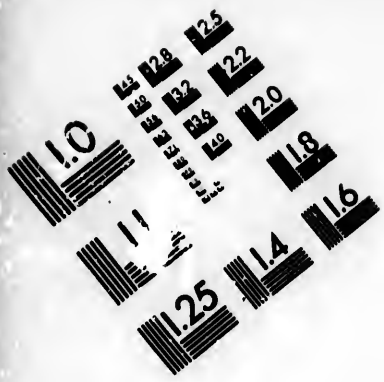

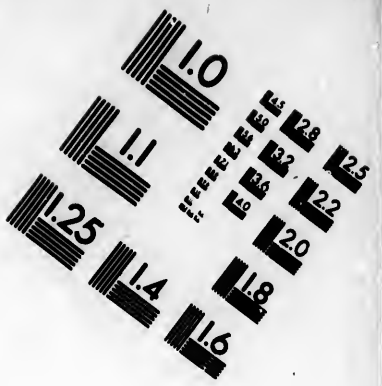

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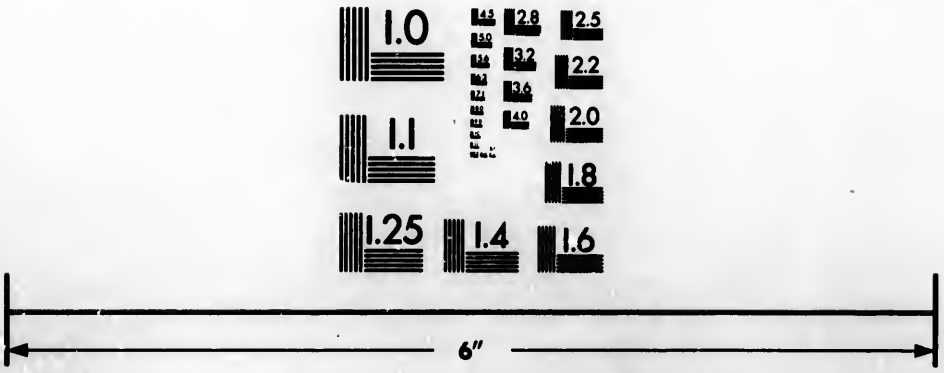

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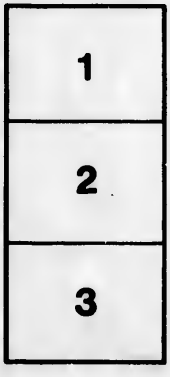

REPORT

ON A SURVEY FOR THE

RAILWAY BRIDGE

Over the St. Lawrence

AT MONTREAL,

SURVEYED IN 1851-52, BY ORDER OF THE COMMITTEE OF THE MONTREAL AND KINGSTON RAILWAY.

Hon. John Young, Chairman.

THOS. C. KEEFER,
ENGINEER.

MONTREAL:
PRINTED BY JOHN LOVELL, AT HIS STEAM-PRINTING ESTABLISHMENT, ST. NICHOLAS STREET.
1853.

map sent to Map Division
on June 10, 1964

Class. no. H12 - 340, Montreal, 1852

PREFACE.

THE question of bridging the St. Lawrence, at Montreal, having recently assumed an important shape, it may be proper here to give some account of its origin and progress.

In 1846, in consequence of some letters written by Messrs. Young and Elder, in the *Economist*, a paper then published in Montreal, a committee was organized who employed Mr. Gay, engineer of the Columbia and Philadelphia Railroad, to make a survey, plans and report. Mr. Gay's report, which with his estimate will be found in the Appendix, was based upon the supposition that no provision for the navigation in this part of the St. Lawrence would be required. No argument is here necessary to shew that any proposition for bridging the St. Lawrence which would involve the obstruction of the navigation, cannot now be entertained.

On the 23rd September, 1846, the following resolution was passed at a meeting of the directors of the St. Lawrence and Atlantic Railroad:

It was moved by Mr. Young, and seconded by Mr. Galt,—

That this board do hereby authorize the company's chief engineer to cause a survey to be made of the proposed bridge across the St. Lawrence, for the purpose of ascertaining its practicability, and an approximate estimate thereof.

The result of this resolution was the line of soundings, alluded to in Mr. Gay's report, but it

does not appear that any plans or estimates were made by Mr. Morton, the company's engineer.

In consequence of the foregoing action, a charter was carried through the House of Assembly in 1847, but was arrested in the Legislative Council.

In May, 1851, the question was revived on the occasion of making the survey for the Montreal and Kingston Railroad. The sum of £1500 was loaned by the St. Lawrence and Atlantic Railroad Company for the above survey, upon the express condition that it should embrace a connection between the two roads—by means of a bridge across the St. Lawrence at Montreal. This appropriation was exhausted by the railroad survey before that for the bridge was completed, and another loan of £150 was obtained from the harbor commissioners, in view of the advantages which the harbor interest would derive from a thorough hydrographic survey of the river opposite Montreal.

The delay in publishing this report has been caused by a deficiency in the means necessary to complete the plans, &c., as fully as was intended. The recent assumption of the enterprise by the Grand Trunk Railway Company of Canada, has rendered any further expenditure upon the part of the committee unnecessary.

TO THE HONORABLE JOHN YOUNG,

Chairman of Committee Montreal and Kingston Railroad.

SIR,

I have the honor to report the completion of the Survey made under the following instructions, received by me on the 3rd of June, 1851 :—

MONTREAL, 3rd June, 1851.

SIR,

The committee appointed at the public meeting, hold in this city on the 3rd of March last, for the purpose of taking such steps as may be necessary for the construction of a railroad from this city to Kingston, request that you will take charge of the survey and location of said road, and in reference thereto, they would wish you to be guided by the following instructions:

1st. You are to choose the shortest and best line, from this place to some point at or near Kingston, which may be found in consideration of the ground, levels, &c., the best adapted for a part of the Great Trunk Line to Windsor opposite Detroit.

2nd. The committee desire that you should report fully your reasons for choosing the line you may adopt, so as, if possible, to satisfy those who may have views adverse to yours.

3rd. The committee also wish you to survey and make full plans and estimates, for a bridge across the St. Lawrence at such point as you may deem best—starting from a supposed terminus on the St. Gabriel Farm, at or near the first basin above Wellington Bridge on the Lachine Canal, and continuing your survey of the road from the opposite bank of the St. Lawrence to the best point of intersection with the Portland Railroad.

4th. After completion of the bridge surveys, plans, &c., it is the wish of the committee that said plans may be submitted to three or more engineers for approval; for although the committee have every confidence in your professional attainments, yet, as this scheme of bridging the St. Lawrence is a work of more than ordinary magnitude and responsibility, and as it is important to create among capitalists as much confidence in its practicability as possible, the

committee are sure you will agree with them in the necessity for submitting your plans, &c., to a board of engineers whose names may be hereafter decided between you and the committee.

Wishing you every success in this enterprise,

I am,

Sir,

Your obedient servt.,

JOHN YOUNG,
Chairman of Committee.

T. C. KEEFER, Esq., Civil Engineer.

A preliminary examination was made during the month of July, 1851, which was suspended in order to proceed with the railroad survey during the summer months. From the knowledge I had acquired of the bed of the River St. Lawrence, while making the survey for the improvement of the rapids under instructions from the department of Public Works in 1850, I was convinced that a thorough hydrographic survey of the shoals opposite Montreal would be required before the bridge site could be selected. The great width of the river—the strength of the current and the irregularity of the shoals would have greatly enhanced the expenditure of time and money by endeavouring to obtain an accurate chart by the use of boats; for this reason it was considered more judicious to postpone the survey until the formation of ice would enable us to fix with economy and certainty the dimensions and positions of the different shoals and channels. The precision acquired by measurements and soundings upon the ice, is invaluable in such an important undertaking, and the results of the survey have fully confirmed my anticipations with respect to the peculiar conformation of the bed of the St. Lawrence opposite Montreal, and its remarkable adaptation for a bridge site.

I will first state what I conceive to be the conditions of bridging the St. Lawrence, and then proceed to a des-

cription of the characteristics and phenomena of the river above and below Montreal, before alluding to the details of the bridge and the principles of its construction.

First. The bridge must be so arranged as not to obstruct the navigation. The navigation of the section of the St. Lawrence in which it is proposed to bridge is in one direction (downward) only—the ascending craft going by canal; also it is confined to daylight, as no craft will attempt to descend the rapids in the night. In so far, therefore, as any bridge may be considered an impediment to a navigation, it is evident, from the considerations above mentioned, that the site proposed would offer the minimum of obstruction. The current being such as to render a drawbridge inadmissible, there is no other means of providing for the navigation than by elevating that portion of the bridge which spans the navigable channel, *above* the limits required for the passage of craft. This height in the case of the Menai Bridge, in Britain, and the Harlaem Bridge, (for the Croton Aqueduct) in America, has been established at one hundred feet.

The bridge site being above the "sea navigation" of the St. Lawrence, I applied at Oswego for information as to the headway required for lake and river craft, and submit the following reply from a most competent quarter. From this it will be seen that with the topmasts struck, the main spars of the largest lake craft stand 86 feet above the water line, so that the provision I have made of 100 feet above low water and 91 feet above highest water at any navigable period, must be considered ample:

"Office North Western Insurance Co.
Oswego, 14th June, 1852.

Thos. C. Keefer, Esq.,
Montreal.

Sir,

At the desire of Messrs. Bronson and Crocker, and complying with yours of 10th inst., I hand you the length of spars of our largest

lake craft navigating between this and Chicago, and occasionally to Montreal.

Our hermaphrodite brigs' (so called) extreme length of foremast is about one hundred and sixteen feet from water line to truck. Length of foremast, from kilson to cap, 58 feet; topmast, from heel to cap, 38 feet; top gallant mast, 21 feet; royal mast, 13 feet; mast head, 6 feet. Deduct for spar from kilson to water line and for mast heads in the doublings leaves the above height. The spars of this class of vessels could be struck to the lower mast head with the same facility as sea-going vessels of same size and rig; they are fitted in the same manner. Our largest fore and aft schooners' main masts are about 90 feet from heel to cap, and top mast 45 feet; deduct four feet from step to water line, and eleven feet for mast head, would leave extreme length of spar from water one hundred and twenty feet. The top mast of this class of vessels could, with little time or trouble, be struck to pass under a bridge if required which would reduce the spars to *eighty six-feet* length.

The highest chimney on any steamer navigating Lake Ontario, including hull of boat, is sixty-four feet from water line to top. This last is the steamer Ontario.

The above dimensions are taken from drafts of our largest lake craft, and I trust will be satisfactory.

Respectfully yours,

WM. MORGAN,
Marine Inspector
for North Western Insurance Co."

To shew the impracticability of accommodating the navigation by means of a "draw-bridge," I would state that the Supreme Court of the United States have decided in the Wheeling Bridge case, that for the current of the Ohio (which is less than that of the St. Lawrence opposite Montreal) a "draw" of *two hundred feet* in width is the least which can be accepted.

Even if it were practicable to meet the requirements of the navigation by a "draw-bridge," it is questionable whether the "high level" bridge would not be preferable. The highest known ice floods have risen to a point 25 feet above extreme low water mark. It would not be prudent to place the superstructure of a bridge

within at least 20 feet of this point, so that *any* bridge over the St. Lawrence at Montreal must be elevated about 45 feet over low water mark. Fixing the abutments, therefore, at this height, the additional cost of elevating the whole bridge gradually from either shore to the height required to pass *over* the navigable channel will not be much greater than the cost of a draw-bridge, and the necessary approaches and expense attendant upon it. The fact that there is but *one* navigable channel, and this so narrow that it can be spanned by a single arch, has enabled me, by elevating to the extreme height *this arch only*, to make an arrangement of the bridge which while it admits of the greatest economy in the construction, enhances the architectural effect, and offers an unmistakeable guide to lead the river craft into the proper channel.

