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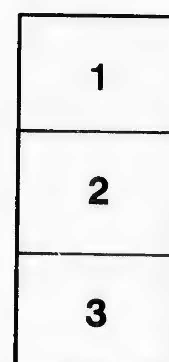
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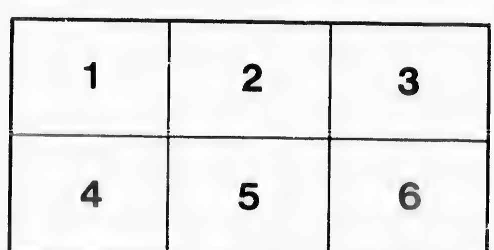
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Canadian Society of Civil Engineers.
INCORPORATED 1887.

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THE CORNWALL CANAL.

By S. Keefer, M. Can. Soc. C. E.

To be read Thursday, November 7th.

Of the first construction of the Cornwall Canal during the years 1834 to 1839, it is proposed in this paper to present to the Society such an account, from personal knowledge, as an assistant engineer, resident on the works during those years, is qualified to give. Reference to the enlargement thereof, now in progress, will also be made as an engineering question.

The Cornwall Canal was the first of the series of canals on the St. Lawrence, constructed for the larger scale of steamboat navigation. In 1832 the legislature of Upper Canada appropriated the sum of $280,000 for the improvement of the navigation of the St. Lawrence, to admit the passage of vessels drawing *nine* feet of water, and recommending the immediate commencement of the improvement between Cornwall and the Long Sault Rapids, stipulating for the completion of the Cornwall Canal before any other works leading to Lake Ontario should be undertaken. A commission was appointed in 1833 to carry out the provisions of the act, and by them the surveys and plans for the works were entrusted to experienced engineers from the United States.

The preliminary survey was conducted by Mr. John B. Mills as chief engineer, with Mr. Benjamin Wright, or Judge Wright, chief engineer of the Erie Canal, as consulting engineer. Mr. Mills brought with him three assistants, and the writer made the fourth. Mr. William J. McAlpine took the levels. The writer made the survey, and Mr. James Worrall and Mr. Charles Mills were the draughtsmen. The field work was soon accomplished. It was begun the 13th May, 1833, and completed 2nd July of the same year. The engineers then proceeded, under the same authority, with the survey of the St. Lawrence thence to Lake Ontario, and submitted plans and estimates for the canals proposed to be constructed at the Long Sault, Farran's Point, Rapid Plat, Point Cardinal and the Galops, amounting in all to $1,294,464. In September and October of the same year the writer assisted Mr. Mills in the survey for a canal in continuation of the Cornwall Canal, and of the same dimensions, in Lower Canada to connect Lake St. Francis with Lake St. Louis, and to overcome the rapids at Coteau, Cedars and Cascades. This survey was confined to the North Shore, and referred to two routes, one along the river bank at these rapids and the other inland.

The following year, 1834, the final location of the canal was begun at Dickinson's Landing, at the head of the Long Sault Rapids, on the 20th May. On the 30th of the same month the Canal Commissioners, of whom Mr. Jonas Jones of Brockville was president, came down to examine the plans and proposed line of canal. They were accompanied by Captain Cole of the Royal Engineers, by their chief engineer, Mr. J. B. Mills, by Judge Wright, the consulting engineer, and by Judge Geddes, another engineer from the Erie and Champlain Canals. As the two American engineers, Judge Wright and Judge Geddes, had borne conspicuous and responsible parts in the construction of the Erie Canal, it was considered that their knowledge of canal works would be valuable to the Commissioners. Captain Cole and Judge Geddes had been specially retained to advise the Board in reference to the selection of the best line for the canal. Mr. Mills had served under Mr. Moncure Robinson, an accomplished and distinguished engineer of Virginia, and came to his work in Canada well informed, and with perfect confidence in his own ability. He was a man of great determination, and having once made up his mind as to his plans, and the course he intended to pursue, he was immovable.

