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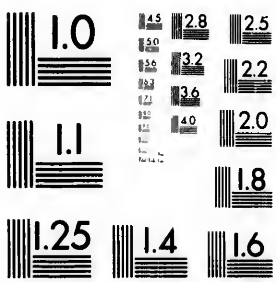

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Water Power and Navigation

OF THE

ASSINIBOINE RIVER.

Report, 5th July, 1888.

BY

H. N. RUTTAN, City Engineer.

Printed by Order of Council of the City of Winnipeg.

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1888.

1888
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ERRATA.

Page 4, line 10, for 8.5 read "3.5."
" 4, " 11, for 465 + read "465 × "
" 7, " 11, for first read "just."
" 8, " for ice flood read "ice flow.'
" 10, " 15, for feet read "foot."

WATER POWER AND NAVIGATION

—OF THE—

ASSINIBOINE RIVER.

OFFICE OF THE CITY ENGINEER,
WINNIPEG, Man., 5th July, 1888.

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 improvement 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 recom- "mend that the Finance Committee provide a sum not more than "$2,000 to be spent in the most beneficial manner under the supervi- "sion 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 information 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 occcasioned 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.

The power to be obtained will therefore depend upon the difference between 90.00 and the elevation of water in the lower reach, which for the past season, at cross-section No. 17, it will be seen has varied from 64.8, ice level, during February and March, to 79.3 on the 26th April. The rise on the 26th April was only temporary and was caused by ice jams in the river. The highest water due to the normal flow of the river occurred on 3rd May and was 71.00, and on 18th May at that point the river had fallen to 68.5.

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, 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 at the points of observation was covered with boulders and stones.

The mean velocities of the stream are taken at .85 of the mean surface velocities,

It will be seen from the table of water elevations that the lowest ice level at section 5 was 64.4. The average thickness of ice at that point was found to be 2 feet. The surface of the water to be used in calculating the discharge was therefore 62.4. At that elevation the mean area of water between sections 5 and 6 was 465 square feet,

Assuming the velocity under the ice to have been 8.5 feet per second, the discharge was:

$$
\begin{aligned}
&465 + 3.5 \times .85 \\
&= 1383 \text{ c. ft. per second} \\
&= 82980 \text{ c. ft. per minute.}
\end{aligned}
$$

There is no previous record of such low water as occurred last winter, the usual winter level being 2 feet higher. This is accounted for by the light rainfall of the last two years.

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 would be intercepted by a dam and would be in addition to the quantity above stated,

The river commenced to rise on the 1st April 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 18th 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 surface velocity between those sections was 3.82 feet per second.

The discharge was therefore

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

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.

Horse-Power of the Assiniboine River.

For the purpose of estimating the horse-power which the Assiniboine River will afford in the City of Winnipeg the site for the dam is assumed to be at cross-section 22 and the average level of the tail race, the elevation of the river at cross-section 17. The elevation of the water in the upper reach is assumed to be 90 00.

The volume of the river is calculated from observations at cross-section 22, except in the case of extreme low water, when the formation of the river bed at cross-section 5 was found to be more suitable.

In calculating the theoretical horse-power the formula used was:

$$
\begin{aligned}
& P = .001892\ Qh \\
\text{when}\ & P = \text{Horse-power.} \\
& Q = \text{Quantity of water in cubic ft. per M.} \\
& h = \text{Head of water from tail race in feet.}
\end{aligned}
$$

Taking the discharge for February and March as before stated, at 82,980 cubic feet per minute, and the water level at cross-section 17 at that time at 64.8, the upper level being 90.00, the horse-power was:

$$
\begin{aligned}
P &= .001892 \times 82980 \times 25.2 \\
&= 3956 \text{ horse-power.}
\end{aligned}
$$

On the 18th May, 1888, the discharge was 298,809 cubic feet per minute. The elevation of the water at cross-section 17 was 68.5. Elevation of the upper level, 90.00.

The horse-power was:

$$
\begin{aligned}
P &= .001892 \times 298{,}809 \times 21.5 \\
&= 12156.
\end{aligned}
$$

The horse-power given above is the theoretical constant horse-power. In case the power was in use for 14 hours per day only, the accumulation of the water during the remaining 10 hours would be made use of, so that at the lowest winter level the power for 14 hours per day would be: discharge per minute, 82,980 cubic feet; discharge per 10 hours, 49,788,000 cubic feet.

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

The flow in 10 hours would therefore fill up about 2 feet in depth of the reservoir; and each day of 14 hours, the supply being run down 2 feet, the increased quantity of water per minute from that source would be 59,271 cubic feet, which, added to the ordinary discharge, would give a total of 142,251 cubic feet per minute.

The horse-power at extreme low water for 14 hours per day would therefore be:

$$P = .001892 \times 142,251 \times 25.2$$
$$= 6779 \text{ horse-power.}$$

The head of water from tail race, h, has been assumed to average the same as for constant flow.

The actual horse power which can be realized by water motors may be taken at .83 of the theoretical horse-power.

The actual horse-power of the Assiniboine, therefore, at lowest water, for day of 14 hours, is 5,626.

The above power could be increased and maintained at 10,000 actual horse-power by constructing a canal from Lake Manitoba to the Assiniboine at Baie St. Paul. The canal should be capable of delivering 150,000 cubic feet of water per minute. If found desirable to reduce the head in the reservoir more than an average of two (2) feet during the day, a smaller canal would answer the purpose.