By increasing the centre span the channel may be crossed higher up and the bridge shortened,—the width of the other spans and the length of the approaches may be increased or diminished and the outline of the structure may be varied, but I am of opinion that the plan now proposed for bridging the St. Lawrence will, in all essential features be found the most secure, effective, and economical.

The second condition is, that the bridge must be a *solid* one adapted to the passage of railway trains.

Suspension bridges in this country have of late been adopted for large bridges, and are now about to be applied to railway purposes. Where a channel is too wide to be spanned by beams or arches, or where the depth of water or narrow chasms make piers or towers impracticable, the suspension bridge is the only and most economical resource. For railway purposes a single span may be made available, but for a long bridge where a succession of spans are required, if constructed in the ordinary manner the vibration would be destructive to the work, and if constructed on any other principle their economical advantages disappear. From the vastly in-

creased quantity of masonry required a suspension bridge would be more expensive in the site proposed than any other class of structure.

The third condition is that the bays or distance between the piers should be as wide as practicable. From economical considerations only the great cost of every pier would dictate the employment of the least possible number; but as the "conditions" proposed have no reference to the *cost* of the structure, I would state that it is on account of the requirements of the timber navigation and the safety and efficiency of the structure itself that I have left a clear water way of about 250 feet for each bay. The usual length of a "dram" of timber floating down the river ranges from 200 to 240 feet, and as rafts are not under the same control as boats but are liable to be driven from one side of the river to the other by wind, the raftsmen cannot select a particular arch for shooting the bridge, nor are they able to prevent its "swinging" and passing broad side through.

The importance of the solid approaches upon the shoals at either end of the bridge (which will be explained in another place) renders it desirable that this arrangement should be maintained, and as thereby a considerable portion of the water way of the stream is occupied—forcing the passage of the river toward mid-channel—it is clear that, unless the number of piers are kept within certain bounds, too much of the area of discharge may be taken up particularly if the large "shoes" of crib work surrounding the base of each pier,—which I consider indispensible, are adopted.

But the most important argument in favor of wide bays is that all risk of an "ice jam" between the piers is thereby reduced if not wholly removed. The greater the distance between the points of support the weaker will be the resistance of any solid sheet of ice arrested by the piers, and the more rapidly it will be borne down, broken,

and driven through by the current and following ice. Although there might be little or no risk to an elevated bridge from the jamming of ice, yet a greater evil, that of a temporary stoppage and overflow of the adjacent bank above the bridge, is incurred by planting the piers too close to each other.

Having stated, first, that the bridge should pass *over* the navigation; second, that it should be a solid railway bridge resting upon piers, and thirdly, that these piers should be as few in number as practicable, I will add, that it is greatly to be desired that so extensive and important a structure could be constructed of some more durable and less inflammable material than wood. The length of superstructure required is above 7000 feet, the cost of which, if constructed of iron, would be about six times greater per lineal foot than if built of wood. The *extra* cost of iron over wood would be about £500,000 or much more than the whole estimate for a wooden bridge. A wooden bridge properly constructed and protected will last at least half a century, and if it were not for the contingency of fire would be all that is needed.

This risk of fire should not, however, operate against the construction of the bridge in wood—if the more expensive structure be unattainable—because it is slight, considering the vast number of wooden railway bridges in America,—and would be reduced in the present instance to a very remote contingency. Cut off by the solid approaches from either shore, and elevated where the wooden structure would necessarily commence from 50 to 100 feet above the water, it is exposed to fire only from the passing of engines. The rails being laid *upon the top* of the bridge—with the exception of the centre span which would be iron—by casing in the sides, top and bottom, no accidental fire could be communicated to it, and as the bridge would be under constant surveillance I consider the risk of fire should be no barrier to its early con-

struction. The width of the spans have been established at nearly the limits of a wooden structure for railway traffic, both for reasons already given, and with a view of replacing, at some future date, the remainder of the hollow wooden beams by similar ones of iron.

It has been proposed to arrange the bridge for ordinary traffic as well as for railway trains. This I have not done, considering it unnecessary—and objectionable if a wooden structure be adopted. In winter the carriage way underneath the rail, being covered, would be impassible for lack of snow; but, if by any arrangement made passable, it would not be used (except for a few days while the ice is forming or leaving) because of the *detour* made by the bridge. For the same reason, ferries, in summer, by running directly to the Bonsecour Market or other desired points, would compete successfully with the bridge for the local traffic. The revenue to be anticipated from this source would not pay the collector, and it would be manifestly imprudent to expose a wooden bridge to the ever active pipes of passing *habitants*.

A path for foot passengers can, however, be projected from the sides of the bridge, which would be profitable, as it must become a favourite resort.

In proceeding to the consideration of the question of the practicability of bridging the St. Lawrence at Montreal, and of the advantages of the site proposed, I feel it necessary to enter at some length into the local phenomena of the river at this point, because it cannot be concealed that there exists a doubt as to the possibility of overcoming the physical as well as financial obstacles of the question. I cannot better introduce this subject than by extracting the following admirable description of winter phenomena in the St. Lawrence, contributed to the Geological Society of London, on the 15th June, 1842, by our distinguished Provincial Geologist, W. E. Logan, Esq.:

"The island of Montreal stands at the confluence of the rivers Ottawa and St. Lawrence, and is the largest of several islands splitting up these mighty streams, which cannot be said to be thoroughly mingled until they have descended some miles below the whole cluster. The rivers first come in contact in a considerable sheet of water called Lake St. Louis which separates the upper part of the Island of Montreal from the southern main. But though the streams here touch, they do not mingle. The waters of the St. Lawrence, which are beautifully clear and transparent, keep along the southern shore, while those of the Ottawa, of a darker aspect, though by no means turbid, wash the banks of the island; and the contrast of colour they present strongly marks their line of contact for many miles.

Lake St. Louis is at the widest part about six miles broad with a length of twelve miles. It gradually narrows towards the lower end, and the river as it issues from it, becoming compressed into the space of half a mile, rushes with great violence down the rapids of Lachine, and although the stream is known to be upwards of eight feet deep, it is thrown into huge surges of nearly as many feet high as it passes over its rocky bottom, which at this spot is composed of layers of trap extending into floors that lie in successive steps.

At the termination of this cascade the river expands to a breadth of four miles, and flows gently on, until it again becomes cramped up by islands and shallows opposite the city of Montreal. From Windmill Point and Point St. Charles above the town, several ledges of rock, composed of trap lying in floors, which in seasons of low water are not much below the surface, shoot out into the stream about 1000 yards: and similar layers pointing to these come out from Longueuil on the opposite shore. In the narrow channel between them, the water, rushing with much force, produces the Sault Normand, and

cooped up, a little lower down by the island of St. Helen and several projecting patches of trap, it forms St. Mary's current.

The interval between St. Helen and the south shore is greater than that between it and Montreal; but the former is so floored and crossed by hard trap rocks that the St. Lawrence has as yet produced but little effect in wearing them down, while in the latter it has cut out a channel between thirty and forty feet deep, through which the chief part of its waters rush with a velocity equal to six miles per hour. It is computed that by this channel alone upwards of a million of tons flow past the town every minute.

Between this point and Lake St. Peter, about fifty miles down, the river has an average breadth of two miles, and proceeding in its course with a moderate current, accelerated or retarded a little, according to the presence or absence of shoals—it enters the lake by a multitude of channels cut through its delta, and forming a group of low flat alluvial islands.

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 cased 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 border thus robs the moving one this still further outflanks the other, until in some part 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 assist 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 an obstacle in its course the momentum of the mass breaks up the striking part into huge fragments that pile over one another: or if the obstacle 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 left 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 phœnomena of the taking, packing and shoving of the ice are so grandly displayed as in the neighbourhood of Montreal. The violence of the currents is here 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 after 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 rest 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 exerts drives the bordage up the banks where it sometimes accumulates to the height of forty or fifty feet. In front of the town of Montreal there has lately been built a magnificent revetment wall of cut limestone to the height of twenty-three feet above the summer level of the river. ***This wall is now a great protection against the effects of the ice.*** Broken by it, the ice piles on the street or terrace surmounting it and there stops; but before the wall was built, the sloping bank guided the moving mass up to those of gardens and houses in a very dangerous manner, and many accidents used to occur. It has been known to pile up against the side of a house distant more than 200 feet from the margin of the river, and there break in at the windows of the second floor. I have seen it mount a terrace garden twenty feet above the bank, and crossing the garden enter one of the principal streets of the town. A few years before the erection of the revetment wall, a friend of mine, tempted by the commercial advantages of the position, ventured to build a large cut stone warehouse. The ground floor was not more than eight feet above the summer level of the river. At the taking of the ice, the usual rise of the water of course inundated the lower story and the whole building becoming surrounded by a frozen sheet, a general expectation was entertained that it would be prostrated by the first movement. But the proprietor had

taken a very simple and effectual precaution to prevent this. Just before the rise of the waters he securely laid against the sides of the building at an angle of less than 45°, a number of stout oak logs a few feet asunder. When the movement came the sheet of ice was broken, and pushed up the wooden inclined plane thus formed, at the top of which, meeting the wall of the building it was reflected into a vertical position, and falling back in this manner, such *an enormous rampart of ice was in a few minutes placed in front of the warehouse as completely shielded it from all possible danger.* In some years the ice has piled up nearly as high as the roof of this building. Another gentleman, encouraged by the security which this warehouse apparently enjoyed, erected one of great strength and equal magnitude on the next water lot, but he omitted to protect it in the same way. The result might have been anticipated. A movement of the ice occurring, the great sheet struck the walls at right angles and pushed over the building as if it had been a house of cards. *Both positions are now secured by the revetment wall.* Several movements of the grand order just mentioned occur before the final setting of the ice, and each is immediately preceded by a sudden rise of the river. Sometimes several days and occasionally but a few hours will intervene between them, and it is fortunate that there is a criterion by which the inhabiants are made aware when the ice may be considered at rest for the season; and when it has, therefore, become safe for them to cut their winter roads across its rough and pinnacled surface. This is never the case until a longitudinal opening of some considerable extent appears in some part of St. Mary's current. It has embarrassed many to give a satisfactory reason why this rule, derived from the experience of the peasantry, should be depended on. But the explanation is extremely simple. The opening is merely an indication that a free sub-glacial

passage has been made for itself by the water through the continued influence of erosion and temperature, the effect of which where the current is strongest has been sufficient to wear through to the surface. The formation of this passage shows *the cessation of a supply of submerged ice* and a consequent security against any further rise of the river to loosen its covering for any further movement. The opening is thus a true mark of safety. It lasts the whole winter, never freezing over, even when the temperature of the air reaches 30° below zero of Farenheit; and *from its first appearance the waters of the inundation gradually subside*, escaping through the channel of which it is the index. The waters seldom or never, however, fall so low as to attain their summer level; but the subsidence is sufficiently great to demonstrate clearly the prodigious extent to which the ice has been packed and to show that over great occasional areas it has reached to the very bottom of the river. For it will immediately occur to every one that when the mass rests on the bottom its height will not be diminished by the subsidence of the water, and that as this proceeds, the ice according to the thickness which it has in various parts attained, will present various elevations after it has found a resting place beneath until just so much is left supported by the stream as is sufficient to permit its free escape. When the subsidence has attained its maximum, the trough of the St. Lawrence, therefore, exhibits a glacial landscape undulating into hills and valleys that run in various directions, and while some of the principal mounds stand upon a base of 500 yards in length by a hundred or two in breadth, they present a height of ten to fifteen feet above the level of those points still supported in the water."

I have italicised some passages in this extract as bearing upon its application to the bridge question. It will be necessary first, however, to review and extend the

description with special reference to the difficulties to be encountered. The disturbance of the river level by the action of the ice is peculiar to Cornwall and points below the Lachine rapids. The current between Caughnawaga and the head of the Lachine rapids, and that at the head and foot of all the rapids above these, except the Longue Sault, viz: the Coteau, Cedars and Cascades, and those of the Ottawa, is not checked and frozen over during the winter as is that of current St. Mary and of the Sault Normand. There is no doubt that if the level of the river opposite Montreal harbour were undisturbed by the action of the ice, the Current St. Mary, the Sault Normand, and the Laprairie basin would remain unfrozen.

