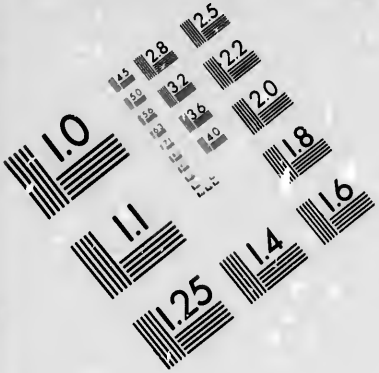

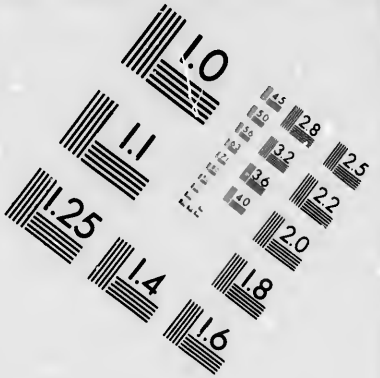

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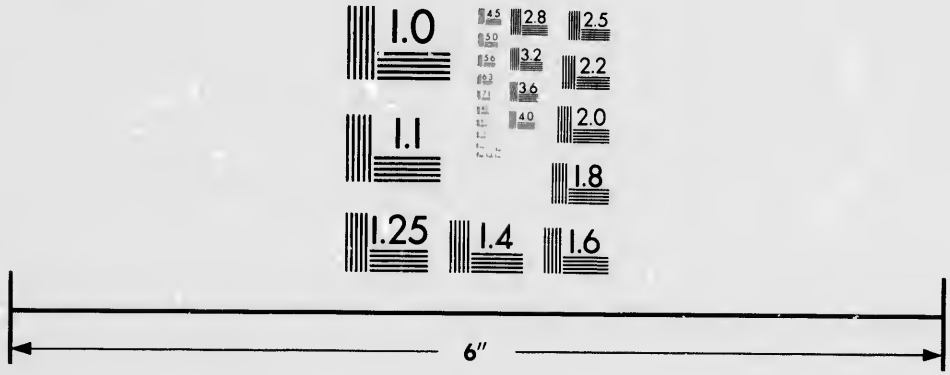

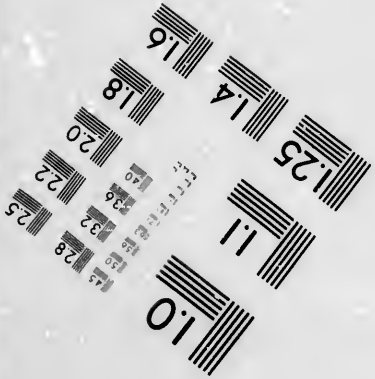

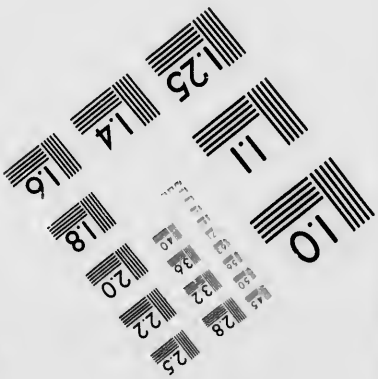

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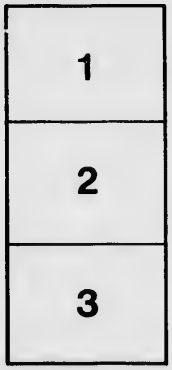

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HARBOUR COMMISSIONERS OF MONTREAL.

REPORT

ON THE

ST. LAWRENCE BRIDGE & MANUFACTURING SCHEME.

BY

JOHN KENNEDY, M. INST. C. E.

13TH DECEMBER, 1882.

PRINTED BY D. BENTLEY & CO, NOTRE DAME STREET, MONTREAL.

REPORT

ON THE

St. Lawrence Bridge and Manufacturing Scheme

BY

JOHN KENNEDY, M. INST. C. E.

Harbour Commissioners of Montreal,

CHIEF ENGINEER'S OFFICE,

MONTREAL, DECEMBER 13th, 1882

H. D. WHITNEY, ESQ.

Secretary-Treasurer

HARBOUR COMMISSIONERS OF MONTREAL.

SIR,

In compliance with instructions from the Board of Harbour Commissioners, and also of the Department of Public Works, conveyed through the Commissioners, I beg to make the following Report upon *The St. Lawrence Bridge and Manufacturing Scheme* usually called *The Shearer Scheme.*

The instructions direct me to report upon the feasibility of the scheme and upon its probable effect upon the Harbour if carried out. By the feasibility of the scheme, I understand not only the practicability of constructing the proposed works, but also the feasibility of attaining the purposes for which the works are designed, and I have therefore considered the question in this sense.

The information furnished me as to the scheme consists of copies of the draft of the proposed Act of Incorporation, presented at the last Session of the Dominion Parliament, and a Report addressed to the Hon. the Minister of Public Works, on the 18th January, 1882, by Mr. F. Foster Bateman, M. Inst. C. E., Engineer for the projectors. Besides these I have been favored with personal explanations by Mr. James Shearer, the originator of the Scheme, and by Mr. Bateman.

PROPOSED WORKS.