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 Navigation of the Assiniboine River.

The Assiniboine River has not been navigated for the past five or six 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 drawing four (4) feet of water.

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 first 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.

By extending the canal which will be necessary to supply the mills below the dam, and constructing locks into the Assiniboine, navigation could be maintained between the Red River 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.

Order in which Works should be Carried Out.

The Assiniboine is not at present navigable, and it cannot be made navigable 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, 5,626 horse-power, 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 works, to push on the construction of the canal to Lake Manitoba at once.

The construction of the works necessary for water power and navigation would thus be divided into two periods: 1st, that of the construction of the dam and a portion of the canal to supply the mills at Winnipeg; 2nd, the construction of the canal from Lake Manitoba to the Assiniboine and of the necessary canal and locks around the dam at Winnipeg.

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 improvements required between the City of Winpeg and Lake Winnipeg.

Memorandum on Ice Flood, 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 time this spring in the night of the 25th of April.

Temporary variations in the level of the 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 not 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 the 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.

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 of 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 moveable portion so arranged that it can be opened while the ice is running, if necessary.

The foundation is assumed to be at an elevation of 56.00, the sill of the submerged portion 76.00, and the crest of the dam 90.00; the total depth from the crest of the dam to the foundation being 34 feet. The dam will be 700 feet in length, extending into the banks on both sides.

The foundation will be on either solid rock or hard pan. The borings not being completed at this date there may be alterations necessary in the foundations which will change the estimated cost to a limited extent.

On the supposition that most of the water may occasionally be drawn from the lower side, the dam has been proportioned to withstand the water pressure on its upper side alone due to its full height. Provision has also been made to permit of the water above the crest of the dam being raised to 92 or 93, though all calculations of power are based upon an elevation of 90 only. The static water pressure against the dam will be 22.56 tons per lineal feet, and against the moveable portion of the dam 3.06 tons per lineal foot.

The area of the moveable portion of the dam provided for the discharge of surplus water will be, below the crest of the dam, 5,600 square feet.

There are five (5) openings for the moveable portion of the dam, each 80 feet by 14 feet. The openings are separated from each other by piers which carry the bridge and truss against which the upper ends of the needles rest.

The piers are 50 feet in length and 10 in width. They are provided with massive masonry ice-breakers.

The moveable portion of the dam consists of pine needles resting their lower ends upon the sill of the submerged portion of the dam, and their upper ends against the truss provided for that purpose. The needles are to be provided with chains and fastenings, so that they can be readily lifted and suspended out of reach of the water. It is proposed to do the work necessary in lifting and replacing the needles by an electric hoist, travelling on a truck along the bridge, the power for which is to be obtained from a water-wheel.

From the memorandum on ice flow attached to this report it will be seen that not much trouble is to be feared from that source. The piers of the dam are to be provided with substantial ice-breakers, and the needles so arranged that they can be raised if necessary while the ice is running.

The 80-foot bays might be fitted with trussed steel gates instead ot the needles, at an additional cost of $20,oco.

It is thought, however, that the arrangement proposed above is more economical, and all the material for construction can be obtained in the country.

The dam is intended to be constructed of masonry and concrete, the trusses and needles of Douglas fir.

The details of the dam have been worked out only so far as is necessary to obtain an estimate of the cost, which will be approximately $250,000.

The needle dam has been thoroughly tested in France and Russia. The greatest objection to it is that the needles require to be caulked, or otherwise made water-tight. This is no doubt a serious objection where the needles require to be frequently opened. Here it would be necessary to open the dam only once a year, for the spring freshets. A regulating weir would be provided in connection with the dam for the adjustment of summer levels.

Canal to Supply Water from Dam to Mills.

Canals may be constructed on either or both sides of the river to supply water to mills; the mills being built between the canals and the river, and the tail water taken into the river by tunnel or open cuts as may in each case be considered advisable.

The canal would be extended only as it was required to supply new mills, or in the event of it being used for navigation.

The expenditure necessary to construct a canal for supplying water to mills for half a mile below the dam is estimated at $50,000.

The estimates given above are intended to cover the cost of making available for use 5,626 horse-power for 14 hours per day, at the season of lowest water in the Assiniboine River.

The additional work necessary to increase the power to 10,000 horse-power would be required also for navigation. The surveys have not been sufficiently extended to enable the cost of the additional works to be estimated.

Observations on the flow of the river are being continued, and more borings are to be made at the site proposed for the dam. The additional information, with a plan of the proposed dam and canal. will be submitted with a future report.

Your obedient servant,
H. N. RUTTAN,
M. Can. Soc. C.E.
M. Inst. C.E.

TABLE OF 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

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 SURVEY.

LIST OF PLANS AND PROFILES, ETC.

(1) General plan of Assiniboine River between Winnipeg and Headingly.

(2) Plan of survey between Assiniboine River and Lake Manitoba,

(3) Profile of traverse on north bank of Assiniboine.

(4) Profile of traverse on south bank of Assiniboine.

(5) Profile from Assiniboine River to Lake Manitoba.

(6) Longitudinal section of Assiniboine River from Winnipeg to Headingly.

(7) Cross sections of Assiniboine River between Winnipeg and Headingly.

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