not at present navigable, and it cannot be made so, without a large expenditure, part of which would be in the construction of a dam at Winnipeg.

In order that the water power may be made available as soon as possible, the following mode of proceeding is suggested, viz:

That permission be obtained from the Governor-General-in-Council to construct the dam at Winnipeg, which will be necessary for both water power and navigation; and that as the river above Headingly cannot be navigated until it has been improved either by the construction of dams or increase in the supply of water, permission be obtained to defer the construction of the locks necessary for navigation around the dam, till the river above has been made navigable. If this course is approved, the minimum expenditure only would be required at present.

There appears to be no reason to doubt that the water power of the Assiniboine River can be leased within one year of the time when it is made available, and that the demand for additional power and navigation to Lake Manitoba will be so great that it will be in the interests of the Government, or of the company undertaking the work, to push on the construction of the canal to Lake Manitoba at once.

NOTE.—The increased supply of water from Lake Manitoba would also much improve the navigation of the Red River, and would largely reduce the cost of any improvement required between the City of Winnipeg and Lake Winnipeg.

MEMORANDUM ON ICE FLOW, 1888.

The ice in the Assiniboine River, in March, 1888, was found to be from 18 inches to 2 feet 6 inches in thickness, that over the more rapid currents being the thinnest.

The ice commenced to move for the first time this spring in the night of the 25th of April.

Temporary variations in the level of water surface were caused during the time the ice was running by partial jams, which occurred at several points on the river.

The extreme range of the variations above or below the normal level of the river does nor appear to have exceeded from 4 to 5 feet.

The ice forms a dam on the surface of the water only; it has never been known to "pile" or jam from the river bed.

Owing to the continued cold weather up to the time the ice commenced to move, it was unusually thick and firm.

About 12 p. m. in the night of the 25th April a jam occurred at the north span of the Osborne street bridge, Winnipeg. The jam was caused by a field of ice 2½ feet thick resting between the north pier and the turn-table fender. The flow of ice continued through the south span, with some interruptions, till 9 a. m. on the 26th, when the flow on that side was also stopped by a jam resting between the shore and fender. The bridge has two (2) clear spans of 120 feet each. This jam kept back the whole of the ice in the river, which gradually melted away and disappeared. On the morning of the 29th the river was clear to within a mile and a half of the Osborne street bridge. During the day this ice gradually disappeared, and at 6 p. m. the last of it was within a few hundred feet of the bridge. At this time the jam at the bridge broke and, in a few minutes, the river was clear.

In dealing with the ice in connection with a dam across the river it may be

(a) held up by pile piers and booms above the dam, or

(b) it may be allowed to run over the submerged portion and between the piers of the dam.

With the increased area of water way above the dam and the holding power of the ice on the bank, due to the constant level, it is not expected that any quantity of ice will go over the dam.

THE DAM.

The chief considerations involved in the construction of a dam across the Assiniboine River are :

(1) That the foundations should be sufficiently good to support the weight of the dam and prevent leakage under it ;

(2) That the dam should be of the proper form and strength to hold the water on its upper side at an elevation of at least 90.00.

(3) That provision should be made for the passage or surplus water during floods without permitting the water immediately above the dam to rise above 90.00, or such other height as may hereafter be found advisable.

(4) That the movable portion of the dam should be as simple as possible so that, if necessary, it could be worked by unskilled labor.

(5) As at seasons of low water the whole volume of the river will be required, the movable part of the dam should be so constructed that it can be made water-tight.

(6) The dam should be so constructed that it cannot be damaged by running ice, and the movable portion so arranged that it can be opened while the ice is running, if neccessary.

A foundation of limestone rock can be obtained at an elevation of 56 or 12 ft. below the river bed.

The crest of the permanent portion of the dam is intended to be at an elevation of 82 or 14 ft. above the river bed.

In order to raise the water to the working level of 90, flash boards 8 ft. in height are used. The flash boards are supported by needles, which in turn are supported by piers at 40 ft. intervals.

A bridge which will be used for traffic purposes and for working the flash boards, will be constructed over the crest of the dam, the lowest member of which will have an elevation of not less than 98.

The above description is in accordance with the plans approved by the Governor-General-in-Council.

If it can be arranged to occasionally flood the land above the dam to a greater elevation than 90, the crest of the permanent dam should be raised to a greater height as suggested by Col. Fanning.