As the result of this examination by the Commissioners, and the engineers both civil and military who attended them, the chief engineer's plan was approved, and the works were placed under contract the same year. It may here be stated that with the exception of a few changes of the centre line at the Long Sault, to throw the canal more inland, the location of the canal as now constructed is the same as that originally projected by Mr. Mills, and adopted by the commissioners.

The engineers determined on locks 55 feet wide 200 feet long between the gates, and with nine feet of water on the sills. These dimensions would allow the passage of vessels 175 to 185 feet long, according to their build. The canal 100 feet wide at bottom and 150 feet at surface to admit of the side paddle steamboats then in use passing each other in any part of the canal. The great capabilities of the screw as a means of propelling vessels had not at that time been developed, and propellers were not then employed in our inland navigation. This accounts for the very generous width given to the canal.

The length of the canal is 11½ miles. There is one guard lock at the head, and there are six lift locks of 8 feet lift each, to overcome the whole fall in the river of 48 feet, from the head of the Long Sault to Cornwall bay at the head of Lake St. Francis. This scale for the navigation of the St. Lawrence was approved by the commissioners and adopted by the government, and became the standard for the other short canals above Cornwall, except that as vessels could there descend the rapids outside these canals with safety the bottom width was reduced to 50 feet. The width of the locks on the Cornwall Canal 55 feet, as fixed by the American engineers, was not in reality available for vessels of that width, owing to the peculiar form of the lockwalls, and therefore when the Williamsburgh canals (the name given to the short canals at Farran's Point, Rapid Plat, and the Gallops) were afterwards constructed, as well as Beauharnois and Lachine canals, the width was reduced to 45 feet, which was considered in better proportion to the length and draught.

An account of these locks as built, with plans of locks, lock gates and the machinery for operating them, was published with the report of Col. Philpotts, R. E., on the proposed enlargement on the Welland Canal in 1840, and need not be repeated here. This report was made under instructions from the Earl of Durham, and was addressed to the Right Honorable Sir Charles Poulett Thompson, Governor General, and published in the "*Professional Papers of the Royal Engineers*," Vol. V, pp. 140 to 193.

THE LOCATION.

In taking his departure from the navigable waters of the St. Lawrence above the Long Sault, the choice of two lines was presented to the engineer. One was to follow along the river bank down to the channel dividing Sheek's Island from the main shore, and the other an inland route up Hoople's Creek, and by a depression half a mile back of the river to meet the same channel at Sand Bridge on Brownell's Bay. The first was along a high bluff bank rising 30 to 50 feet above the river, all side cutting, and the other a thorough cut.

The engineer having instituted a comparison between these two lines decided in favour of the one by the river, as being a mile and a quarter shorter, and saving $120,000 in cost. An engineer's assistant may not question the superior judgment of his chief, but loyally accept his decision, seeing he is in no way responsible.

The correctness of this estimate has recently been called in question, but whether right or wrong no good end can be served by the discussion of it now, for the very good reason that the officially adopted line has been constructed, and in use for half a century without accident or failure of any kind. The subject is now a dead issue.

It may be observed, however, that the front or river line being all in side-cutting with short delivery into the river, a cubic yard of material could be moved at less cost than in a thorough cut inland, where it has first to be elevated, and then carried some distance into spoil bank. Probably two yards could be moved on the front line at the same cost as one yard on the inland route, or double the quantity for the same cost.

THE SUMMIT LEVEL.