The main features of the Scheme as set forth in the Bill and in Mr. Bateman's Report, are an embankment dam across the main Channel of the St. Lawrence, from the Montreal abutment of the Victoria Bridge to St. Helen's Island, and a high level Bridge across the remaining part of the River between St. Helen's Island and the East or St. Lambert Shore.

The embankment is intended to be "76 feet wide at the top, with a solid masonry wall on the river or upper side, and will be left on the harbour side in an unfinished condition, at a slope of 3 to 1, until such time as the requirements of the Harbour of Montreal may necessitate from time to time the finishing of portions on that side."

"A highway 30 feet wide, with a trottoir 10 feet wide, and a double track of rails will run along the embankment. The top of the masonry wall on the outer or river side of the embankment, at the point at which it starts (the north-west corner of the west abutment of Victoria Bridge) will be of the same height as that abutment, or about 30 feet above the ordinary level of the St. Lawrence. It will run thence to St. Helen's Island, rising gradually to a height of 60 feet above the ordinary water level, which height it will attain when it arrives at the point at which the proposed bridge will commence."

"The embankment will be provided with three series of controlling sluices. These sluices will be capable of passing into the Harbour 486 million cubic feet of water per hour, and will be placed at 11 feet 6 inches below the ascertained low level of the water of the St. Lawrence."

"The embankment will further be supplied with thirty-five sluices, for milling, lifts and manufacturing purposes. These sluices will be capable of discharging into the Harbour about 364 million cubic feet of water per hour. They should be generally superintended and controlled by the Harbour Board, but will be used at the same time independently and without restriction for the above-mentioned purposes."

"The highway and railroad will run along the embankment having connection with the different lines running to Montreal, with a gradient of about 1 to 250 to the point on St. Helen's Island from which it is proposed to throw the bridge across the river."

The bridge between St. Helen's Island and the St. Lambert shore will be 3,050 feet clear length between the abutments, and will have eleven lattice spans of 250 to 294 feet each, or should Government require it, a suspension bridge with four openings will be substituted. The clear height from high water to the bottom of the bridge is shown on the plans as about 48 feet.

It is proposed to remove Moffat's Island, the old St. Lambert or Grand Trunk Wharf, and all obstructions to the flow of water and ice through the South Channel, or that between St. Helen's Island and the St. Lambert Shore; to straighten and widen it at certain points, and excavate throughout its length a navigable channel, which, according to the Bill shall not be of a less width than 300 feet, with a low water depth of not less than 16 feet.

The Channel between St. Helen's Island and Ile Ronde, will be straightened and widened, so as to pass a maximum quantity or water of some 85 million cubic feet per hour.

Levees will be built wherever necessary, to prevent the flooding of low lands, either above or below the works.

Power is asked in the Bill for the construction of Basins and Wharves, but their proposed character and position are not defined.

ADVANTAGES CLAIMED.

The promoters of the scheme, state, in effect, in the preamble to the Bill, and in the Engineer's Report, that the proposed works will, amongst other things, secure the following advantages:—

1. Increased Harbour accommodation in the Port of Montreal.
2. The rapid current of 12 miles an hour between Sous le Mont and Ile Verte will be completely done away with.
3. The present carrying down of detritus by the ice, and deposit of the same in the deep portions of the Harbour will be stopped, and the sediment formed by local causes may be scoured out at high water by the discharge from the large sluices.
4. The Current St. Mary will be reduced from its present rate of 8½ miles per hour, to a maximum rate of 5 miles per hour.
5. The water in the Harbour will not be lowered, but the Harbour Board will be able to regulate it and keep it at a uniform depth by means of the sluices in the embankment.
6. The packing of ice in the Current St. Mary, and consequent rise of water in the Harbour and lower portions of the City, and the piling of ice on the wharves, will be prevented.

7. The embankment and bridge will allow of railway connection between Montreal and the St. Lambert shore.

8. A footpath and roadway will be provided for foot passengers and ordinary vehicles.

9. Water power will be provided by thirty-five sluices for milling, lifts and manufacturing purposes.

In looking at the scheme as thus sketched out, it appears to me, that as a mere matter of construction and maintenance, the proposed works are entirely feasible. It can hardly be called an easy thing to build the portion of the dam and the sluices which are to be placed in the deep channel, but there are no extreme difficulties in the way. The building of the bridge is a simple mattter and presents no difficulties. Neither is there anything in the main features of the design which need make it difficult to secure the details from damage by the action of the ice.

In considering the feasibility of the scheme in the wider sense of producing the physical effects for which it is designed, I purpose to touch upon the above points of advantage claimed by the projectors, and then to deal with other features which appear to me of importance.

1.—*Increased Harbour Accommodation.*

The Bill, in Section 8, asks for power "to construct and maintain locks, "gates, sluices, basins, wharves, water-powers, mills, machinery, warehouses, "sheds, buildings, elevators, weigh-beams, and all such other work;" and especially "for facilitating the unloading, shipment, storing and handling of "merchandise," etc., "such erections being subject to the approval and consent "of the Board of Harbour Commissioners of the Port of Montreal."