CANALS TO SUPPLY WATER FROM DAM TO MILLS.

Canals may be constructed in either or both sides of the river. Mills and power houses being built between the canals and the river, and the tail water taken into the river below the dam by tunnels or open cuts as may be considered advisable.

COST OF WORKS.

The revised estimated cost of the works in accordance with plans approved by the Governor-General-in-Council is as follows :

Dam	$150,000
Canal head gates..................................	35,000
Mill head gates..................................	30,000
Canal..	20,000
Locks for navigation..............................	150,000
Protection to C. P. R. bridge..................	5,000
Land submerged, 120 acres....................	12,000
Land and buildings damages..................	10,000
Land for canal, mill site, etc	20,000
	$432,000
Eng'ing 5 per cent. and contingencies 10 per cent.	64,800
	$496,800

H. N. RUTTAN,

M. Can. Soc. C. E.
M. Am. Soc. C. E.
M. Inst. C. E.

APPENDIX.

VELOCITY OF WATER.

Cross Section No. 5.

Date 1888.	Elevation of Water.	Mean Surface Velocity in Feet per Second.
May 1...	71.18	2.47
" 2...	70.91	2.63
" 12...	68.65	3.47
" 18...	67.86	3.20
" 28...	66.15	2.56
	Cross Section No. 22.	
May 1...	72.05	3.22
" 2...	72.15	3.39
" 12...	71.80	3.65
" 18...	71.28	3.82
" 28...	70.54	3.26

ELEVATION OF FLOOD OF 1882, AT DIFFERENT CROSS SECTIONS, AS POINTED OUT BY OLD SETTLERS.

Cross Section No. 22...........	91.05
" No. 34...........	91.60
" No. 39...........	97.70
" No. 42...........	105.83
" No. 45...........	106.10

ELEVATION OF FLOOD OF 1850, AS POINTED OUT BY OLD SETTLERS.

Cross Section No. 22...........	98.55
" No. 30...........	96.80

ASSINIBOINE RIVER.

Table f Elevations of Water in River, 1888.

Date of Level.	No. of Cross-Sections as per Plan.										
	V.	XVII.	XXII.	XXV.	XXVI.	XXVIII.	XXX.	XXXIV.	XXXIX.	XLIII.	XLV.
April 2	...	...	...	...	...	76 0	80.3	80.8	85.3	90.0	91.1
" 3	64.6	65.1	70.8	71.5	73.0	...	...	...	...	...	...
" 16	64.1	64.8	70.3	72.9	73.2	76.3	80.2	81.7	85.4	90.1	91.4
" 23	73.4	73.4	74.4	76.0	76.6	79.4	83.1	84.9	88.7	93.3	95.1
" 24	74.6	74.6	74.9	...	...	...	...	87.9	90.7	95.0	97.8
" 25	75.3	76.6	79.6	...	...	...	...	...	...	...	...
" 26	77.4	79.3	82.6	84 4	85.4	87.3	87.6	87 1	89.7	94.1	96.5
" 30	71.6	71.9	72.3	75.1	75.3	78 3	82.0	83.8	87 1	91.8	93.9
May 1	71.2	71.4	72.0	...	...	...	...	...	...	...	...
" 2	70.9	71.4	72.1	...	...	...	...	...	...	...	...
" 3	70.1	70.9	71.8	75.2	75.8	78.6	82.2	84.2	87.5	92.1	94.2
" 7	68.9	69.4	71.7	75.5	76.3	78 9	82.5	84.4	87.8	92.5	94.6
" 12	68.6	69.3	71.8	...	...	...	...	...	...	...	...
" 15	68.3	69.0	71.6	75.2	76.0	78.7	82.3	84.2	87.6	92.1	94.3
" 18	67.9	68.5	71.3	...	...	...	...	...	...	...	...
" 22	67.0	67.6	70.9	74.5	75.1	78.1	81.7	83.5	...	...	...
" 23	66.9	67.5	70.8	74 4	75.0	78.0	81.6	83.5	...	...	...
" 24	66.7	67.3	70.8	74.3	75.0	78.0	81.5	83.4	...	...	...
" 25	66.6	...	...	...	...	...	...	...	...	...	...
" 26	66 4	67.1	70.7	74.2	74.8	77.8	81.4	83.1	86.4	91 1	93.0
" 28	66.2	66.7	70.5	...	...	...	...	...	...	...	...
" 29	66.0	66.7	70.5	73.9	74 5	77.5	81 2	83.1	...	...	...
" 30	65.9	66.5	70.4	73.8	74.4	77.4	81.1	83 0	...	...	...
" 31	65.9	...	...	...	...	...	...	...	...	...	...
June 6	65.3	65.9	70.0	73.2	73.9	76.9	80.7	82.1	...	...	...
" 8	65.4	65.9	70 0	73.2	73.8	76.9	80 8	82.0	...	...	...
" 11	65.3	65 7	69 8	73.0	73.6	76.7	80.6	82.0	...	...	...
" 19	69.4	69 6	70.1	72.9	73.4	76.5	80.4	81.7	85 1	89.7	91.6
" 25	69.1	69.1	69.8		...	...	...	...	...	...	...
July 10	67.7	68.0	70.4	73.8	74.3	77.4	81.1	82.7	85.9	90.7	92.6