There can be no doubt that the engineer was perfectly right in maintaining his summit level, and carrying it on as far as he could, so as to command the table-land eastward of Milleroches, to his first lift lock, but his location of the canal along the three miles of circuitous side cutting, from the Long Sault to Milleroches, cannot be approved, when there was, as will appear from what follows, no necessity for resorting to such a hazardous location, but in view thereof a safe and less costly means of keeping up the summit level. The maintenance of the summit level was correct in principle, because when the line had reached Milleroches, the engineer was independent of the river, and thence to Cornwall could locate his lock to the best advantage. On the other hand, many of the contemporary engineers, both civil and military, who had other plans to suggest seemed to have lost sight of this essential principle. They proposed to lock down into the Sheek's Island channel, and to render it navigable by dams at Moulinette and Milleroches, or simply by one dam at the latter place made high enough to drown out the rapids at the former. It appears this was suggested in order to avoid the great cost and risk of hanging up the canal in side cutting on the north shore; but by this proposed drop to a lower level they had to encounter a deeper cutting of some seventeen feet or more eastward of Milleroches till the first lift lock was reached. They all suggested that a low dam, to serve merely as a coffer-dam, should be thrown across the shallow channel, called the "*Snye*" at the head of Sheek's Island, to shut off the water coming down that channel during the construction of the proposed works at Moulinette and Milleroches, or possibly to serve, if maintained, as a regulating bulk head for the supply of the canal after it had been built. Mr. Peter Fleming, Mr. Samuel Clowes, Judge Geddes and Captain Cole, R. E., favor plans of this sort; but Mr. Clowes went beyond the other engineers, and suggested a lock in the dam at Milleroches, and continuing the canal along the margin of the open St. Lawrence to the head of the Cornwall Rapids, and thence along in front of the town to the bay below Cornwall.

Of all these rival schemes the assistant engineer was at the time entirely ignorant, and in no way concerned with them, being then actively employed in the location survey of the chief engineer's adopted line. But while so engaged, he had naturally become familiar with the physical features and capabilities of the country for canalization, and began to form opinions of his own on the subject. To him it appeared a surprising circumstance, that after all the array of professional skill that had been convened to assist the Commissioners in the selection of the most feasible plan, they should all have overlooked one simple and obvious idea that would have given a satisfactory solution of the main difficulty with which they were all contending—namely, the cost and hazard of carrying the summit level of the canal along the left bank of the river, where the surface of the canal would be from 16 to 24 feet above the surface of the river, and where the suitableness or otherwise of the material for making sound banks was as yet unknown.

The idea that presented itself to the mind of the writer was to have no canal at all on the north bank, but in lieu thereof, to raise the dams at the head and foot of Sheek's Island, high enough to retain the summit level of the canal, and transform the river valley into a fine broad basin, making that the canal. If both dams were raised to the same level, they would obviate the necessity of constructing three miles of canal along the north shore. The foundations for these dams would be secure, for they would be on hard, gravelly earth or solid rock. The width of the channel at the head of the Island is 230 feet, according to the survey presently to be referred to, and at the foot of the Island 330 feet. In both cases the water is quite shallow—the same quantity passing at both places, and the banks are high. Sheek's Island would form the south, and the main land the north bank of the canal, or basin, created by the two dams. The upper dam, if raised five feet above canal surface, would stand 26 feet high in the middle, and the lower dam 40 feet high, allowing in both cases for four feet of water in the rapids, which is believed to be in excess of the actual depth.

The idea of two dams *of the same height*, both raised to summit level does not appear to have been grasped by any of the engineers before mentioned, and when the assistant engineer ventured to suggest it to his chief, it was treated with scant courtesy, and at once dismissed, and was never again referred to. Could it be that the chief did not understand what his assistant proposed? It is believed that a survey and comparative estimate, if made at that time, would certainly have settled the question in favor of his plan.

THE CONSTRUCTION.

Mr. Mills remained in charge of the works as chief engineer, until 1st June, 1836; when, owing to a difference that arose between him and the Commissioners, he gave in his resignation, and was succeeded by Colonel Phillpotts, of the Royal Engineers. In the two years of his official connection with the canal, he had, with the approval of Mr. Benjamin Wright, settled all the plans for the mechanical structures and earth works, and considerable progress had been made in their construction before Colonel Phillpotts assumed command. The writer had been placed in charge of the works on the upper division, a little over seven miles in length, including the guard lock and the first lift lock, and continued in charge of the same under Colonel Phillpotts until the work was suspended.