The powers asked for are merely permissive, and would give the Company the right, under the approval of the Harbour Commissioners, to make basins, wharves, etc., should they choose to do so; but neither here nor elsewhere in the Bill, nor by the plan, do I find that the Company is obliged to construct anything which would, in the ordinary sense, afford increased harbour accommodation. The plan shows an embankment wide enough for railways and roadways, and a line of possible widening, but no basins nor wharves are shown. Mr. Bateman's Report however explains that it is intended that the embankment "would be "left on the Harbour side in an unfinished condition at a slope of three to one "until such time as the requirements of the Harbour of Montreal may necessitate "from time to time the finishing of portions on that side," and also that, as the removal of Moffat's Island and the excavation in the south channel will not yield sufficient material to finish the embankment, the balance must be taken from the Harbour, and therefore the proposed Company will be able "to offer to the "Harbour Commissioners the advantage of deepening the Harbour to whatever "depth might be considered necessary within reasonable distance of the proposed "site of the embankment, without any considerable extra cost to themselves."

Taking Mr. Bateman's report as indicating the ultimate intention of the Company, and that the Bill may yet be amended so as to include it, it appears to me that the increased Harbour accommodation will at first be merely such increased depth or area of basins as this excavation will make, and at subsequent times, when the embankment may be widened, it will be provided with a line of wharf on its Harbour side.

Mr. Bateman has kindly informed me that he estimates about a million cubic yards of excavation will thus be required in the first instance from the Harbour. In considering how this may be utilized, it appears to me that at first some 100,000 cubic yards will be taken up in lowering the present bottom of the upper portions of

the Harbour, in order to compensate for the lowering of the water surface which I think will take place for reasons hereafter given. To get a practical idea of what may be done with the remainder of the excavation, it may be considered as sufficient to make the deep water of the Harbour 200 feet wider than at present, from the head of the Windmill Point Basin to the lower end of Victoria Pier. This, or something equivalent, would be felt as a very great convenience in moving vessels in the Harbour, but it could not be considered as increased accommodation, in the sense of providing more berths for ships. The increase, in that sense, would only be made when the Company from time to time, finished up portions of the Harbour side of the embankment, and faced them with wharves. The whole, when completed, and without interfering with the Bell, Newton and Fleming scheme, would afford a range of about 6,000 feet, or 1 1/7 miles of new wharfage fronting the City and extending from opposite Black's Bridge to the head of St. Helen's Island. As to access by land, for cartage, its upper end would be distant, for instance, from the Custom House about 1¾ miles, or a little farther than the Adams Tobacco Factory, while the St. Helen's Island end would be 2 9/10 miles, or nearly the same as Ruisseau Migeon, but with the additional disadvantage of the intervening draw-bridges on the Lachine Canal.

The controlling sluices are shown on the plan as arranged in three groups, the middle group facing the Island Wharf, and the others at about 1,600 feet, clear distance on each side. In the intervening spaces, and in the spaces towards the ends of the embankment, are arranged the mill or scouring sluices. Each group of controlling sluices occupies 450 feet, or in all 1,350 feet, and the remaining 4,450 feet of the wharf is occupied with the mill sluices; that is to say, the whole wharfage will be pierced with openings through which it is intended to pour about three-fourths of the low water flow of the St. Lawrence. Each of the thirty controlling sluices is intended to discharge, when needed, 16,200,000 cubic feet of water per hour through a culvert 40 feet wide, and each of the thirty-five mill sluices is to discharge 10,400,000 cubic feet per hour through a culvert 20 feet wide. The depths of the sluices at the finished outlet are not shown on the plans: but supposing them to be, say 22 feet, or as deep an ordinary basin would well allow, the controlling sluices would each discharge a stream of 40 feet wide by 22 feet deep, with a speed of 3½ miles an hour, while the mill sluices would each discharge a stream 20 feet by 22 feet at 4½ miles per hour.

Within the length of an ordinary steamer there would be at least two of the mill sluices, or about five of the great controlling sluices, and it is, I think, obvious that with such powerful discharges of water no vessel could either moor or move in front of them with safety, or in other words the wharf with the sluices as arranged would be unfit for berthing vessels.

A more favorable arrangement of sluices can doubtless be made; but at the best, three-fourths of the water which flows under the Victoria Bridge in autumn must be brought through a wharf which is shorter than the clear opening of the Bridge by two spans, and the flow will certainly create currents of most objectionable kind and strength.

2.—*Abolishing the rapid current of* 12 *miles an hour between Sous le Mont and Ile Verte.*

The only point thereabouts at which there is a current approaching this rate, is that known as Sault Normand, where the water drops over the side of a shoal and shows as a broken rapid at low stages of the river. This sault is directly below the middle group of the great controlling sluices, and until the shoal is removed the water from the sluices will flow over it, and make, I think, a current practically the same as at present. After the wharf is built and a deep water basin made in front of it, the site of the sault will be occupied by the larger but slower flow from the sluices already described. This will certainly be a consequence of the completion of the scheme, but it appears to me rather as an incidental matter than a point of advantage in itself.