Table of Elevations of Water in River.—Cont.

Date of Level.	No. of Cross Sections, as per plan.											
	V.	XVII.	XXII.	XXV.	XXVI.	XXVIII.	XXX.	XXXIV.	XXXIX.	XLIII.	XLV.	Mouth of River.
July 12, 1888..	....	....	....	....	....	....	....	....	....	....	....	67.1
" 16, " ..	67.5	67.8	70.4	....	....	....	....	....	....	....	....	66.6
Aug. 14, " ..	64.1	64.4	69.3	72 1	72.6	75.9	79.8	80.9	84 2	89.1	90.6	....
" 28, " ..	63.7	63.9	69.2	71.7	72.2	75.5	79.4	80.5	83.8	88.7	90.1	....
Sept. 10, " ..	63.3	63.6	68.9	71.2	71.6	75.0	79.0	80.0	83.2	88.1	89.6	....
" 24, " ..	63.2	63.4	68.8	71.0	71.3	74.9	78.9	79.7	83.0	88.0	89.4	....
Oct. 6, " ..	63.1	63.3	68.8	70 8	71.1	74,6	78.7	79.6	83.0	87.9	89.3	....
" 15, " ..	63.3	63.4	68.8	70.9	71.3	74.8	78.9	79.7	83.1	88.0	89.3	59.2
Nov. 6, " ..	63.3	63.6	69.0	....	....	....	....	....	....	....	....	59.7
" 13, " ..	....	....	68.8	....	....	....	....	....	....	....	....	....
" 28, " ..	....	....	69.2	Ice	lev'l	....	....	....	....	....	....	....
Jan. 2, 1889..	63.5	63.7	69.4	....	....	....	....	....	....	....	....	59.3
" 23, " ..	63.6	64.1	69.7	....	....	....	....	....	....	....	....	59.4
Mar. 2, " ..	63.9	65.2	70.3	....	....	....	....	....	....	....	....	60.0
Apl. 10, " ..	64.7	65.1	69.5	....	....	....	....	....	....	....	....	63.4
" 17, " ..	64.3	64.1	69.5	....	....	....	....	....	....	....	....	61.6
" 26, " ..	64.1	64.5	69.3	....	....	....	....	....	....	....	....	60.8
May 3, " ..	63.8	64.1	69.1	....	....	....	....	....	....	....	....	60.7
" 10, " ..	64.0	64.3	69.3	....	....	....	....	....	....	....	....	60.6
" 17, " ..	63.8	64.1	69.2	....	....	....	....	....	....	....	....	60.3
" 23, " ..	64.1	64.4	69.3	....	....	....	....	....	....	....	....	60.3
" 24, " ..	....	....	69.3	....	....	....	....	....	....	....	....	....
" 30, " ..	63.8	64.1	69.2	....	....	....	....	....	....	....	....	60.0
June 7, " ..	63.6	63.7	69.1	....	....	....	....	....	....	....	....	59.6
" 13, " ..	63 5	63.7	69.0	....	....	....	....	....	....	....	....	59.2
July 22, " ..	....	....	68.8	....	....	....	....	....	....	....	....	....
Aug. 12, " ..	....	....	68.6	....	....	....	....	....	....	....	....	....
Sept. 9, " ..	62.8	63.0	68.6	....	....	....	....	....	....	....	....	58.1
" 16, " ..	62.6	62.9	68.5	....	....	....	....	....	....	....	....	58.0
" 21, " ..	62.6	63.0	68.6	....	....	....	....	....	....	....	....	58 0
" 27, " ..	62.6	63.0	68.6	....	....	....	....	....	....	....	....	58.6
Oct. 5, " ..	62.7	63.0	68.6	....	....	....	....	....	....	....	....	58.7
" 15, " ..	62.6	63.0	68.5	....	....	....	....	....	....	....	....	58.4
" 22, " ..	62.6	63.0	68.5	....	....	....	....	....	....	....	....	58.4
" 29, " .	63.0	63.4	68.8	....	....	....	....	....	....	....	....	58.5
Nov. 5, " ..	63.0	63.3	68.7	....	....	....	....	....	....	....	....	58.4
" 12, " ..	62.7	63.1	69.0	....	....	....	....	....	....	....	....	58.6
" 19, " ..	62 5	62.9	68.8	Ice	lev'l	....	....	....	....	....	....	58.3
" 26, " ..	62.8	63.2	69.1	....	....	....	....	....	....	....	....	58.3
Dec. 10, " ..	63.0	63.3	69.4	....	....	....	....	....	....	....	....	58.3
" 27, " ..	....	....	69.4	....	....	....	....	....	....	....	....	....
Jan. 9, 1890..	....	....	69.5	....	....	....	....	....	....	....	....	....
" 25, " ..	....	....	69.7	....	....	....	....	....	....	....	....	....
Feb. 5, " ..	....	....	69.8	....	....	....	....	....	....	....	....	....
" 19, " ..	....	....	69 8	....	....	....	....	....	....	....	....	....
Mar. 4, " ..	....	....	69.9	....	....	....	....	....	....	....	....	....
" 12, " ..	....	....	70.4	....	....	....	....	....	....	....	....	....
" 19, " ..	....	....	70.6	....	....	....	....	....	....	....	....	....
" 26, " ..	....	....	70.6	....	....	....	....	....	....	....	....	59.2