Lakes St. Louis and St. Francis freeze over, and although vast quantities of ice descend and are formed in the rapids above them during the whole winter, the ice does not pass on *under* the frozen surface of the lake or produce any permanent or important effect on the level of the river. It piles at the foot of the rapids, where it is destroyed gradually on the approach of spring—without passing through the lakes. Also, after the Laprairie basin becomes frozen over, large quantities of ice are still brought down and piled at the foot of the Lachine rapids, which remain there.

All the destructive effects of the ice are incidental to the elevation of the river and the sudden "slipping" of some of the ice dams, and it becomes important therefore to consider *where* and *how* these are formed—and whether they can be ameliorated or guarded against.

The ice first "takes" in Lake St. Peter, fifty miles below this city, *after* the St. Lawrence has received the main branch of the Ottawa, and several large streams from the north and south shores. The stopping of the ice on the shoals in and at the entrance to this lake, gradually raises the level of the St. Lawrence as far up as Bout de l'Isle and Point Aux-Trembles, but seldom to a

height greater than five feet, which therefore is for this portion of the river the excess of the winter level over that which obtained before the commencement of frost. This amount of elevation would on account of the current be but slightly felt in Montreal harbour, where the average excess of the winter over the autumnal level of the water is three times as great. We thus find the water standing at a winter elevation in our harbour of fifteen or twenty feet, while twelve miles below us at the same moment of time the elevation does not exceed five feet. Similar investigations will shew that the principal obstructions are found between Montreal and Longue Pointe. The "longitudinal opening" in the Current St. Mary, described by Mr. Logan, proves that the greatest encroachment on the discharge of the stream takes place at this point.

The ice also takes at the head of Isle Bourdon or Porteous' Island,(at Bout de l'Isle,) among the first points: no drift ice therefore comes out of the Ottawa to block up the main channel of the St. Lawrence and set the waters back upon Montreal: and since there are no streams coming into the St. Lawrence between Montreal and Bout de l'Isle, the materials of the ice dams must be derived from points adjacent to and *above* the city.

It is therefore certain that the inundations are to be attributed to dams formed by ice floated *past* the city, that they are not the result of operations going on *below* us, and which cannot be influenced by improvements here. Having established the point where the ice dams are made, it is important next to examine the area from which they draw their supplies.

The length of river which sends down ice for the formation of these dams is about fifty miles—extending from Montreal to lake St. Francis. This lake being comparatively deep becomes frozen over early, and arrests the ice which descends from Prescott and the intermediate islands—another stretch of about fifty miles of river. Corn-

wall therefore presents phenomena similar to Montreal. The great distance, numerous islands, the strong currents and rapids between Prescott and Cornwall, send down inordinate quantities of ice, which being arrested by the solid crust over the lake St. Francis, "flashes" the river opposite Cornwall. In like manner the current, the rapids of the Coteau, Cedars, Cascades, and the Sault St. Louis and Normand, bring down the manufacture of fifty miles of river to be arrested principally between Montreal and Longue Pointe. The shallow expanses of Lake St. Louis and the Laprairie basin are of no value in arresting the ice on account of their strong currents. If Lake St. Louis were frozen over at the same time with Lake St. Francis—the winter inundations at Montreal would be diminished about 50 per cent; but as it does not present a barrier to the ice descending from the rapids above it until about the same time that the river is closed opposite Montreal—it affords no protection. It is worthy of remark, however, that the causes which produce the closing of Lake St. Louis and the river opposite Montreal at about the same time, have no connection with each other. The river takes *here* because by the rise of water the current is slackened, and the floating ice from above is arrested against the "bridge" below, without current enough to force it under—like logs in a boom: whereas the level of Lake St. Louis is not altered, but a certain time and degree of cold are necessary to enable the opposite bordages to encroach upon its strong current. If the early part of the winter be mild or changeable and accompanied by much wind, these bordages may be broken off repeatedly by the swell before they are closed; but if the winters sets in, as in December last, (1851) with uninterrupted severity, this lake is closed sooner—less ice descends and a diminished rise of water is the result at Montreal. This explains the ap-

parent anomaly of greater inundations in "open" winters and less in severe ones.

The Laprairie basin is so extremely shallow that it is not frozen over until its depth is increased about ten feet by the action of the ice dams below. While this lake-like expanse is of no more value than Lake St. Louis in arresting the early ice,—its extensive shoals and margins furnish proportionally the largest in quantity and the most formidable in character of the *materiel* of which the ice dams are composed. The ice which descends from points above the Lachine rapids, is composed of "fragments of the glacial fringe broken off by the wind, and enlarged in their descent by the cold;" but in the Laprairie basin the strong clear ice which forms round the islands, rocks, and upon the shore and shoals with the first frosts, is forced up and broken off from its attachment to the sides and bottom by the hydraulic lift of the subsequent rise of water, and—from the peculiar bend of the coast between Longue Pointe and the Lachine rapids—there exist no projecting "jetties" of land to retain this formidable bordage in the place of its formation. With the rise of water the current "in shore" increases and sets the whole field, sometimes half a mile in width and two or three miles in length, in motion. These form the "league after league" mentioned by Mr. Logan, and by their momentum these masses break up the resisting "bridge" and force under with such violence the blocks which form the dam. This process may be repeated—a new bordage being broken off by a second rise of the water and sent down to aid in a still further elevation of the river. When a sufficient quantity has thus been sent down to raise the level of Laprairie basin about ten feet the current therein is so diminished that it becomes frozen over, and then all further supply is cut off.

The natural inference from the foregoing is, that if the bordage ice can be retained *in situ* and the "taking over" of

Laprairie basin thereby be expedited, a very great portion of the supply furnished for the ice dams would be cut off and the intensity of these be correspondingly diminished. This hypothesis is confirmed by the fact that in severe winters when the ice takes rapidly there is a lighter inundation than in milder ones. In the former case the *time* required to close the river (and therefore the quantity of ice which can pass down in a given time) is a minimum, while in the latter the stopping and starting, the freezing and "slipping" extend over a longer period of time,—and a greater quantity of ice passing down, a greater dam is formed and a greater inundation takes place. A most important effect of a protracted closing over of the open water is the greatly increased quantity of snow which, falling in this water is converted into "*frasil*" or "anchor ice," and having about the same specific gravity as water is carried *under* the sheet-ice, and "banks" upon the shoals, reducing the waterway of the stream.

For the foregoing reasons I am led to the conclusion that the intensity of the ice phenomena at Montreal is due to the great area of open water which exists until January above the city, the absence of natural features above us for arresting or retaining the ice formed within this area, and to the existence of such features immediately below and opposite to the city.

Inasmuch as the natural bridges of ice wherever formed, have the effect of arresting its further descent—which descent is the sole cause of the winter inundations—I am of opinion that an artificial bridge, in so far as it will aid in arresting descending ice, retain *in situ* the bordages, elevate the level of the water—thereby diminishing the current,—and expedite the closing over of the river above us—will unquestionably tend to diminish rather than to increase the intensity of the winter inundations at Montreal.

DESCRIPTION OF THE SITE.

The site selected for completing the connection between the eastern and western sections of the Canada Grand Trunk Railway by a bridge at Montreal is upon the "ledges of rock composed of the trap lying in floors," —described by Mr. Logan as extending from Point St. Charles diagonally and downward across the general course of the stream to Moffat's Island and the eastern shore at St. Lambert.

The governing point of the location is the narrow channel (the only navigable one) abreast of Moffat's Island which is here only about one hundred yards wide between the lines of ten feet at low water.

The distance of this single navigable channel from the island of Montreal, measured on the proposed line of the bridge, is 5200 feet, and from the southern main 4800 feet. The height of the banks on either shore is about thirty feet. By elevating the centre arch of the bridge (which spans the navigable channel) 100 feet over summer level of water, and by embanking about ten feet on the natural level at each shore, the gradient to be overcome is sixty-three feet and as the distance in both cases is nearly a mile it is one common on railways. On account of this gradient it is important that the bridge should be straight; and starting from the governing point—the navigable channel alluded to,—a straight line which will avoid deep water, the canal, and buildings of the city, must cross the river somewhat diagonally and strike Point St. Charles. This line although oblique with reference to the general trend of the shores is in reality at right angles *to the channel.* The bridge location follows the shoal water and the line of the "trap floor" through which the river has cut a passage at the navigable channel (as usual at right angles)—the course of which is *across* the general direction of the stream and strikes toward the quays at Montreal.

Considering the "channel" as that portion of the stream having a greater depth than *nine* feet at extreme low water, the width of it on the bridge line as stated is about 360 feet, or about 300 feet between the lines of ten feet water. If the centre span be executed in wood, the piers would encroach upon the "channel" as above defined. It would be better to have the centre span on any location 400 feet wide, which will involve a tubular beam of iron at an additional expense of about £43,000. This additional expenditure I would recommend as this arch will be exposed to the chimneys of passing steamers; moreover by making it of iron it cuts off the communication in the event of fire—exposing only half the structure.

While the selection of the site has been governed by the accidental conditions of the river, it possesses a variety of advantages which under such circumstances could hardly have been anticipated.

1st. The location is on the most direct line of connection for the Grand Trunk Railway. This road, without reference to the bridge, would on approaching the city cross the canal at the only convenient point (which is near Gregory's and above all the basins) and proceed down to Point St. Charles for its freight terminus and for a connection with the harbor independent of the canal. The bridge line is a continuation of the main track coming down to Point St. Charles.

2nd. The line in the river runs upon a rock bottom and in more shallow water than can be found upon any other direct line crossing the St. Lawrence. It is a remarkable fact that the shoalest water to be found in the St. Lawrence below Lake Ontario is on the *last* rapid—the Sault Normand opposite Montreal.

The width of the river and consequent length of the bridge is not only counteracted by this shoal water (fully half of the whole distance being less than five feet deep,) but this width involves little disadvantage, because the distance

between the only navigable channel and the shores admits of a gradient, which passing *over* the limits required for the navigation, yet descends at once so as to strike the business level at both of these shores.

3rd. The ice seldom lodges *above* the line of the bridge although it always does to a greater or less degree immediately below it. Nuns' Island gives a direction to the current which throws the ice against Moffat's Island where it piles with great force. The shoal which is suspended from the lower end of Nuns' Island to the centre channel will act as a breakwater to the western half of the bridge against the effect of "bergs" of ice. The average depth of water on this shoal not exceeding seven feet, detached ice breakers can be constructed upon it at a moderate cost, which will break the momentum of large descending fields,—while accumulations of ice having too great a draught of water to pass under the arches will be "picked up" by this shoal before reaching the piers of the bridge. On the eastern half of the bridge the greater portion of the work will derive much protection against the effects of descending ice, by the works of the Champlain and St. Lawrence Railway and by the natural breast work of Moffat's Island.

4th. The site, while it possesses all the advantages of a line in the rapids where there is but one navigable channel, not only has that channel narrower than any available one in the rapids above, but this rapid is so moderate as not to offer any great impediment to the work of erection, and construction, and for three months in the year is frozen over and accessible at every point upon strong ice.

5th. Terminating at Point St. Charles in immediate contiguity with the canal basins, the water level of which aided if necessary by an additional supply from the head of the Lachine rapids can be conducted over hundreds of acres both on land and in the river,—the bridge will lead all the railroads from the

southern shore to the only point where they can be placed in immediate connection with the navigation and receive supplies " ex-warehouse," or direct from inland or sea craft for distribution to every part of New England or the Lower Provinces. In connection with this subject I have projected a scheme of docks around Point St. Charles, which shews the capabilities of the place in point of extent to be at least equal to that of Liverpool, Glasgow, or London, and which may be taken up in sections and extended as required for the increasing wants of commerce.

The importance of this point, its fitness for a general railway terminus in connection with the sea and inland navigation, is explained at large in the appendix in an extract from my unpublished Report on the Montreal and Kingston Railway, and also an extract from a lecture before the Mechanics Institute of this city.