Altogether clear of the Sault Normand, and Sous le Mont, and between them and Ile Verte, there is the Boat and Raft Channel, the head of the pocket

in fact, with a current averaging only 6½ miles an hour through which the river steamers run with ease, and very often tow barges besides. This important Channel can hardly be said to be altered by the embankment, for it will be entirely closed, and it therefore forms a feature in the scheme of such moment as to require separate consideration

3.—*The stoppage of the present carrying down of detritus by the ice and the deposit of the same in the Harbour, and the provision for scouring out local deposit by the sluices.*

The shoals immediately above the Harbour are formed almost entirely of soft rock overlaid in places with boulders and gravel. Boulders even of large size, are known to be occasionally lifted by the ice and dropped in the Harbour, and enough gravel is scoured down by the violent currents formed under the ice jams to be felt in the cost of dredging. I cannot, however, think this a matter of serious expense; for it must be remembered that the great bulk of the dredging of recent years has been for deepening the Harbour to keep pace with the deepening of the Ship Channel, and not for merely clearing out yearly deposit. But whether much or little be now brought down, I quite agree with Mr. Bateman that the embankment would effectually stop it for the future.

As to the deposit from local causes, by which I understand sewage deposit, rubbish from ships, etc., which collects at the wharves, I cannot see how the lesser scour which would be obtained from the sluices would clear this out when the winter and spring flood of the river at present fail to do so On the contrary, it seems to me that the reduced current, especially during winter, would allow the deposit of some of the sewage matter now swept away.

4.—*Reduction of the St. Mary's Current from its present rate of 8½ miles to a maximum of 5 miles an hour.*

At low water I find the highest mean rate, taken with a loaded rod, of 20 feet depth, and showing fairly what a ship has to stem, to be about 4¾ miles at the head of St. Helen's Island; 6 miles at the Canadian Rubber Factory, Papineau Square, and 7 miles at the middle of Ile Ronde, where it attains the highest speed. At ordinary high water of 22 feet on the sill, the rate at Ile Ronde rises to 7½ miles, and at other places in proportion. In every case the speed falls off rapidly towards the shores, and vessels according to their draft can find water at one fourth to one-third less speed of current. The highest rate at Ile Ronde extends only about a quarter of a mile in length up and down.

With the embankment built and 935 million cubic feet per hour flowing past Ile Ronde, the maximum rate of current at the centre at low water would, I estimate, be reduced to about 5½ miles an hour, and at high water it would be reduced to 4¾ miles.

These reductions are less than Mr. Bateman gives, but they are enough to be felt as a great relief to slow vessels, and especially to tows in ascending the current. But troublesome as the current St. Mary is, it does not seem to represent a very serious money loss. An average of four ordinary screw tugs do all the casual towing and moving of vessels of all sorts about the Harbour, and less than half their time is spent in the current, or because of it. The Harbour Commissioners' chain tug, built under special circumstances expressly to do the towing in the current, and successful mechanically, was found to be unneeded. After lying on her station, ready at signal for two or three seasons with nothing to do, she was withdrawn, and has been laid up uncalled for during the past four years With these facts in mind as regards the whole current, it would seem that taking away only about a third of its rate can hardly be of such practical value as to be much felt.

5.—*The water in the Harbour not to be lowered, but the Harbour Board by means of the Sluices to be able to regulate it to a uniform depth.*

Mr. Bateman makes the present summer fall, or difference in level between the surface of the water at the foot of the Lachine Canal and the foot of the Current St. Mary, to be 2 feet 3 inches. My own observations make it somewhat less than this, and go to show that it may be taken as between 22 and 24 inches. I find, too, that the swift water of the Current St. Mary does not suddenly lose nearly all its velocity, but at the Hudon Cotton Mill has a rate of nearly 4 miles, and at a mile further down, 3½ miles an hour, and also that on being reduced in velocity at the foot of Ile Ronde it throws up a stationary wave of only about 1½ to 3 inches. From this and the present current rates, I estimate that with the sluices in the embankment discharging 90 per cent. of their intended capacity, or 765 mil-million cubic feet per hour, there would, at time of low water, be about eight inches lower water in the Harbour at the foot of the canal than at present, the loss decreasing to about six inches at the middle of Ile Ronde, and running out to nothing at the Hudon Cotton Mills. At high water of 22 feet on the lock sill, the loss above Military Basin would be 13 to 14 inches, and below that it would run out to nothing at Hochelaga

These results differ considerably from Mr. Bateman's, as a mere matter of data and calculation, but practically the difference is of little importance; for, at the worst, the loss of 8 inches and under, at the time of low water, could be easily compensated for in the dredging which must be done to find material for the embankment, and the larger lowering of 13 inches when the river is as high as 22 feet on the sill, or 5 feet above low water, would be rather a benefit than otherwise.

6.—*The prevention of the packing of ice in the Current St. Mary, and consequent rise of water in the Harbour and lower parts of the City, and the piling of ice on the Wharves.*

The packing of ice in the Current St. Mary, would, I think, most certainly be stopped by the proposed embankment. If the controlling sluices be kept closed in winter as intended, the whole Harbour from the Hudon Cotton Mill up, would have only about one-fifth the present rate of currents, and would freeze over in a smooth sheet like any other slack water. So much of the rise in the upper part of the Harbour, as is due to ice jams in St. Mary's Current, would also be prevented, but below that matters would probably be just the same as now; for it must be remembered that a frequent cause of the rise from ice jams is the ice gorge *below* St. Mary's Current, and not in it or above it. In the great flood of 1861, when Griffintown, Victoria Square, and St. Paul Street were overflowed, the water at the foot of McGill Street was at the worst only 3 feet 2 inches higher than at Hochelaga, and about half of this would be due to the natural fall between these points.