Date of Level.	No. of Cross Sections, as per plan.											
	V.	XVII.	XXII.	XXV.	XXVI.	XXVIII.	XXX.	XXXIV.	XXXIX.	XLIII.	XLV.	Mouth of River.
Apl. 2, "	....	....	70.8	....	....	....	....	....	....	....	....	59.4
" 9, "	....	....	70.6	....	....	....	....	....	....	....	....	60.0
" 16, "	....	....	70.1	....	....	....	....	....	....	....	....	62.2
" 23, "	....	....	69.7	....	....	....	....	....	....	....	....	63.0
" 30, "	....	....	69.4	....	....	....	....	....	....	....	....	61.8
May 7, "	....	....	69.5	....	....	....	....	....	....	....	....	61.3
" 17, "	....	....	69.5	....	....	....	....	....	....	....	....	60.6
" 26, "	....	....	69.3	....	....	....	....	....	....	....	....	60.3
" 31, "	....	....	69.3	....	....	....	....	....	....	....	....	60.3
June 7, "	....	....	69.4	....	....	....	....	....	....	....	....	....
" 14, "	....	....	69.5	....	....	....	....	....	....	....	....	60.7
" 21, "	....	....	69.2	....	....	....	....	....	....	....	....	60.2
" 28, "	....	....	69.1	....	....	....	....	....	....	....	....	60.0
July 5, "	....	....	69.2	....	....	....	....	....	....	....	....	60.0
" 12, "	....	....	69.3	....	....	....	....	....	....	....	....	60.0
" 19, "	....	....	69.3	....	....	....	....	....	....	....	....	59.7
" 26, "	....	....	69.2	....	....	....	....	....	....	....	....	59.8
Aug. 2, "	....	....	69.1	....	....	....	....	....	....	....	....	59.5
" 9, "	....	....	69.0	....	....	....	....	....	....	....	....	58.7
" 16, "	....	....	69.0	....	....	....	....	....	....	....	....	58.6
July 6, 1891	....	....	69.9	....	....	....	....	....	....	....	....	....
Jan. 20, 1893	....	....	70.0	Ice	....	....	....	....	....	....	....	....

Elevation of River Bed at minimum channel width of 40ft.

	V.	XVII.	XXII.	XXV.	XXVI.	XXVIII.	XXX.	XXXIV.	XXXIX.	XLIII.	XLV.
Elevation	59.0	59.4	66.9	68.8	69.1	72.4	76.0	75.9	79.8	84.0	86.8

FROM METEOROLOGICAL OFFICE, TORONTO.