It will be at once seen on reference to a map, that *the whole* of the channel between Nuns' and Montreal Islands may be filled with water and made available for the navigation. Also by obtaining (upon top of the embankment) permanent access to Nuns' Island, the outer coast of that island presents an extensive frontage and deep water where barges and lake and river craft not drawing over nine feet water may load for ports below.

It is only by an artificial harbor accommodation like this that Montreal can ever hope to share with Quebec any portion of the export trade in deals. Bright deals brought by railway to Point St. Charles and Nuns' Island, could afford this transportation on account of the higher price these command over those which have been floated. This trade by attracting a larger marine to this port could not fail to give an important impulse to our commerce.

Lastly. The excellence of this site,—opposing only a single navigable channel which is trumpet mouthed and therefore affords safe and easy access to the passage of the bridge,—is strikingly shown in the features of prac-

ticability, of economical arrangement, and the minimum of gradient which are here attainable.

If the navigable channel were a quarter of a mile or more in width, as it is both above and below the proposed line of the bridge, it would be necessary to elevate *all* that portion of the bridge which spanned this channel, one hundred feet. This would shorten the distance in which the ascent from the shore to the highest point of the bridge must be made, so as either to increase the gradient to an impracticable figure or augment the cost and length of the bridge. The increased cost might make it commercially impracticable, and the increased length might throw the terminus on shore at a point which would greatly damage if not destroy its commercial usefulness. Again, if there were *several* navigable bays under the bridge these would be separated by piers splitting the current, so as to make the navigation dangerous.

The economical arrangement consists in the fact that it will only be necessary to elevate the *two* piers embracing the channel to the height of one hundred feet above the water; over these a rectangular tubular beam (30 feet deep, and assisted by arches if of wood, but without arches and of less depth if of iron) will be laid,—*through* which the trains will run. The piers immediately on either side of these central ones will only be raised seventy feet above the water, and from these toward either shore the height of the piers will gradually diminish, in proportion to the gradient of the bridge. The trains will run *upon the top* of the bridge in ascending from either shore to the centre arch, and the depth of the tubes (thirty feet) will *without additional cost* make up so much of the required elevation of the track and thus be a substitute for a corresponding amount of masonry in the piers. This dropping of the bridge immediately on either side of the centre span is here admissible—because no masted craft will pass under the side arches—but would obviously be inadmissible

if the navigable channel extended over a greater portion of the river.

The comparative lightness of the gradient is due to the existence of the single narrow channel and its position nearly in the centre of the bridge line, from the combined effects of which the greatest possible distance is obtained for surmounting the difference of level between the shores and summit of the bridge.

PRINCIPLES OF CONSTRUCTION.

In the foregoing part of this report, the plan of the proposed bridge has been partly developed, but in consequence of its relation to the action of the ice, its peculiar position and arrangement, it will be necessary to allude to it more fully.

The importance of retaining the "bordage" ice *in situ* has been explained, and for this purpose, that part of the bridge extending from the shores over the shoals, to the depth of five feet water, being a distance of 450 yards on one side and 570 on the other, is designed to be a solid causeway or embankment carried above the level of the highest winter flood; from which point to the level of the rails it may be carried up by a viaduct of arches—an embankment, or trestle work for the present. If the scheme of docks which I have proposed at Point St. Charles be carried out, this causeway would become one of the dock walls, and the arches erected on it to give the proposed ascent to the bridge might be converted into warehouses. If the channel between Nuns' Island and Point St. Charles be dammed an immense amount of ice which now goes down to aid in flooding the water back on Montreal would be retained harmless until it melted in the spring.

On the south eastern shore the great width and dead shoal water around the Laprairie basin, form square miles of ice which so soon as it is freed from its attach-

ment to the shore, is carried by the throw of the current directly down through the *now* important channel between Moffatt's Island and the St. Lambert side. The works of the Champlain and St. Lawrence Railroad Company, although incomplete and not high enough, retained this bordage *in situ* during last winter, (1851—1852) and this in connection with the fact that the winter set in with great severity was one cause why the inundation at Montreal was less than usual,—was unaccompanied either on the formation or departure of the ice with any "shoves"—and that the surface of the river opposite Montreal presented the evenness of a mill pond instead of the ragged quarry aspect of broken ice usually seen.

The St. Lambert approach to the bridge, in conjunction with the work of the Champlain Railroad Company, will have the effect of retaining in its place the ice formed between Moffatt's Island and the south shore, and thus prevent the descent of a bordage of equal width as high up, at least, as a point abreast of Nuns' Island. The retained bordage above Moffatt's Island, with that resting on Nuns' Island and the south western abutment of the bridge, will increase in width so as gradually to narrow the passage between the Nuns' Island and the eastern shore, and will thus aid in arresting the descending field of the upper bordage and close the Laprairie basin at the earliest date. A few ice breakers judiciously distributed over the shoals, while they would break the shock of fields descending against the bridge, would aid in retaining the bordage and thus expedite the freezing over of this basin.

The solid approaches will be cheaper and more substantial than any other portion of the bridge of equal length; and in fact no substitute which will bring the rails down to the level of Point St. Charles can be devised for them, except that of extending the piers and bays to the shore and carrying the masonry up to the level of the

rails. A system of masonry arches giving free passage to the water would be exposed to the risk of being blocked up and overthrown by the " shoves " of the ice.

To carry out the arrangement of descending from the central arch to each shore on the top of the tubes, it is evident (since the depth of these are 30 feet under the rails) that as the shore is approached the lower side of the tubes would be brought within the reach of the winter flood. Before this point is reached, therefore, the arrangement and character of the structure must be changed, and as it would destroy the effect of the bridge again to elevate the tubes and run *through* them—the solid causeway is necessary. It is true that by abandoning the proposed arrangement of running on top of the tubes, raising the masonry of all the piers to the level of the rails, and continuing the piers and tubes to the shores—the solid approaches can be dispensed with; but I consider that there are objections to such an arrangement exclusive of economical considerations and the loss of the effect of the solid approach in retaining the bordage. If the spans are such that tubes whether of iron or wood are required,—passengers would be confined in a tunnel two miles in length with all its disagreeable connections, and if the spans are so narrow as to admit of an iron bridge open at the top—the side trusses would yet be necessarily so high that it would become a long trough which unless open at the bottom would fill with snow, while it would effectually deprive the passengers in summer of that view from the windows of the train which will constitute one of the great attractions of the bridge. On the other hand by the arrangement proposed the appearance of the bridge with passing trains is improved—the snow is avoided—the monotony of the outline is broken by the single elevated tube in the centre, and the channel is thereby clearly displayed to the navigation. The pleasure and comfort of the passengers is enhanced—economy

and safety to the structure are secured—and, if built of wood, the risk of fire is greatly diminished.

THE PIERS. The most important question in connection with the structure is that of the piers. The superstructure and approaches are simple matters, and so would the piers be were it not for the ice phenomena. Many persons (astounded by the commotion when a "shove" takes place) entertain the belief that piers cannot be made to stand in the river below the Lachine rapids, or at least below Nuns' Island; but the simple contrivance described by Mr. Logan shows how easy it is to *elude* the effects of the ice however difficult it may to *oppose* them. That the ice is not, as is often remarked, "irresistible," may be proved from the fact that the islands, rocks, wooden wharves and stone quays have not been removed by it. Probably there is no point where the ice strikes with greater force than against the long wharf at the Bonsecour Market—but this cribwork has resisted the shock, and forced into the air a broken heap of fragments. The power required to crush a cubic inch or foot of ice is very much less than that required to crush stone, iron or wood. If therefore there is mass enough or support enough, as is annually proved by the stone quays of Montreal, the ice is broken into fragments or ground into powder;—but the simpler, more economical and effective method is that universally employed where ice is to be encountered of *turning the ice back upon itself* and leaving the first arrivals to take the shock of all that follows after. By sloping the up-stream face of a pier or ice breaker so that the ice will ride up upon it, the stability of the pier is increased by the additional weight piled upon it and a heavy rampart of ice receives all future assaults.

But it is to be expected that the violence of the ice shocks will be diminished rather than increased by the erection of a bridge. At present when a dam slips and

the ice begins to move it is carried on with increasing momentum until it strikes the shore. But if sustained at intervals of 100 yards or less across the stream by piers, the initial velocity would be checked and the ice would rise and fall *in situ* with the variations of the water level.

The plan I have proposed contemplates the planting of very large "cribs" or wooden "shoes" covering an area of about one-fourth of an acre each, and leaving a clear passage between them of about 240 feet—a width which will allow ordinary rafts to float broad-side between them. These "islands" of timber and stone will have a rectangular *well* left open in the middle of their width toward their lower ends, out of which will rise the solid masonry towers supporting the weight of the superstructure, and resting on the rocky bed of the river. This enclosure of solid crib work, all round the masonry yet detached from it, will receive the shock, pressure, and "grinding" of the ice, and yield to a certain extent by its elasticity without communicating the shock to the masonry piers. These cribs, if damaged, can be repaired with facility, and from their cohesive powers will resist the action of ice better than ordinary masonry. During construction they will serve as coffer dams, and—being formed of the cheapest materials—their value as service ground or platforms for the use of machinery, the mooring of scows, &c., during the erection of the works will be at once appreciated. Their application to the sides of the piers is with particular reference to preventing the ice from reaching the spring of the arches which will be the lowest and most exposed part of the superstructure if wood be used.

The class of superstructure proposed for these wide spans, if of wood, would be a strong rectangular open built hollow beam, assisted by a deep open built arch. The two systems of arc and truss, however objectionable in iron bridges, have been proved to be susceptible of advantageous combination in the numerous and excellent

bridges built on what is known as the "Burr" or Pennsylvanian principle—decidedly the best class of wooden railway bridges in existence. The elasticity of timber permits both systems to come into play without injury to either when a strain is upon them, (which is not the case with iron) while the too great elasticity of the wooden arch is counteracted by the rigidity of the truss to which it is attached.

Experiment at Menai proved the superiority of the rectangular form for hollow beams in iron. It is somewhat singular, that the best form of wooden bridge in America for wide spans was, long previous to the Menai experiment, a type in wood of the celebrated tube. The strength of both bridges is collected near the four angles; the sides top and bottom, in the iron wonder, serving chiefly to maintain the relative position of the vital parts. The strength of the wooden tube must be wholly in the top and bottom chords—the inferior capacity of wood for the connection of its parts being in some measure compensated for by the practicability of employing the auxiliary arch.

The wooden railway bridges of America are progressive improvements upon the ordinary road bridges of Pennsylvania and New England, in which there was apparently an excess of strength:—the arc carrying the load and the truss (with plates instead of chords for the top) being a mere frame work to preserve its shape. In adapting these structures to the passage of railway trains every part has been from time to time increased in weight and size as experience dictated, but it is questionable whether as a class they are not generally too light, and wanting in that inertia which attempts at stiffness cannot compensate for, and which is requisite to absorb a portion of the momentum communicated to the structure by the sudden impact of locomotives weighing twenty-five to thirty tons, and moving at a speed of thirty miles the hour. These wooden bridges with arcs included, are not more

than one-third or one half the weight of tubular iron ones for the same span.

I have proposed a class of superstructure more weighty than usual, and while recognizing the objections to the extra weight to be sustained, I conceive it practicable to build a truss of the long span proposed which shall sustain at least its own weight, and to apply an auxiliary arc to that truss which can at least resist the effect of the load.

While instances are numerous of the failure of wooden bridges not supported by arches, by their in time sinking below the horizontal line, I am not aware of any well built "Burr," bridge having failed from this cause, although many have spans of 200 feet.

EFFECT OF THE BRIDGE.

I have already given some of the reasons why I entertain the opinion that the construction of a bridge, which will occupy a considerable proportion of the area of discharge, will nevertheless tend to diminish rather than to increase the intensity of the winter inundations.