Guagings are kept at Hochelaga only occasionally, so that neither averages nor extremes can be got at with exactness, but from a number of isolated measurements and general knowledge of the matter, I should estimate that the higher floods would be one to four feet less with the proposed embankment than without it. This would by no means do away with floods, but it would be a very beneficial reduction.

As regards the lodging of ice on the wharves in the spring, there would with the embankment be no piled up masses as are often left now, but the wharves would overflow from the rise of the river below as at present, and sheet ice forming at the high level would often be left on top of them when the water fell. There would be no current to form piles as now, but there might be plenty of smooth sheet ice instead.

7.—*Providing Railway connection between Montreal and St. Lambert Shores.*

It is obvious that this most important object would be attained, and in what seems to me a most excellent and effective manner.

8.—*Highway and foothpath connection between Montreal and St Lambert.*

This new and important desideratum would also be attained, though perhaps not in quite as convenient a form as could be wished. The great height of the bridge, the length of the combined bridge and embankment, and the position of the shore ends, would, I think, always be felt as disadvantages in so important a thoroughfare.

9.—*Providing Water Power at the Embankment.*

The Scheme would certainly supply water power of great extent and fairly satisfactory character during summer, but in winter it would, I think, be so inconstant as to be practically useless.

During the taking and breaking up of the ice in every autumn and spring, there are periods, varying from a few days to several weeks, when the river at and below Hochelaga and the Boucherville Islands, is nearly or wholly covered with stationary ice, while from there to Lachine, and often through Lake St Louis, there is open water and running ice. During such times the floating ice brought down by the Lachine Rapids and passed through the Harbour, packs under and amongst the stationary ice and gorges the channel below the City. The hydraulic condition of the river below is also changed from an open channel to a closed one with doubled perimeter, and from these causes the surface level rises so as to obliterate the swift current at the site of the embankment; or in other words, the water power at such times would be drowned out by back water.

Following the drowning out of the current, and after a lapse of time determined by the quantity of running ice, come the great "ice shoves," for which the St Lawrence at Montreal is noted. A glance at the map of the river and its shoals opposite the City, reveals the causes which make the main body of the water flow strongly towards the Montreal shore, bringing with it fields of ice which are thrown against the bank and piled up in huge masses. From the plan of the scheme too, it will be seen that the line of embankment is almost exactly parallel with the Montreal shore. The main shoals, the deepest water, the set of the current above the dam, and the narrowing in of the river below it, all bear substantially similar relations to each other and to the dam, as the same features do to each other and to the shore opposite the central part of the City; and plainly the causes which now work to heap up mounds of ice on the City front would hereafter act upon the dam, and would as certainly lodge the ice in similar great masses reaching to the bottom and choking the sluices beyond possibility of usefulness until cleared in the spring.

In all our northern rivers that are used for water power, and do not freeze over, it is well known that more or less difficulty is experienced from anchor ice or *frasil*, but probably in no river is it formed on a grander scale than in the St. Lawrence, and at few places is it gathered in greater quantity than at Montreal.

The long stretch of open and agitated water in and above the Lachine Rapids, supply the required conditions for its formation and storage in vast quantities, and with every rise of temperature masses are detached and swept down and lodged under the solid ice of the Laprairie Basin, the Harbour of Montreal and the River far below.

Winter surveys in the Harbour, show that nearly the whole area from Victoria Bridge to Hochelaga, is filled to depths of 10, 15 or even 30 feet, and great spaces are often packed full to the bottom. And this occurs not only, nor chiefly, in the slacker currents, but in the fastest as well. In the swiftest part of St. Mary's Current, it is always found, and sometimes in such quantity as to occupy at least one-third of the channel section. Last winter the St. Lambert Channel at the site of the proposed bridge, was also filled so as to reduce it to less than half its effective capacity.

With this enormous supply of *frasil*, and with the current sweeping the front of the embankment, the conditions are precisely such as are requisite to fill the sluices and flumes, and choke fast the gates and water wheels, and thus further contribute to render useless the water power during the winter.

But a scheme of water power fit for use only in summer, cannot be considered a completely, or at least a commercially, feasible one. Few mills or factories using large power, can afford to be idle during winter, and if they cannot have water they must have steam, which in this case would mean steam power four or five months of the year with water wheels and flumes of unusually large size, in order to utilize a very low water fall for the remaining months.

There are some notable examples of factories on the St. Lawrence Canals, where the power is from water part of the year, and steam and water together the remainder, but in these cases the falls are high, and therefore the wheels and flumes small, construction and land are cheap, and the lease or purchase of water merely nominal. With the present scheme all these would be reversed.

Lifts and warehouses for goods and grain are mentioned as cases in which a summer power only is required, but all that would probably be needed in this way on a mile and a quarter of wharf, would not utilize the power of a single sluice of the size proposed.

OTHER EFFECTS OF THE SCHEME.

Floods from Ice Shoves.