CHARLES CARPMAEL, Director.

TOTAL PRECIPITATION (RAIN AND MELTED SNOW) AT CERTAIN STATIONS IN MANITOBA DURING THE YEARS 1886, 1887, 1888 AND 1889 TO 1ST SEPTEMBER.

STATION.	Lat. N.	Long. W.	RAIN AND MELTED SNOW.			
			1886	1887	1888	1889 to 1st. Sept.
Winnipeg	49.53	97.7	14.84	17.98	17.04	9.38
Portage la Prairie	49.57	98.10	12 06	17.32	18.71	?
St. Albans..................	49.38	99.33	12.29	18.94	17.90	7.35
Minnedosa	50.10	99.47	11.62	18.16	15.55	8.45
Hillview	49.55	100.36	13.35	24.66	12.10	9.61
Russell	50.47	101.20	14.40	20.61	19.72	5.35

TOTAL PRECIPITATION OF RAIN AND SNOW AT CERTAIN STATIONS IN MANITOBA FROM SEPT. TO DEC., 1889, (INCLUSIVE), AND DURING THE YEARS 1890, 1891 AND 1892.

STATIONS.	Lat. N.	Long. W.	1889 Sep. 1, to Dec. 31.		1890		1891		1892	
			Rain	Sn'w	Rain	Sn'w	Rain	Sn'w	Rain	Sn'w
Winnipeg ..	49.53	97.7	3.41	21.6	19.84	38.3	15 57	38.6	17.59	46.4
*P. la Prairie	49.57	98.10	2.24	0.00	2.73	36.5	21.14	32 6	15.73	42.5
St. Albans..	49.38	99.33	3.70	13.9	19.23	15.3	16.02	34.4	11.26	39.7
Minnedosa .	50.10	99.47	1.60	17.8	16.61	45.2	12.23	38.9	9.99	42.2
Hillview ...	49.55	100.36	0.31	19.11	22 47	26.1	11.66	40.00	14.11	61.00
†Russell	50.47	101.20	0.94	15.10	15.59	50.6	9.50	45.8	1.22	17.8

*No observations from June to October, 1890.
†Station closed end of May, 1892.

EXTRACTS FROM REPORT OF THE COMMITTEE ON WORKS OF THE CITY COUNCIL OF WINNIPEG, DATED 29TH JULY, 1889— IN ANSWER TO QUESTIONS ASKED BY PARTIES LOOKING INTO THE FEASIBILITY OF THE SCHEME.

Rental price of water at the following places :

	Price per H. P. per Annum.	Authority.
Minneapolis - - -	$20.00 - -	J. T. Fanning.
Lawrence, Mass. - -	14.12 - -	H. F. Mills, Engineer.
Lowell, Mass. - - -	75.00 - -	Wamesit Co., Lowell.
Birmingham, Conn. -	20.00 - -	Ousatonic Water Co.

In comparing the above with prices at Winnipeg it should be remembered that fuel is much higher here than in the East.

The evidence before the committee shows that the cost of running steam engines in Winnipeg is 3 to 4 cents per horse power per hour for engines up to 60 horse power.

	Price per H.P. per day 24 hours	Price per H.P. per year 365 days.	H. P. of engine.
F. J. Bowles -	90 to 96 cts.	$328 to $350	10 to 60
A. Chisholm -	abt. 72 cts.	$262	40
* G.V.Hastings	17	$62	Large comp'd
Water Power, Wpg. -	av. 6 cts.	av. $20	———

The report of the Chief Engineer of the Philadelphia " Water Works, gives data, showing that the cost of rais- " ing water to their reservoirs by steam power, coal being " $5.12 per ton, exceeded the cost by water power, on an " average, six-fold, and it can safely be asserted that the " average cost of steam power for manufacturing purposes " in the United States is at least seven times the cost of " water power here (Holyoke, Mass.)

In Winnipeg, where fuel is more expensive than in the East, the difference in cost will be much more in favor of water power than the above.

POSSIBLE DAMAGE FROM OVERFLOW.

The line to which the overflow above the dam will reach, will be determined before the construction of the works, and the lands which will be overflowed will have to be expropriated or bought. If an elevation of 90 is adopted at the extreme flood level,.then the quantity of land which will be required will be about 100 acres, as shown on the plan of the River. No *damage* which cannot be foreseen and provided for as above can occur.