It must be borne in mind that this inundation is in no way connected with floods or freshets induced by a greater flow of water in the river than usual. On the contrary it occurs at a time when the discharge of the St. Lawrence *is a minimum*—when the surface drainage and all the streamlets are cut off by frost. At low water in summer that portion of the "*battures*" at each shore which it is proposed to occupy with solid wing-dams for approaches to the bridge are nearly dry, and the amount of obstruction offered to the flow of the stream would be scarcely perceptible at this season *above* the bridge. For this reason the proposed waterway in winter, if kept clear, should be sufficient to pass the volume without creating any important rise of water above the bridge. Any in-

crease, therefore, in the level of the water *above* the Bridge arising from dams of ice below it would not be due to the structure unless aided by a "jam" at the bridge, nor would this become important unless superadded to the effect of an extraordinary flood.

The area of the water section of the river at the site of the bridge is in ordinary winters more than double that in summer, although the flow of water remains the same—the velocity only being diminished. The effect of a bridge by preventing the descent of a large portion of the materials which now aid in forming the ice dams, and by concentrating the current in the main channels would, in my judgment, prevent the grounding of the ice at many points where from the great breadth of the river, the distribution of the current over its whole surface (and therefore its reduced power) it now grounds; and, particularly, by restoring to current St. Mary that portion of the flow which the ice dams now drive through the channel east of St. Helen's—would aid in keeping the former channel clear and thus diminish the packing which is here so formidable.

There are but two ways in which the bridge can produce an effect upon the river—and in either case the result will be the same—viz.: the Laprairie basin will "take" at an earlier date and at a lower level than it now does. Taking the most alarming view of the case, viz: that the first ice which descends in December is arrested and chokes up a portion of the water way between the piers. A rise of water is the consequence which, if maintained, so deadens the current in the Laprairie Basin that it is frozen over—the further descent of ice and of course the further elevation of the water is arrested. If this first rise is not maintained it will be because the additional head of water acquired will cut out the obstruction and avert the inundation.

In the event of the early ice being arrested as above

the consequence will be that the river would remain open during the winter opposite Montreal as it now is opposite Caughnawaga.

But if, (as is most probable), the first coming ice passes under the arches and descends to form the ice-dams below,—the water rises and breaks off the bordages—the current slackens, and before the Laprairie basin has reached the point at which it now generally freezes the bridge by its piers and approaches will have arrested the now slowly moving bordage and close the river. Thus Laprairie basin is the guage of the inundations—and although the level at which it now closes varies with the severity of the season—it is manifest that any bridge must tend to expedite rather than retard this consummation.

It may still be feared that the bridge will increase the inundation when the ice breaks up in spring. The worst case is when the ice gives way in Lake St. Louis, and descends into the Laprairie basin upon the top of the local ice there—before the latter has started. But as the bridge will retain the ice in the Laprairie basin longer than usual, (although being above it will not delay the opening of navigation in Montreal harbour,) the result will be that the Lake St. Louis ice will be received by the solid crust of the Laprairie basin at the foot of the Lachine rapids—and any temporary "flashing" will be confined to these rapids, where it can do no harm.

The "longitudinal opening" in the current St. Mary will probably be regularly extended up to the bridge, as the concentration of the current caused by the latter, will tend to cut through the surface ice—keeping an open channel opposite Montreal, and ensuring the quiet and gradual departure of the ice without shoves.

To bear out the assumption that "obstructions" in the St. Lawrence at Montreal would diminish the winter inundations, it may be remarked that these last have cer-

tainly not been increased by the canal and harbour improvements. It is a well established fact that the water has not stood so high by at least four feet since the wharves were constructed as before.

It is an encouraging reflection that the progress of improvement which follows the demands of commerce may have the same ameliorating effect upon the character of our river as that of cultivation on the soil. If this were not probable, the prospects of the future commerce of Montreal would be gloomy indeed. The new wharves at Caughnawaga and Lachine will aid in retaining the bordages and future improvements—when the Board of Works make permanent instead of floating Light-Houses—will will further aid in arresting the descent of ice from L. St. Louis. There is very little doubt but that a line of piers across this lake near Isle Dorval would very much diminish the annual inundations at Montreal.

The real difficulty with the St. Lawrence opposite Point St. Charles—the point where a "jam" is most feared—seems to be a superabundance of room. The great breadth of the river and the diminished current here when the water is high permit the ice to ground on these shoals—whereas if the channel were confined somewhat as it is in summer, the water would maintain its passage —as it does *at the head* of every rapid in the St. Lawrence and Ottawa.

But assuming that the bridge fails to diminish the winter floods, and that it should increase them. The extra inundation will be confined to the shores above Point St. Charles, and it is important to consider what can be done.

It would be but a slight expense to run a dyke or levée at the few low points where the river would overflow its banks and to turn the course of the River St. Pierre so that it may discharge *below* the bridge. This stream

should have been turned when the canal was constructed. The canal is a perfect barrier against any inundation above Point St. Charles but by unnecessary culverts it's protection is rendered nugatory.

The advantages of turning the River St. Pierre from Gregory's to the bay under Point St. Charles near Tate's dry docks are important. If, as is very probable, future improvements should render a dam or dams across the channel between Nun's Island and point St. Charles necessary, and that the tail water from the wheels of the new water works be discharged into this stream, it would secure the maximum fall to the tail race as well as guard against back water on the wheels, to have the outlet of this stream below Point St. Charles instead of above it.

This point disposed of there remains only the low grounds about Laprairie. Should it prove that there arose a greater inundation than usual at this now exposed point, —all that can be said is that the interests at stake are slight and unimportant compared with the great national advantages of a bridge; and therefore it would be necessary either to purchase out the damaged property or take steps to protect it,—which ever course might from the extent of the evil prove to be the most advantageous.

ESTIMATE AND REVENUE.

The cost of bridging the St. Lawrence, from Point St. Charles across Moffatt's Island to the St. Lambert shore, will of course depend upon the plan and material employed ; but as the financial obstacles have hitherto been the barrier to its commencement it is necessary to present estimates shewing the least amount for which a serviceable structure can be attained, as well as estimates for a completed and durable work worthy of the great interests which it affects.

Recognizing the principle that it is the duty of an

engineer to shape his plans according to the wants and necessities of the case, it will be evident that the class of structure undertaken will be governed by the prospective revenue—if it be viewed in the light of an *independent* commercial speculation. But if, as I conceive it should be, it be made to partake of the character of a national work it should be built for all time—the expense limited only to the means to be attained. As a connection of the two sections of the Grand Trunk Railway, its cost should be distributed over the whole line; and however unprofitable it may now appear as an independent stock, it will, in a thousand direct and indirect ways, pay almost any cost.

Any estimate of revenue must be based upon an assumed traffic, an assumed toll, and the percentage of return which may be required by the stockholders.

The tonnage of such a bridge will be influenced by the rate of toll: for although the bridge should undoubtedly command the traffic of the railway lines converging at Montreal, the amount of what may becalled "through" traffic, passing between the east and west viâ Montreal, will be governed by the facilities afforded upon this route, and particulary by this bridge.

The adoption of the broad guage for the Grand Trunk Line inasmuch as it enforces transhipment of all freights passing between Boston, New York, and the manufacturing districts of New England on the one hand, and Canada and the North Western States upon the other, will, in my judgment, divert much of this traffic from the Canada line viâ Montreal, and thus reduce the value of the bridge stock. Every lake and river port between Prescott and the River St. Clair, will be a point of transhipment from the Canadian to the American routes: and as in most cases the latter form the shortest connexion with New York and Boston, there will be no inducements to take the Montreal route if transhipment here is

inevitable. These ports will favor transhipment and a direct trade with opposite American ones,—which can only be successfully counteracted by possessing the ability to run the same cars without transhipment from any railway point in Canada, over this bridge, into New York and Boston and return them freighted with imports.

It is, therefore, difficult to base a calculation of what the tonnage over this bridge will be under the broad guage system. We cannot take the precedents of the river traffic or that which reaches Lake Champlain, the Hudson River, and New England, by the canals and narrow guage lines of the United States. All our inland trade is with New York and Boston, approachable only by the narrow guage, and it can hardly be assumed that the broad guage connection about to be opened with Portland will enable that town to rival the low freights, the larger markets, and more extended commerce of those cities. The most reliable support of the bridge should be what may be called the local trade of Montreal, and that of such interior lines as may first "crop out" here, and which are therefore not exposed the attractions of American routes above us.

Again—competition is so close upon the routes through Ogdensburgh, Cape Vincent, and Niagara that the tariff will much influence the tonnage over the bridge: and for the local trade of Montreal it must compete with the Caughnawaga route, where—by an unbroken ferry and barges prepared for railway trains—cars may be run directly into Montreal.

The cost of ferriage from this city to the south shore including the loading and unloading will be about 2s. 6d. per ton. The ferry has the advantage of being able to run to any of the warehouses on the water where freight is to be received or delivered; but as there must be cartage on the city side to and from the ferry this may be set off against the same to the railway station, so that in sum-

mer the Bridge would command a toll equal to the cost of ferriage and the premium which shippers would pay to avoid one handling of their goods. It must, however, be remembered that in summer freight brought by water would, if destined for a southern market, most probably be stored at Longueil or St. Lambert if it were an object to evade the bridge toll.

In winter the ice for a great part of the season would be the most formidable competitor to the bridge. As the cost of cartage would be but slightly increased by crossing to Longueuil or St. Lambert, when once loaded, over that of carting to the freight terminus connected with the bridge (which must be south of McGill Street) it is to be expected that produce collected in the city for southern markets will escape the bridge tolls unless these are very low, or unless the same rates of freight are charged on all the roads from St. Lambert and Longueuil, as from Montreal.

Thus it will be seen that from the competition of American lines above us, the Caughnawaga ferry and the ice in winter opposite Montreal, a high rate of toll cannot be counted upon. Nor indeed would it be policy to adopt high rates. The traffic of which the bridge will receive a share is a growing one. A million of tons at one shilling, will yield double the revenue of one hundred thousand tons at a dollar per ton of toll.

I will not attempt to estimate the average tonnage and rate of toll which may be charged for the next twenty years and thus determine the amount which may now be expended on a bridge, but with the rate of return which it is usual to anticipate from such structures in this country, and in view of the fact that the broad guage has been adopted for the trunk line, I have come to the conclusion to recommend a superstructure chiefly of wood if the project is to be taken up as a self-sustaining commercial speculation.

The cost of an efficient railway bridge upon the site proposed, with a superstructure of wood for the side arches and a wrought iron tube for the centre one—the whole resting upon abutments and piers of substantial masonry, and having approaches formed by solid embankments of earth will be £400,000 Currency. With an iron superstructure in the side arches the cost would be increased to £900,000. Cy.

My instructions having in view the connection of the Canada Grand Trunk Railway I did not deem it necessary to examine sites for the bridge above Nuns' Island, as the *detour* would be objectionable, the cost at least as great, and facilities for construction less. The arguments in favor of sites above Point St. Charles are, a supposed greater immunity from the action of ice, and less risk of inundating the city by reason of the "obstruction" which it is presumed by some the bridge will cause. As I do not entertain any apprehensions on either score, I have selected the present site as the most convenient, and in every respect the most eligible one.

APPENDIX.

Extract from Report on Montreal and Kingston Railway, made in January, 1852.

MONTREAL TERMINUS.

The position of Montreal at the head of sea navigation, and connected by several lines with adjacent New York and New England, requires that extensive and special provision be made for the *freight terminus* of the Grand Trunk Railway, independently of passenger accommodation. Looking to the certainty of the operation of the road in connection with the shipping in Montreal harbour, either before or after the closing of the canals (or during their temporary suspension by accident) for *heavy* freight, and at all times during the season of navigation for emigrants and their bulky baggage as well as for light and valuable goods comprising what is known as "express freight." I consider it indispensable that there should be direct communication between the rail and the river, so that goods and baggage can, whenever required, be transported directly from the vessel to the rail and *vice versâ*. There are three plans by which this may be effected. The first is by establishing the terminus on the north side of the canal, above Wellington street, at or near the Seminary basin. The objections to this course are many, and in my judgment fatal. 1st. To reach this point, that thoroughfare St. Joseph street must be crossed, entailing a permanent evil, both on the road and the community. 2ndly. Sufficient room for the necessary establishments could not here be obtained without approaching too near Griffintown, whereby the terminus would be brought into dangerous proximity with the town in case of fire.