By far the greatest question raised by the Scheme is that of its probable effect upon the height of the River at the time of the great "Ice Shoves." Sir Wm. Logan has vividly described, and clearly discussed the causes of these grand phenomena of the St. Lawrence, and the following extract from his description will greatly assist in considering them in relation to the question in hand:—

"The frosts commence about the end of November, and a margin of ice of some strength soon forms along the shores of the river and around every island and projecting rock in it; and wherever there is still water it is immediately caked over. The wind acting on this glacial fringe, breaks off portions in various parts, and these proceeding down the stream, constitute a moving border on the outside of the stationary one which, as the intensity of the cold increases, is continually augmented by the adherence of the ice sheets which have been coasting along it; and as the stationary one thus robs the moving one this still further outflanks the other, until in some parts the margins from the opposite shores nearly meeting, the floating ice becomes jammed up between them, and a night of severe frost forms a bridge across the river. The first ice bridge below Montreal is usually formed at the entrance of the river into Lake St. Peter, where the many channels into which the stream is split up greatly assists the process.

As soon as this winter barrier is thrown across (generally towards Christmas) it of course rapidly increases by stopping the progress of the downward floating ice, which has by this time assumed a character of considerable grandeur, nearly the whole surface of the stream being covered with it, and the quantity is so great, that to account for the supply, many, unsatisfied with the supposition of a marginal origin, have recourse to the hypothesis that a very large portion is formed on, and derived from the bottom of the river where rapid currents exist.

But whatever its origin it now moves in solid and extensive fields, and wherever it meets with obstacles in its course the momentum of the mass breaks up the striking pack into huge fragments that pile over one another; or if the object be stationary ice, the fragments are driven under it, and there closely packed. Beneath the constantly widening ice barrier mentioned, an enormous quantity is thus driven, particularly when the barrier gains any position where the current is stronger than usual. The augmented force with which the masses then move pushes and packs so much below that the space kept for the river to flow in is greatly diminished, and the consequence is a perceptible rise of the waters above, which indeed from the very first taking of the "bridge," gradually and slowly increases for a considerable way up.

There is no place on the St. Lawrence where all the phenomena of the taking, packing, and shoving of the ice are so grandly displayed as in the neighbourhood of Montreal. The violence of the currents here is so great, and the river in some places expands to such a width, that whether we consider the prodigious extent of the masses moved, or the force with which they are propelled, nothing can afford a more majestic spectacle or impress the mind more thoroughly with a sense of irresistible power. Standing for hours together upon the bank overlooking St. Mary's current, I have seen league after league of ice crushed and broken against the barrier lower down, and there submerged and crammed beneath. And when we reflect that an operation similar to this occurs in several parts, from Lake St. Peter upwards, it will not surprise us that the river should gradually swell.

By the time the ice has become stationary at the foot of St. Mary's current, the waters of the St. Lawrence have usually risen several feet in the Harbour of Montreal, and as the space through which this current flows affords a deep and narrow passage for nearly the whole body of the river, it may well be imagined that when the packing here begins, the inundation rapidly increases. The confined nature of this part of the channel affords a more ready resistance to the progress of the ice, while the violence of the current brings such an abundant supply, and packs it with so much force that the river, dammed up by the barrier which in many places reaches to the bottom, attains in the Harbour a height usually twenty, and sometimes twenty-five feet above its summer level; and it is not uncommon between this point and the foot of the current, within the distance of a mile, to see a difference in elevation of several feet which undergoes many rapid changes, the waters ebbing or flowing according to the amount of impediment they meet with in their progress, from submerged ice.

It is at this period that the grandest movements of the ice occur. From the effect of packing and piling, and the accumulation of the snows of the season, the saturation of these with water and the freezing of the whole into a solid body, it attains the thickness of ten to twenty feet and even more; and often it has become fixed as far as the eye can reach, a sudden rise in the water (occasioned no doubt in the manner mentioned) lifting up a wide expanse of the whole covering of the river, so high as to free and start it from the many points of rock and resistance offered by the bottom, where it had been packed deep enough to touch it, the vast mass is set in motion by the whole hydraulic power of this gigantic stream. Proceeding onward with a truly terrific majesty it piles up over every obstacle it encounters; and when forced into a narrow part of the channel the lateral pressure it there asserts drives the bordage up the banks, where it sometimes accumulates to the height of forty or fifty feet."

In looking more closely at the physical characteristics which contribute to produce these grand phenomena, it will be seen that after passing the Lachine Rapids with a fall of some 30 feet, the River widens into the Laprairie Basin 4 miles in breadth, and is again narrowed by the abutments of the Victoria Bridge to 6,570 feet, or 1¼ miles. Opposite Montreal, where divided by St. Helen's Island, it has a width of 1,900 feet in the Montreal channel, and 2,700 feet in the St. Lambert channel, making 4,600 feet, or ⅞ of a mile total water way, measured at the high water line. Below St. Helen's and Ile Ronde the river unites and passes Longueuil with a breadth of ⅝ of a mile, and again widens out to the Boucherville Islands which it passes in a main channel 1¼ miles wide, and another a quarter of a mile wide. Between the St. Lambert and the old Brassey wharf, just below the Victoria Bridge, the river's breadth is reduced to 5,000 feet, or a little under a mile, (counting in the openings in the St Lambert pier,) but at high water these wharves are submerged to a considerable depth and floating ice passes freely over them. At Ile Ronde too, where the St. Mary's current is narrowed, the Island is submerged at high water, and the loss of breadth is made up by the enlargement and deepening of the channel between Ile Ronde and St. Helen's.