AS TO THE POSSIBILITY OF THE SCHEME BEING A FAILURE.

The scheme has been now under discussion for two years. Surveys have been made, and reports obtained from the City Engineer and from Mr. J. T. Fanning, Chief Engineer, of the St. Anthony Falls Water Power Company at Minneapolis. The scheme has been examined by several other practical engineers. Mr. Ruttan and Mr. Fanning report positively that the scheme can be carried out without any danger of failure, and in no instance has anyone suggested a reason why the scheme should fail.

THE DANGER OF FREEZING.

The arrangement of the mills here would be very similar to that at Keewatin and Minneapolis, where no trouble from frost has been experienced.

It is stated by Mr. Fanning in his report, and by several practical millers that there is no danger from frost. Among others Mr. G. V. Hastings, now manager of the Keewatin Mill says, referring to this scheme : "I have had experience with water mills, and do not anticipate any trouble with frost in winter."

AS TO SCARCITY OF WATER WITHOUT THE CONSTRUCTION OF A CANAL.

The Assiniboine has three times the drainage area of the Mississippi at Minneapolis, and as settlement advances and trees are planted, the average quantity of water in summer will increase. It is not considered that the canal to Lake Manitoba is at all necessary for City power purposes, and it will not be wanted for outside manufactures until the Assiniboine power has been fully rented.

[See extension and amendments 54 and 55 Vic., Ch. 108, copy attached.]

Dominion Act.

An Act to enable the City of Winnipeg to utilize the Assiniboine River Water Power.

Whereas the City of Winnipeg has, by its petition, in effect prayed to be granted certain rights over the Assiniboine River, in the Province of Manitoba, for the purpose of utilizing and making available the water power of the said river for supplying the said city with water and light and for other purposes, and as the said river is a navigable river, the said city desires to obtain authority from the Parliament of Canada to utilize the water of the said river for the purposes aforesaid, and it is expedient to grant the prayer of the said petition; Therefore Her Majesty, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:—

1. The City of Winnipeg may use and make available the water power of the said Assiniboine River for supplying the said city with water and light; and may construct all necessary works therefor; and may use or lease such surplus portions of the said water power as from time to time are not needed for supplying the said city with water and light, for such other purposes as the city has authority for, under the statutes in force from time to time relating to the said city.

2. No work for utilizing or rendering available the water of the said river, for the purposes aforesaid shall be commenced or proceeded with until the said city of Winnipeg has submitted to the Governor in Council plans of the said works and of all the intended works thereunto appertaining, nor until the plans and the site of the said works have been approved of by the Governor in Council and such conditions as he thinks fit to impose for securing the free navigation of the said river and the public good have been complied with; nor shall any such plan be altered or any deviation therefrom be allowed, except by the per-

mission of the Governor in Council and upon such conditions as he imposes.

3. The Governor in Council may from time to time, notwithstanding the approval of any plans or works, require the same to be altered, or other works to be added or substituted, so as to make the works effective for the purposes intended, and so as to protect as far as possible the public interests and the rights which may be affected by the exercise of the powers conferred by this Act.

4. Nothing herein contained shall be construed to limit or interfere with the rights of any person or corporation whose property may be injuriously affected by the exercise of any of the powers conferred by this Act.

5. The rights and powers hereby conferred shall cease and determine, if the works hereby authorized are not commencod within two years from the passing of this Act, and completed within four years therefrom.

Manitoba Act.

An Act respecting the City of Winnipeg.

[*Assented to 31st March, 1890.*]

Whereas by Chapter 89 of the Statutes of Canada, passed in the fifty-second year of Her Majesty's reign, the City of Winnipeg, is, by the Parliament of Canada, auhorized to utilize the water power of the Assiniboine River ; and

Whereas, it is expedient that this Legislature should give the said City power and authority to prosecute the said work;

Now, Therefore,

Her Majesty, by and with the advice and consent of the Legislative Assembly of the Province of Manitoba enacts as follows ;

1. The City of Winnipeg is empowered to make available the water power of the Assiniboine River by constructing the necessary dams, locks, canals, gates, wastegates, and other works necessary or expedient for the above purposes, and by keeping the same in repair, subject to the provisions of this Act.

2. Nothing in this Act contained shall be construed to conflict with the provisions of Chapter 89 of the Statutes of Canada passed in the fifty-second year of Her present Majesty's reign.