3rdly. The wharf room would be limited by the capacity of the Canal; the ingress and egress of vessels be interrupted by the numerous craft of all kinds, wood boats, &c., which congregate at the lower end of the Lachine Canal; and—until the latter is deepened above Wellington bridge—seagoing craft would be unable to approach the terminus. The efficiency of the road would be dependent upon the conditions and vicissitudes of the canal navigation. These con-

ditions are, that no craft having a greater length than 200 feet, or width, over all, of more than 45 feet can pass the locks, and reach a canal terminus. To assume that no craft exceeding these dimensions will ever come to Montreal, would be to ascribe a finality to naval architecture, which cannot be justified by the experience of the present day.*

The vicissitudes are, that the river navigation may be open for vessels before and after that of the canal has been suspended, or that the knocking out of a lock-gate, the breach of a mill flume, the sinking of a stone boat or leak in a mitre sill, may at any time suspend the navigation in which case the canal terminus could only be relieved by a ruinous cartage.

To obtain a terminus on the river, inasmuch as no sufficient space is to be found from the canal to the foot of St. Mary's current, it will be necessary either to extend the railway throughout the whole length of the city, to Hochelaga Bay, or Ruisseau Migeon, or to cross the canal and reach deep water at the foot of the Point St. Charles shoal.—The inconvenience to the road and the town of the former route need not be enlarged upon, and as it would only be adapted to the river business it would not meet all the requirements of a freight terminus at Montreal.

Looking to the future of this city, the trade with the railways on the south side of the St. Lawrence must be provided for, and also the connexion with the eastern portion of the trunk line.

A railway bridge when built, must be placed above the present harbor, and to reach it, the Lachine Canal is to be crossed. The freight terminus therefore should be situated so as to be equally accessible to the inland trade with the United States and the sea and river trade through the Montreal harbor, and should therefore be *above* instead of below the latter.

The direction of the railway line coming from Lachine is generally parallel to the canal, but between Côte St. Paul and the St. Gabriel locks, the canal for a short distance bears up towards the Mountain, and immediately turns again and runs directly to the Wellington bridge. This short tangent at the St. Gabriel farm-house has been selected for passing the canal, because here it makes the greatest angle with the railway, and its banks at the point nearly coincide with the adjacent surface. A railway bridge at this point

* The capacity of ocean screw steamers coming to Montreal, inasmuch as the draught of water is limited by Lake St. Peter, will be governed by their *length*. In my opinion this length will much exceed two hundred feet, the limit of the canal locks.

would be above all the basins, and not interrupted by vessels entering from the river only to load or discharge, without passing through the canal. Leaving the track of the Lachine road near the old wind-mill and before it reaches the Tanneries road, the line crosses the canal at the point above mentioned, runs through the open fields and crossing the Lower Lachine road about 500 yards from the canal, it curves so as to strike the river at the head of the little bay under Point St. Charles: thence running down along the outside of the new road in rear of the mills, it reaches deep water abreast of the entrance to the canal.

The unoccupied ground bounded by the Lower Lachine road, the Board of Works property and the river, affords an admirable site for all the establishments connected with a railway terminus. From this point, freight may be sent or received from ocean craft, river or ferry boats, or from the south shore when a bridge is constructed. For the present the buildings could all be confined to the main shore, and wharves be constructed similar to those in the harbor with moveable fittings, allowing it to be covered by the water in winter. The extent of accommodation here would be greater than could be afforded elsewhere, because the lower edge of the Point St. Charles shoal, has a frontage of nearly half a mile upon deep water and directly opposite this, there is an island shoal nearly thirty acres in extent with an average of about seven feet only at low water. This shoal could be reached by a temporary bridge from the main one under Point St. Charles, in which case it would present a circumference of about a mile, and of course, that much additional accommodation.

The shoal bay into which the mill races are discharged is the least exposed (of any part on the river front) to the action of the ice,—the line of the ice movement being thrown out by Point St. Charles. Ultimately it is to be expected that these shoals, comprising several hundred acres of now unprofitable area, will be permanently and usefully occupied. If enclosed by a water tight wall or embankment, any required extent may be converted into docks filled with 20 feet water (either from the canal or from a aqueduct brought from the head of the Lachine rapids,) and be connected directly with the harbor by the largest class locks. These docks could be surrounded by warehouses or mills, and afford winter quarters to craft laying up here. Elevated above the highest rise of water, they would be a virtual extension of the main shore, into the river, and by leaving an outer unoccupied wall to receive the shoving of the ice, the inner ones would be as secure as the upper canal basin. This would probably be the cheapest and most effectual mode of erecting a

barrier between the river and any permanent structure either for wharves or other purposes, and its bearing upon the point proposed for a railway terminus will be at once seen.

With respect to a passenger terminus, it will be better to use that of the Lachine road, having both termini under the same roof: the present building to be enlarged; or a new one constructed, which if required, can be placed near the Hay Market. This station would be most convenient for passengers, for supplies intended for immediate consumption in the city, and for "express" freights from the city.

Extract from lecture delivered before Mechanics' Institute, January, 1853.

In consequence of the limited frontage between the shoals under Point St. Charles, opposite the canal, and Current St. Mary, there is an insufficient amount of harbour accommodation, and the value of that we have is reduced by local phenomena. The rise of water in winter, and the shoving of the ice prevent the erection of warehouses on the wharves, and of permanent machinery for discharging cargoes, so that the commerce of the port, particularly its business as an entrepot, is burdened with a heavy charge for drayage. The same local phenomena prevent us from laying up craft for the winter in the harbour. Fortunately indeed for the city, there is within reach of it a remedy for this objection. We are in the same position as a tide-water port (in consequence of this winter rise of water,) and have the same need of docks, but we have not the flux and reflux of the tide to work them with; but we have an abundant supply of water close at hand at a sufficiently high level for this purpose. The canal basins are docks precisely similar to the kind which must be resorted to; but, although these are a great relief to the harbour, they will not be accessible, on account of the shortness of the locks, to screw-steamers and the largest class of craft which may be expected at Montreal, and they are moreover no more than sufficient for the trade of the canal itself.

We must, therefore, "fence in," from time to time, as many acres of Point St. Charles shoals as may be required, and fill up the enclosure with water from the canal, or from the river above the rapids. No excavation is required, and these basins may be approached through the canal until the arrival of longer or wider craft calls for the construction of larger locks.

Point St. Charles is the proper point for the railway freight termini, and for the railway bridge: the docks in the river at this point would therefore be accessible to railway tracks, so that the vessels and the railroad cars can, when necessary, be brought side by side, and elevators worked by water-power be employed to discharge grain. These facilities should not be confined to any one railway; it is the best arrangement for all railroads, terminating on either side of the river below the Lachine rapids. The natural causes we have alluded to will always operate largely against both the Champlain and St. Lawrence and the St. Lawrence and Atlantic Railroads, in any attempts they may make to do an extensive business in connection with the river. Shallow water, strong currents and winter rise of the river, make the system of docks or basins such as those at the canal almost indispensible at St. Lambert and Longueuil, but the high head of water is wanted there. The Portland road looks to the river St. Lawrence for its principal business: but to conduct this business—particularly the transport of wheat, corn, barley, &c., profitably and on terms of equal competition, with rival roads, it is indispensible that it should be able to have warehouses and elevators alongside of the craft coming down from the western lakes. Moreover if these south-shore railroads make their termini in Montreal, they will get rid of the steamage of deeply laden western craft from the canal, over and up to Longueuil and St. Lambert.

Before these roads undertake any extensive expenditure in the river opposite Montreal, it behoves them to investigate the bridge question, and see whether the expenditure which they propose to make if invested in a bridge will not be more profitably applied than elsewhere.

The city of Montreal should meet the bridge question heartily and liberally, as a matter of self-interest. If the railway termini are permanently established on the opposite shore, and no provision be made for a bridge, the imperfect mode of communication will create an interest there, which, instead of being auxiliary (as Brooklyn and Jersey City are to New York) will be rival—and from their perfect communication with all the important parts of America (south, west, and east,) will possess all the elements of absolute independence. Fortunately for the interests of this city, the local unfitness of the southeast shore for a good connection with the St. Lawrence, in addition to the necessity for an unbroken communication with the line of western railroads terminating in Montreal, brings not only a powerful but a mutual interest in this bridge question, which guarantees its early achievement.

REPORT AND ESTIMATE

OF

EDWARD F. GAY, ENGINEER, UPON BRIDGING THE ST. LAWRENCE AT MONTREAL.

To JOHN YOUNG, ESQ., *Chairman of Committee, for procuring Plans, Estimates, &c., for a Bridge across the St. Lawrence at Montreal.*

SIR,

In making the examinations requisite to ascertain the practicability of building a permanent bridge across the river St. Lawrence, in the vicinity of the city of Montreal, as well as the expense thereof, I have necessarily been dependant in a great measure, upon information received at Montreal, (from gentlemen familiar with the subject,) as to the general character of the river during the formation of ice, in the early part of the winter, and its breaking up in the spring. The data thus obtained, confirmed as it is, by impressions derived from a personal examination of the river, and by my familiarity with the operations of large bodies of ice on streams somewhat similar, enables me to express the opinion, that any attempt to construc a permanent bridge across the St. Lawrence, below Nun's Island, or between it, and the lower end of St. Helen's Island, would be attended with great risk, if not prove a total failure. This is inferred from the fact, that the river is so much contracted in its width at St. Helen's Island, as to form a natural dam, sufficient to obstruct the free passage of the ice, during its formation, and breaking up, and thus cause an accumulation of both ice and water opposite the city, which would endanger and probably destroy any structure of the kind, that might be attempted at that point.

A reconnaissance was made of the western shore of the river, extending from the city about two and three fourth miles, up to the head of Nun's Island, and of the island itself. Also of the eastern shore from Laprairie down to St. Helen's Island. And subsequently, such instrumental examinations were made of both shores and island as were considered necessary, to the proper selection of a site for a bridge, and to obtain the requisite data for an estimate of its cost, &c. The preliminary surveys made resulted in a more minute examination of two lines across the main channel of the river, as presenting features more favourable for the location of a bridge, than were found at any other point in the vicinity of Montreal.

These I shall denominate, the "upper" and "lower" lines. The

" upper line" extends from a point on the island, (about one fourth of a mile below its head) across to the eastern shore, near the dwelling of Pierre Rousseau, about two and a half miles below Laprairie.

The " lower line" extends from a point about half a mile above the foot of the island, across the main channel, to the house occupied by Charles Mayo.

Both of these lines are common to one line across the west channel of the river, a few rods below the 'Nuns' buildings on the island, and either of them are considered as favourable for the construction of a permanent bridge, although the " upper line" would be preferred, in consequence of the average depth of the water, being less upon it, and of the current being more gentle, and therefore more favourable for the operations attending the erection of the works. The greater width of the river, too, would afford more ample security against an accumulation of ice, and accidents therefrom, but I do not consider these advantages sufficient in the present case to compensate for the greatly increased cost of a bridge upon the " upper line," over that of the " lower," upon which latter, I am fully of opinion, that a permanent and substantial bridge can be built, without encountering any difficulty of a serious character.

Another line has been examined across the river, under the direction of Mr. Morton, chief engineer of the Atlantic and St. Lawrence Railway, to whose kindness I am under obligations for a copy of the soundings taken upon it, which is the more valuable, as affording comparative evidence of the accuracy of our measurement.—

This line (which may be denominated, the "railroad line") crosses the west channel, about one fourth of a mile below the site which I have selected, and being near the foot of the Island, is considered objectionable, as a bridge upon it would be exposed to the re-action of the ice from the main channel. This line leaves the east side of the island, about one hundred yards below our " lower line" and intersects the eastern (main) shore, about 4500 feet below it, at a point which I understand to be on the projected centre line of the Atlantic and St. Lawrence Railway.