The height of the river at which the great ice packs take place, varies very much, but taking 15 feet above low water at Montreal and 10 feet above low water in the Laprairie Basin as common heights, the depth of water over a large area in the central part of the Basin, will then be from 20 to 25 feet, and at the Victoria Bridge 14 to 28 feet. In the Current St. Mary, 1,900 feet wide, the greatest depth will be 65 feet, and the average 35 feet, giving a cross section of water way of about 73,000 square feet. The St. Lambert Channel of 2,700 feet, (or say ½ a mile,) is 26 feet maximum, and 15 feet average depth with 40,000 square feet cross section. In the two channels at St. Helen's, there is therefore at this height of water a sectional area of 113,000 square feet, equivalent to an average depth of 24½ feet over the whole 4,600 feet width. At Victoria Bridge the sectional area, after deducting the piers, is about the same; at Longueuil it is considerably larger, and at Boucherville it is over twice as large.

As regards currents, the motive power in ice shoves, there is in summer a rate of about 1½ to 3 miles an hour in the main channel through the Laprairie Basin; 3 to 6 miles between the piers of the Victoria Bridge; 4¾ to 7½ miles in the St. Mary's Current; 3½ to 4 miles at Hochelaga, and about 2½ miles further down. In winter the packing of the ice into inverted shoals, solid islands and dams of every size, often throws the currents entirely out of their ordinary courses and changes them to any speed from a sluggish flow to a rush of 10 or 15 miles an hour.

The condition of the ice itself and the force with which it is brought down by the currents, are well described by Sir Wm. Logan in the extract already given; but it must be noted, that as regards the Harbour, the ice fields are now limited in their breath to the 330 and 240 feet which can pass the spans of the Victoria Bridge.

The gorging of the river and the formation of ice dams are, however, not due to the size of the masses, but to their quantity, for only such blocks as can be rolled under the stationary ice are effective in choking up the water channel.

In investigating the practical consequences of ice jams, as distinct from their causes, it appears at once that it is only the floods which accompany the jams that are of serious importance. The movements of the ice itself for the most part occur within well known limits and are easily guarded against, but the floods extend over great and indefinite areas and work serious damage.

For instance the flood of April, 1861, already mentioned, was caused by the packing of the ice at one or more places about the Boucherville Islands. The water rose until at McGill Street it stood 25 ft 2 ins. above low water, (42 ft. 2 ins. above the lower lock sill, Lachine Canal) flooding the low parts of the City and causing great suffering and damage. A considerable part of Longueuil, St. Lambert and Laprairie Villages, and a large area of country on that side of the River, and along the Lower Lachine Road on the other side, were also submerged and serious damage done. In April, 1865, another flood occurred, only 1 ft. 6 ins. lower, and with proportionate damage. In April, 1858, a flood occurred from a jam somewhere in the neighborhood of the Victoria Bridge, and the water in the Laprairie Basin was raised to 44 feet above the level of the Lock Sill, or about 14 feet above low water, and overflowed more than half the ground from Point St. Charles to half a mile above the St. Pierre Road, and between the river and the Water Works Aqueduct. In January, 1857, during a period of unusual cold, a great part of the ordinarily open water of the Lachine Rapids was frozen over, and on the ice breaking loose shortly after, it packed in the upper part of the Laprairie Basin, then partly burst away and reformed at Nun's Island, when the water in the Basin above suddenly rose to 17 feet over low water at the St. Pierre Road, 19 feet at Mr. J. S. Hall's, and 24 feet at Mr. Lesage's. The Lachine Rapids were almost obliterated; the whole country between the River and the Aqueduct overflowed; the Aqueduct banks were sufficiently overflowed to pour river water down the Aqueduct and flood the Water-works Wheel-house; the ice shoved over the river bank and road near Nun's Island, and demolished two houses and did much petty damage.

These and other instances which might be quoted, all go to show that the channels of the river are already too small, that they are liable to be choked with ice in any winter, and the experiences of the past to be repeated.

But in the Scheme it is proposed to close up the Main Channel on the Montreal side of St. Helen's Island, which is two-thirds of the whole water way of the river, and turn its flow through the other third alone.

It is not at all a question of the capacity of the St. Lambert Channel as compared to that of the Montreal Channel; but as compared to their capacities combined; and as compared to the capacity of the whole river channel in the vicinity. Whatever increase of capacity the St. Lambert Channel can have given it by the highest permissible rise of water with the completed scheme, it may have, and does have now; and it has the main, or Montreal channel, beside, with all the addition that the same rise of water will make in that too. It is not proposed to do anything of importance towards enlarging the St Lambert Channel; for the deepening of a portion for the boat channel will just about compensate for the space taken by the piers of the proposed bridge and will leave its capacity practically the same as now. The water is intended to be raised high enough to force itself through, but no elevation of the surface, within the safe flood level, can give this channel alone a sectional area equal to that of both

channels. But it is not a mere question of sectional area, for manifestly the great depth of the central part of St. Mary's current, is a safe-guard against its being choked by the ice while a shallow one is especially liable. If however a pack does take place in the deep channel of sufficient extent to retard the water and cause it to rise farther up, the St. Lambert Channel comes in to assist, and the two together pass the water with ease.