3. The said City shall have power to lease to any company or individual the whole or any portion or portions of the said water power for any term of years at any rental to be agreed upon, and shall have power to enforce payment of the rent by distress and otherwise.

4. The land and buildings which may be necessary for the carrying on or completion of this work may be acquired by the City by purchase or by and under the expropriation and arbitration provisions of the Municipal Act of this Province, subject to the provisions of this Act.

5. The City shall have power to acquire by purchase or by expropriation as aforesaid, all lands which are overflowed by, or otherwise damaged by or which may in the opinion of the City Council be in danger of being damaged by the overflow of water or otherwise caused by the erection of such dam and other works, and this clause shall apply to lands lying outside of the limits of the City of Winnipeg as well as within the limits, and the said lands may be by the City thereafter leased or sold if not required for the purposes of the works. Nothing shall be done under this section unless and until the money necessary to pay all damages which may be occasioned by the exercise of such power has been realized from the sale of debentures as hereinafter provided.

6. The City shall have power by by-law to appoint three commissioners for entering into contracts for the construction of the above works, for superintending the construction thereof, for managing the works when completed, and

by by-law to provide for the election of the said commissioners by the electors from time to time and at such periods and for such terms as the council may appoint by the by-law authorizing the election.

7. In order to raise money to prosecute such work, the said City shall by by-law have power to issue debentures which shall be a first charge upon the undertaking, the lands, buildings, dams, canals and all other property, rights, tolls, income and franchises secured by this Act.

8. The said debentures shall state on the face thereof that they are issued pursuant to this Act, and that the City of Winnipeg is not liable for the payment of the principal or interest, and the same and each thereof shall thereby be and become a first mortgage and charge upon the said works, property, franchise, tolls and revenues as aforesaid without priority, amongst themselves.

9. The said debentures shall be for such amounts, and payable at such place, and at such times, and at such rate of interest as the City by by-law shall fix and determine, and the said City of Winnipeg, shall, in case such debentures are issued, apply the moneys produced from the sale of such debentures to the building and carrying on of the said works and not otherwise.

10. In case debentures are issued as hereinbefore provided, the tolls, income and rents and other revenue arising from such undertaking shall be first applied in payment of interest on the debentures and in providing for a sinking fund, if such fund is by the by-law directed to be provided for.

11. The said City shall not be in any way liable to the holders of the said debentures for the payment of the principal or interest secured thereby.

12. The City shall not expend any moneys upon the said works, nor enter into any contract or liability in respect thereto, unless the City has first received the moneys so to be expended from the sale of the debentures above mentioned, or from some company or person to whom the works to be erected are leased or agreed to be leased. Provided, that the City may expend a sum not exceeding

ten thousand dollars upon any preliminary or other proceedings arising out of or incidental to the works hereby authorized.

13. This Act shall come into force on the day it is assented to.

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54 AND 55 VICTORIA, CHAP. 108.

An Act to revive and amend the Act to enable the City of Winnipeg to utilize the Assiniboine River water power.

[*Assented to 31st July, 1891.*]

Whereas the City of Winnipeg has by its petition prayed for the passing of an Act to extend the times for the commencement and completion of the works authorized by the Act passed in the fifty-second year of Her Majesty's reign, Chapter eighty-nine,

Intituled "An Act to enable the City of Winnipeg to utilize the Assiniboine River waterpower, and that the said City be authorized to transfer its rights to construct, own, and operate the said works and
appurtenances to some Company or person upon such conditions as are agreed upon, subject to the right of the City to the user of such water power as is required for the purposes mentioned in the said Act, and

Whereas it is expedient to revive the said Act and to grant in part the prayer of such petition.

Therefore, Her Majesty, by and with the advice and consent of the Senate and House of Commons of Canada enacts as follows :

1. Subject to the provisions of this Act, the Act passed in the fifty-second year of Her Majesty's reign, Chapter eighty-nine, is hereby revived and declared to be in force, and the times limited for commencement and completion of the works authorized by that Act are hereby extended

for two and four years respectively from the passing of this Act, and failing such commencement and completion within the said time, the powers granted for such construction shall cease and determine.

2. The said City may assign and transfer to any Company or person upon such terms and conditions as are agreed upon between the City and such Company or person, any or ali of its rights, franchises and powers in respect of the construction, ownership and operation of the works authorized by the said Act and by this Act subject to the user by or supply to the City of water-power for the purposes mentioned in the said Act.

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