I consider the " railroad line," decidedly objectionable as the site for a bridge, for the following reasons, viz:

1st. The current is much stronger, and the water generally deeper than upon either of the lines, which I have examined. 2d. The narrowness of the river at that point, which would be still further contracted by the erection of the requisite number of piers. And 3rd. The current would intersect the face of the piers in an oblique

direction, all which are obviously calculated to endanger the permanence of a bridge, if built upon that line.

On our reconnaissance of the eastern shore, it was observed, that from Laprairie to the railroad line, a considerable portion of the high ground forming the natural bank of the river recedes from the water surface and thus forms low flats contiguous to the river. Points were therefore selected, for both the lines examined, upon which the banks are bolder, and of course more favorable both for the operations attending the construction of the work, and for the formation of approaches to the bridge (when finished) by railroads or other improvements.

The width of the river (east channel) on the upper line is 12320 ft.
" " " lower line is 9900 "
" " " railroad line about 8900 "

The length of a bridge, therefore, across the east channel, upon the "lower (or preferred) line," would be about 2,400 feet less than the "upper line," and about 1000 more than the "railroad line"—which is sufficient to allow for the construction of all the piers proposed, and still leave a larger water way than is furnished by the entire width of the river on the "railroad line," exclusive of piers. which is important, to admit a free discharge of water, and prevent the ice from *clogging* at the piers in winter.

Under all the circumstances, therefore, I cannot hesitate to recommend the selection of the "lower line," before described, as the most suitable site for the bridge, and have prepared the plans and estimates predicated upon it. It is probable, however, that on a definite location of the work, some small deviation may be made calculated to facilitate the construction of the bridge, or afford accommodation for the several roads approaching it, yet the amount of work to be done, upon which the accompanying estimate is based, will not be essentially changed.

The plan of superstructure designed for the bridge across the St. Lawrence, is that known in Pennsylvania, as "Burr's combined truss and arch bridge," which is decidedly the most simple and effective plan of bridge that has been introduced into use, in this country. The accompanying plans will show the form of the bridge, both in its finished and unfinished state. It is designed with a double roadway, each of which are twelve feet wide, and fourteen high in the clear. The original plan has been modified, and improved in strength, by the addition of extra arches, floor girders, &c. so as to enable it to sustain the weight of heavy railroad trains, if required to do so; indeed the whole bridge has been planned with

that view, and is designed, when built, to form a substantial and durable structure. If, however, it should be required merely as a common travelling road bridge, a less amount of materials and work would be necessary in its construction, and its cost would be two dollars per foot lineal, (or $25,080) less than the present estimate.

But as it is presumed that this bridge, when built, will form the leading avenue for all the railways, as well as common roads entering Montreal, from the south and east, its original construction should be such, that no additions, alterations, or improvements would be required, to enable it to sustain any amount of trade or travel that may offer for passage over it, and if built upon the plan proposed, it will be fully competent to do so.

The masonry of the abutments and piers, is designed to be of the most substantial character. The surface of the exterior stone to be dressed in courses, and the interior work to be laid with level beds, uncoursed and well bonded. The pier heads forming the ice breakers, to be faced with timber one foot thick, secured to the walls with iron straps and bolts in such manner that it may be renewed at pleasure; the masonry of the pier heads is also intended to be secured in each course, with iron clamps. The thickness of the piers is designed to be eighteen feet at the "skew backs," or springing line of the arches. The faces of both abutments and piers to have an even batter of one inch per foot rise, from bottom to top. No offsetts, or projections are contemplated for ornament, in order that a smooth and even surface may be presented, for the action of the ice. The masonry of the piers, where the water is more than two feet in depth, is intended to rest upon a solid foundation of hewn timbers, bolted together, and sunk upon the solid rock bottom of the river, from which all earth or loose stone must previously be removed by dredging.

The clear width of each span of the bridge, or space between the piers, at the "skew backs," is designed to be two hundred feet. The ends of the arches (or segments) to be eighteen feet, and the underside of the chords and truss work to be twenty five feet above low water.

It has been suggested that the construction of a "draw" in the bridge would be required. If so, it is to be regretted, as the shallowness of the water near the shores, would require the location of the "draw" to be made in the channel at considerable distance from the shore, in order to accommodate the river trade, or rather masted vessels descending the river.

And as a "draw," exceeding sixty feet in length cannot well be

made sufficiently strong for the purpose of railway travel, it must be evident that the erection of two piers in the river channel, within sixty feet of each other, would be calculated to obstruct the passage of the ice, and perhaps jeopardise the safety of the bridge, more especially, as the superstructure of one hundred and twenty feet, of one span, next the "draw," would have to be constructed three feet nearer the surface of the water than would otherwise be required, in order to allow the "draw" to be moved back within it. It is to be hoped, therefore, that the construction of a draw may not be found necessary.

The vast importance of a permanent bridge across the St. Lawrence, at Montreal, and its tendency when finished, (by the facilities for intercourse which it will offer,) to develope the resources, and promote the prosperity of the province generally, must be obvious to any one who is familiar with the river in that vicinity, and has reflected on the subject. And it certainly would afford cause of great regret, if the authority for building the bridge should be coupled with conditions calculated to impair its safety or its usefulness when done.

The following estimate has been made out with much care. The quantities cannot be essentially varied, unless by a change of plan or location.

The prices have been calculated according to the value of labour and materials at Montreal, and the amount of the estimate is believed to be sufficient to cover the cost of the bridge complete, and also the expense of opening a common road across the island, to connect the bridges, for which the ground is favorable. But, should the grading on the island be required for railroad purposes, an allowance should be made for that object, the cost of which, I have no data for estimating, and which would necessarily depend upon the character of the work to be done.

ESTIMATE FOR BRIDGE ACROSS THE ST. LAWRENCE RIVER AT MONTREAL.

Bridge on west channel,.....	2640 feet.
" east "	9900 "
Total length of bridge,.....	12,540 "

12,540 lineal feet of superstructure at $14,.....	$175,560.
40 feet finished ends to bridge, at $15,.....	600.
62,500 perches masonry, at $4,.....	250,000.
560,000 cubic feet timber foundations, at 10 cts.,.....	56,000.
Clearing foundations of 55 piers, estimated at $200 each,	11,000.
Iron for piers and foundations,.....	5,500.
10,000 cubic yds. excavation and embankment, at 20cts.	2,000.
	$500,660.
Add for contingent and unforeseen expenses, 5 per ct.	25,033.
Total,.....	$525,693.

The estimated cost of a bridge on the "upper line" is $613,321.

The position of both the "upper" and "lower" lines examined, will be seen by reference to the accompanying map, together with the profiles, exhibiting the soundings on each line.

All which is very respectfully submitted by

Your obedient servant,

EDWARD F. GAY,

Civil Engineer.

Philadelphia, Penn., December 22, 1846.

A register of the fluctuations of the water in Montreal harbour is given in the following pages. The highest water noted since this register has been commenced is "3 feet over coping;" this was on the 6th and 14th January, 1853. The level of coping is 31 feet 3 inches above the lower sill of the lock. According to this, 17 feet 9 in. would be the extreme range between highest and lowest water marks, as far as shewn by this register; but this does not correspond with other observations, which go to shew the range to have reached 21 feet in January last, which was about four feet lower than the highest known flood—that of January 18th, 1837. In January, 1838, (a remarkably "open" winter) the water rose within 8 inches of the mark of the previous year.

DEPTH OF WATER ON THE LOWER SILL OF LOCK No. 1, ON THE LACHINE CANAL.

Days of the Month.	JANUARY.		FEBRUARY.		MARCH.		APRIL.		
	1851.	1852.	1851.	1852.	1851.	1852.	1850.	1851.	1852.
		ft. in.	ft. in.	ft. in.	ft. in.	ft. in.		ft. in.	ft. in.
1st.	...	11 in. over Coping.	27 2	27 1	29 1	16 7	.....	30 6	28 11
2nd.	...	6 in. over Coping	27 9	26 4	29 3	17 11	.....	31 6	28 1
3rd.	...	level with Coping	29 9	27 6	29 7	17 11	.....	31 7	27 10
4th.	.....	33 9	29 8	28 0	28 10	16 9	...	8 in. over Coping	27 11
5th.	.....	33 9	29 0	29 11	28 6	17 7	...	level with Coping.	28 1
6th.	.....	33 6	28 2	29 4	28 6	17 10	...	1 ft. under Coping	28 0
7th.	.....	4 in. over Coping.	27 5	29 2	27 7	17 10	.....	31 0	28 9
8th.	.....	33 2	26 0	18 0	27 8	17 5	.....	29 6	28 11
9th.	.....	30 7	26 3	17 1	28 0	18 0	.....	29 6	29 1
10th.	.....	30 11	26 0	18 2	28 9	18 1	.....	27 2	29 2
11th.	.....	30 10	27 3	18 10	28 4	17 7	.....	26 2	29 4
12th.	.....	31 10	28 1	18 9	27 6	18 1	.....	25 7	20 4
13th.	.....	31 6	23 1	28 0	27 7	18 4	.....	25 2	29 7
14th.	.....	31 9	29 0	28 0	27 0	18 7	.....	24 9	29 6
15th.	.....	30 9	29 3	28 0	26 10	24 2	.....	23 11	29 10
16th.	.....	30 2	28 6	17 3	27 0	29 6	.....	23 9	30 0
17th.	29 5	29 6	28 6	17 2	27 1	29 4	.....	23 9	30 2
18th.	28 10	29 6	27 11	17 0	27 6	29 11	.....	23 6	32 10
19th.	28 3	29 6	27 10	17 2	27 9	29 3	.....	23 6	32 4
20th.	28 10	29 3	28 0	17 2	28 6	29 4	.....	22 9	30 6
21st.	29 0	29 8	28 2	17 2	28 8	29 6	.....	23 5	30 0
22nd.	29 0	29 6	28 2	17 2	28 7	29 7	.....	22 1	29 10
23rd.	29 0	29 1	27 10	17 6	28 7	29 4	.....	22 0	29 6
24th.	27 11	29 1	29 2	18 2	27 10	29 0	.....	22 0	29 0
25th.	28 10	30 0	29 0	17 10	28 10	29 5	.....	21 11	28 2
26th.	28 8	30 5	29 2	17 2	28 10	29 0	.....	21 10	26 3
27th.	27 10	29 2	29 3	16 11	29 1	29 5	.....	22 1	24 7
28th.	27 9	29 4	29 7	17 2	29 0	28 10	21 4	22 0	24 0
29th.	29 2	29 5	.....	17 0	29 8	28 7	22 0	22 1	23 6
30th.	28 3	28 9	.....	.....	30 4	28 4	22 8	22 3	23 7
31st.	27 6	28 9	.....	.....	30 1	28 0	.....	.....	.....