The bottom of the St. Lambert Channel, even when cleaned out as contemplated in the scheme, will be higher than the river bottom elsewhere in the vicinity. Apart from the boat channel in it, the bottom will be about five feet higher than the present bed of the river in the main channel above it; in fact the embankment and the St. Lambert shore may be looked upon as the banks of a huge mill race, and the bottom at the site of the proposed bridge, as the weir over which the surplus water is to pass. Or, to place it in a form which we may more readily realize:—Suppose that eleven of the south-eastern spans of the Victoria Bridge on the St. Lambert shoals be left open, and that the intended embankment, sluices and all, to be placed from the eleventh to Nuns' Island, so as to close the remaining fourteen spans on this side, and to pass the whole river, or at least seven-eighths of it, through the eleven open spans. And, to complete the comparison, suppose the river bank at St. Lamberts to be filled out above the bridge to the end of the abutment, there would then be practically the same condition of things as proposed in the scheme. There would be the same funnel shape for the ice to wedge into, and the same bridge and shallow bottom to obstruct its getting through. With such conditions, and they are fairly similar, any resident of Montreal will readily see the certainty of such ice jams as would produce most disastrous floods over the whole banks of Laprairie Basin.

But returning to the actual scheme; it will be remembered that the controlling sluices are intended to be shut in the fall and kept so until spring, and only the mill sluices, with a nominal discharging capacity of about one-fourth of the river, are to be kept open. The contingency of an ice jam at the proposed bridge suggests the opening of the sluices to pass the surplus water through the embankment, but it is more than probable that such a jam would also choke the mouths of the sluices and render them unfit for use precisely when needed for relief.

It has been suggested that the speed of the current in the St. Lambert Channel, after the carrying out of the Scheme, would sweep the ice through it and prevent a serious block; but Mr. Bateman estimates that the current in the St. Lambert Channel would be 1½ miles less, or at most no greater, than that in the St. Mary's Current, where so much packing now takes place.

Mr. Bateman's report states that levees will be built wherever necessary, to prevent low lands being flooded, but nothing of the kind is mentioned in the Bill, nor shown on the plans, and it can hardly be understood that the brief statement in the report would insure the construction of works of the required magnitude. In fact, Mr. Bateman, says that while the proposed works are expected to raise the water at Laprairie only 4½ feet, the lowest land is some 11 feet above present water, and it is therefore impossible that it would be flooded. But it floods already. With all the channels we now have, several square miles of country have been submerged and people have paddled over their farms in canoes.

In view, therefore, of the known choking of the St. Lawrence by ice in the greatly larger, and deeper, and better formed channels in the vicinity of Montreal, I am decidedly of the opinion that to attempt to confine the river to the St. Lambert Channel in winter, as proposed in the Scheme, would cause much greater and more frequent floods, on the banks of the Laprairie Basin and in the neighborhood of the proposed embankment, than have hitherto occurred.

Deviation of the Navigable Channel between the Harbour and Victoria Bridge.

The new channel which is proposed in compensation for closing the present one, would pass round the south-east side of St. Helen's and Ile Ronde, nda enter the Harbour at Hochelaga. It would, according to the bill, be not less than 300 feet wide and 16 feet deep at low water, and its greatest current as estimated by Mr. Bateman, would not be over 7 miles an hour. It is intended too, that passengers may be landed from the Laprairie and other boats on the up stream side of the embankment.

The breadth and depth of the proposed new channel east of St. Helen's, appear to me to be sufficient for the requirements of navigation, and although I am at a loss to see how its current, under the conditions sketched out in the bill, would not considerably exceed 7 miles an hour, I have no doubt that it could easily be so arranged as to have speeds not exceeding some of those in the present current. Its chief disadvantage is obviously its circuitous course: it would add 2½ miles to every trip to and from the upper part of the harbour, with the additional disadvantage that there would either be the Current St Mary, or that in the new channel to be ascended every trip; while now there is a current only one way. Practically, it would amount to about 20 minutes extra running in each down trip, and 30 minutes in each up trip of a boat capable of making 12 miles an hour in still water. Beyond the extra running of boats, and loss of time to their passengers, I see no important objection to the proposed deviation of the channel.

For rafts, the St. Lambert Channel would be equally as good as the present Main Channel and it would be a benefit of some importance to have them prevented from passing through the harbour.

The plans show a clear headway under the proposed bridge of only about 48 feet, which is 12 feet less than that under the Victoria Bridge, and this is, I think, an objectionable feature in the Scheme.

Although not strictly within the scope of my instructions, it may not be out of place to draw attention to the fact that the wharfage proposed in the Scheme, would be within the boundaries of the Montreal Harbour. The bill, as I understand it, would confer upon the Company independent powers to act as wharfingers at their own wharves, and there might thus be established within the Harbour a system of wharfage, which to say the least, might be very embarrassing to the Harbour Commissioners in carrying out their Public Trust.

Yours respectfully,

JOHN KENNEDY.

Chief Engineer.