Days of the Month.	MAY.			JUNE.				JULY.			
	1850.	1851.	1852.	1849.	1850.	1851.	1852.	1849.	1850.	1851.	1852.
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
1st.	21 9	22 4	23 7	24 5	23 9	23 10	22 9	19 7	19 0	21 0	21 6
2nd.	22 8	22 6	23 7	24 3	22 9	23 9	22 8	19 6	19 0	21 2	21 8
3rd.	23 0	22 8	23 6	24 1	22 9	23 7	22 8	19 4	18 10	21 0	22 0
4th.	23 4	22 9	23 6	24 11	22 6	23 6	22 5	19 4	18 10	20 11	22 0
5th.	23 6	22 9	23 4	23 9	22 2	23 3	22 4	19 0	18 10	20 7	22 0
6th.	24 0	23 0	23 4	23 9	21 6	23 1	22 3	19 7	19 0	20 5	22 0
7th.	24 4	23 1	23 5	23 6	21 6	22 10	22 2	19 9	19 0	20 7	21 9
8th.	24 6	23 2	23 7	28 2	21 6	22 9	22 1	19 9	18 10	20 6	21 7
9th.	25 4	23 0	23 11	23 1	21 6	22 8	21 9	19 9	18 10	20 6	21 7
10th.	26 3	23 0	24 4	22 11	21 3	22 6	22 0	19 7	19 9	20 6	21 7
11th.	25 10	22 7	24 7	22 8	20 10	22 6	22 3	19 7	18 7	20 6	21 6
12th.	26 0	22 8	24 9	22 4	20 10	22 5	22 2	19 5	18 6	20 5	21 6
13th.	26 0	22 6	25 0	22 0	20 8	22 6	22 6	19 4	18 6	20 5	21 5
14th.	25 8	22 9	25 9	22 0	20 8	22 3	22 5	19 4	18 6	20 4	21 5
15th.	25 6	22 9	24 11	21 7	20 8	22 1	22 6	19 4	18 6	20 4	21 7
16th.	24 6	22 11	24 10	21 6	24 0	22 0	22 7	18 10	18 9	20 2	21 7
17th.	24 0	22 10	24 10	21 6	20 2	21 9	22 9	18 7	18 6	19 9	21 7
18th.	24 4	23 1	24 7	21 3	20 0	21 6	22 8	17 11	18 10	19 7	21 7
19th.	24 0	23 3	24 6	21 1	19 9	21 6	22 9	17 9	18 10	19 6	21 7
20th.	24 0	23 3	24 5	21 0	19 9	21 5	22 8	17 11	18 10	19 6	21 5
21st.	23 9	23 6	24 4	21 0	19 6	21 5	22 6	17 6	18 10	19 6	21 3
22nd.	24 0	23 10	24 3	20 10	19 6	21 6	22 4	17 0	19 6	19 7	21 3
23rd.	24 0	24 4	24 1	20 8	19 6	21 4	22 1	18 1	19 6	19 6	21 0
24th.	24 0	24 4	24 1	20 7	19 6	21 2	22 0	18 0	19 3	19 6	19 10
25th.	24 0	24 6	24 0	20 6	19 6	21 3	21 10	17 10	19 0	19 6	19 6
26th.	24 0	24 9	23 9	20 4	19 6	21 3	21 8	17 7	19 0	19 7	19 4
27th.	24 0	24 6	23 7	20 4	19 3	21 2	21 6	17 9	18 10	19 9	19 8
28th.	24 0	24 5	23 5	20 0	19 3	21 2	21 5	17 10	18 10	20 1	19 10
29th.	24 0	24 4	23 3	19 10	19 1	21 2	21 7	17 10	18 6	20 3	20 1
30th.	23 6	24 3	23 0	19 2	19 0	21 2	21 7	17 8	18 3	20 2	20 3
31st.	23 2	23 11	23 1	.....	.....	.....	.....	17 9	18 6	20 1	20 3

DEPTH OF WATER ON THE LOWER SILL OF LOCK No. 1, ON THE LACHINE CANAL.

AUGUST. SEPTEMBER. OCTOBER. NOVEMBER. DECEMBER.

29th.	29	2	29	5	.....		17	0	29	8	28	7	22	0	22	1	23	6	24	0	24	4	23	3	19	10	19	1	21	2	21	7	17	10	18	6	20	3	20	1
30th.	28	3	28	9	.....		.....		30	4	28	4	22	8	22	3	23	7	23	6	24	3	23	0	19	2	19	0	21	2	21	7	17	8	18	3	20	2	20	3
31st.	27	6	28	9	.....		.....		30	1	28	0	.....		.....		.....		23	2	23	11	23	1	.....		.....		.....		.....		17	9	18	6	20	1	20	3

DEPTH OF WATER ON THE LOWER SILL OF LOCK No. 1, ON THE LACHINE CANAL.

Days of the Month.	AUGUST. 1849.		1850.		1851.		1852.	
	ft.	in.	ft.	in	ft.	in.	ft.	in.
1st.	17	8	18	6	19	11	20	0
2nd.	17	6	18	10	19	8	20	0
3rd.	17	6	18	6	19	7	19	11
4th.	17	6	18	6	19	7	19	10
5th.	17	0	18	5	19	1	19	11
6th.	16	10	18	5	19	4	19	9
7th.	16	10	18	5	19	2	19	9
8th.	16	10	18	4	19	1	19	7
9th.	18	3	18	4	18	11	19	8
10th.	18	3	18	3	18	10	19	6
11th.	17	0	18	2	18	11	19	4
12th.	17	0	18	2	19	0	19	2
13th.	17	0	18	1	18	11	19	0
14th.	16	6	18	1	18	11	19	0
15th.	17	6	17	8	18	9	19	0
16th.	17	6	17	9	18	8	19	0
17th.	17	6	17	9	18	8	19	0
18th.	17	8	17	6	18	7	19	0
19th.	17	8	17	6	18	5	19	0
20th.	17	8	17	6	18	4	19	0
21st.	17	10	17	4	18	4	18	1
22nd.	17	10	17	4	18	4	18	7
23rd.	17	10	17	2	18	3	18	7
24th.	17	10	17	1	18	4	18	8
25th	17	8	17	0	18	4	18	9
26th.	17	7	17	2	18	5	18	9
27th.	17	7	17	3	18	0	18	9
28th.	17	6	17	2	18	1	18	9
29th.	17	6	17	2	18	0	18	9
30th.	17	6	17	2	17	10	18	9
31st.	17	9	17	1	18	0	18	9

Days of the Month.	SEPTEMBER. 1849.		1850.		1851.		1852.	
	ft.	in	ft.	in.	ft.	in.	ft.	in.
1st.	17	6	17	1	17	3	18	7
2nd.	17	6	17	1	17	3	18	6
3rd.	17	3	17	2	17	5	18	7
4th.	17	0	17	1	17	0	18	7
5th.	17	0	17	1	17	0	18	4
6th.	17	0	17	2	17	2	18	3
7th.	17	0	17	5	17	1	18	3
8th.	17	4	17	6	17	3	18	3
9th.	17	4	17	4	17	2	18	3
10th.	17	4	17	5	17	0	18	4
11th.	17	4	17	5	17	0	18	4
12th.	17	8	17	5	17	0	18	3
13th.	18	0	17	5	17	2	18	3
14th.	17	8	17	5	17	4	18	3
15th.	17	8	17	2	17	3	18	3
16th.	17	6	17	2	17	2	18	2
17th.	17	8	17	2	17	3	18	2
18th.	17	8	17	1	17	5	18	3
19th.	17	8	17	1	17	4	18	3
20th.	17	6	17	4	17	4	18	2
21st.	17	8	17	3	17	4	18	2
22nd.	17	3	17	2	17	7	18	1
23rd.	17	0	17	2	17	6	18	1
24th.	17	0	17	2	17	5	18	0
25th	17	6	17	2	17	3	18	0
26th.	17	8	17	2	17	0	18	1
27th.	17	8	17	0	17	2	18	1
28th.	17	10	17	0	17	1	18	1
29th.	17	10	17	0	17	0	18	1
30th.	17	10	17	0	17	2	18	1
31st.	.....		.....		.....		.....	

Days of the Month.	OCTOBER. 1849.		1850.		1851.		1852.	
	ft.	in.	ft.	in.	ft.	in.	ft.	in.
1st.	17	10	17	0	17	3	17	2
2nd.	17	10	17	1	17	1	17	3
3rd.	17	4	17	4	17	3	17	3
4th.	17	6	17	4	17	3	17	3
5th.	18	8	17	6	17	3	17	1
6th.	18	0	17	6	17	0	16	10
7th.	17	0	17	7	16	11	16	11
8th.	17	8	17	7	17	0	17	0
9th.	17	8	17	7	17	0	17	1
10th.	17	5	17	5	17	0	17	0
11th.	17	10	17	4	17	0	17	0
12th.	17	10	17	3	17	0	17	2
13th.	17	10	17	3	17	0	17	1
14th.	17	6	17	4	17	2	17	.
15th.	17	6	17	4	17	2	17	1
16th.	17	6	17	4	17	2	17	2
17th.	17	6	17	5	17	2	17	3
18th.	17	6	17	6	17	2	17	1
19th.	17	4	17	7	17	3	17	0
20th.	17	4	17	7	17	2	17	2
21st.	17	1	17	7	17	2	17	2
22nd.	17	0	17	7	17	3	17	3
23rd.	17	0	17	11	17	3	17	3
24th.	17	4	17	10	17	4	17	2
25th	17	1	18	0	17	4	17	1
26th.	17	1	18	4	17	4	17	3
27th.	17	3	18	4	17	7	17	3
28th.	17	3	18	4	17	6	17	4
29th.	17	3	18	4	17	5	17	5
30th.	17	6	18	3	17	5	17	5
31st.	17	6	18	3	17	4	17	6

Days of the Month.	NOVEMBER. 1849.		1850.		1851.		1852.	
	ft.	in.	ft.	in	ft.	in.	ft.	in.
1st.	17	6	18	3	17	5	18	8
2nd.	17	6	18	4	17	5	18	10
3rd.	17	6	18	2	17	7	18	11
4th.	17	5	18	0	17	7	19	0
5th.	17	5	18	0	17	7	19	4
6th.	17	5	18	2	17	6	19	3
7th.	17	6	18	0	17	6	19	1
8th.	17	7	18	0	17	7	19	0
9th.	17	7	18	0	17	7	19	2
10th.	17	7	17	9	17	7	19	4
11th.	17	10	17	6	17	8	19	6
12th.	17	10	17	6	17	3	19	6
13th.	17	10	17	5	17	4	19	7
14th.	17	10	17	4	17	1	19	7
15th.	18	1	17	4	17	2	19	7
16th.	17	4	17	5	17	0	19	4
17th.	18	6	17	7	17	0	19	3
18th.	18	6	17	9	17	0	19	3
19th.	18	6	17	9	16	11	19	1
20th.	18	7	18	0	16	11	18	10
21st.	18	3	18	0	17	0	18	7
22nd.	18	1	18	0	17	3	18	7
23rd.	18	1	18	0	17	3	18	6
24th.	18	0	18	0	17	1	18	6
25th	18	0	17	9	17	4	18	5
26th.	18	0	17	7	17	5	18	5
27th.	17	11	17	7	17	4	18	6
28th.	18	3	17	0	17	5	19	6
29th.	18	8	17	0	17	5	19	10
30th.	18	3	17	6	17	5	19	10
31st.	.....		.....		.....		.....	

Days of the Month.	DECEMBER. 1849.		1850.		1851.		1852.	
	ft.	in.	ft.	in	ft.	in.	ft.	in.
1st.	18	3	17	11	17	0	19	9
2nd.	18	3	18	4	17	0	19	7
3rd.	18	3	18	1	17	0	19	6
4th.	17	10	17	9	17	6	19	4
5th.	17	10	18	0	17	6	19	3
6th.	17	10	17	9	17	1	19	3
7th.	17	10	17	9	17	2	19	3
8th.	17	10	17	7	17	4	19	5
9th.	17	6	17	8	17	7	19	6
10th.	17	3	18	4	17	9	19	6
11th.	17	3	18	4	18	0	19	6
12th.	17	3	18	8	19	0	19	8
13th.	17	0	18	11	20	0	19	9
14th.	17	6	18	9	23	7	19	8
15th.	17	10	19	10	24	10	19	7
16th.	17	8	19	9	24	9	19	7
17th.	17	10	19	10	26	7	19	5
18th.	17	10	20	2	26	0	19	7
19th.	17	10	21	4	29	8	20	2
20th.	18	4	23	3	31	3	19	8
21st.	19	4	24	2	33	4	19	7
22nd.	18	7	25	4	31	0	19	10
23rd.	19	10	29	11	31	6	20	3
24th.	19	10	32	5	1 9 over Coping.		20	3
25th	19	10	33	0	level with Coping.		20	3
26th.	22	5	.....		8 in. under Coping.		20	6
27th.	24	7	.....		3 ft. under		21	1
28th.	25	10	.....		2 ft. under		21	7
29th.	27	0	.....		2 in. under		22	0
30th.	27	0	.....		8 in. under		23	3
31st.	29	5	.....		1 6 under.		24	3