A map of the river St. Lawrence, immediately south of the canal, has been prepared (Plate .....), shewing the several islands and channels between them, through which the main navigable channel downwards pursues its tortuous course, and also the boundary line between Canada and the United States. This map has been copied from the very careful hydrographic survey of the U. S. Corps of Engineers, made in the years 1871, 1872 and 1873, and is the most recent, as well as the most correct, chart extant. From this, it will be seen that Sheek's Island is Canadian, while Barnhart's Island is American, and that the channel dividing them, through which the boundary line is drawn, is not navigable, nor is the small channel between Sheek's Island and the Canadian shore fit for navigation. Therefore, there can be no reason why Sheek's Island should not be utilized for canal purposes, seeing it is only intended to rest the ends of the two dams upon it, and to flood a few acres of the low land fringing its northern border.

THE EARTH WORKS.

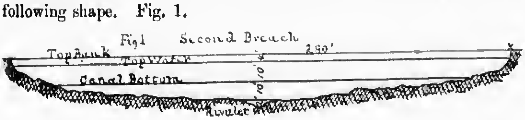
In order to represent more clearly the peculiar character of earth works on the first reach, four cross-sections have been plotted from the original field notes and records, and numbered 1, 2, 3, and 4. (Plate ......). A hand sketch marked (A) is also given on the face of the map in further explanation.

Cross-section No. 1 is given to shew the deepest cutting on Section No. 1; the Long Sault section, which is 9294 feet in length, and the enormous amount of material that was wasted in these rapids—all carried away by the current to the lower parts of the river, in order that the prism of the canal might be cut out of the solid ground without encroaching on the bed of the river.

The material through which the canal was made along the rapids is characterized by Sir William Logan, as "*Glacial drift with boulders.*" The upper part of this section, for nearly a mile, is covered with a stiff brown clay, which was soon dissolved and carried off when thrown into the deep swift current, which at this place runs smoothly at the rate of ten miles an hour. No attempt was made to save it by crib-work or otherwise. The gravelly earth underlying this brown clay becomes gradually harder and deeper as the lower end of the section is approached, until it is developed into hard pan, and beyond the limit of the section into indurated or cemented gravel that required to be blasted before it could be removed. There was no more clay at the lower end of the section, and the boulders amounted to one-sixth of the entire mass. The mixture of gravelly earth and hardpan was the very best material for making a solid water-tight bank, and it might have been economized much more than it was for that purpose. The military engineers, who occasionally visited the works during their progress, entertained the opinion that it was impossible to encroach upon the bed of the river, that the current would have its own way, that the artificial works put in it would not stand, and that the river would ultimately return to its original bed! It is very possible these opinions might have influenced the management, for the centre line was moved at the upper end from 30 to 70 feet, and then back to zero again, by gentle curves over 4,200 feet; and at the lower end from 0 to 74 feet and back again to 0, over 3,000 feet, leaving only some 2,100 feet of the original centre line unchanged.

But facts are stronger than opinions. It is a fact that the bed of the river was encroached upon along the swift broken water towards the lower end of the section, viz., on sub-sec. F. of No. 1 (Plate ....). The hand-sketch (A) on the map (Plate ....) explains how this was done. By taking advantage of certain salient angles or points along the rapids, a bank of earth and stones was run out to the outer slope of the canal embankment and protected by a mass of boulders. Then the boulders kept in reserve for the occasion were used to form a barrier against the river between these salient points along the outer edge of the slope, enclosing a pond of still water, which was then filled with earth to form the base or body of the embankment, the abrasion of the natural bank by the current during the ages past had favoured these operations by forming a margin of comparatively shallow water between the projecting points, varying from 6 to 10 feet deep, whereas further out, from soundings taken in the rapids, the depth was from 20 to 30 feet. The bank built in this way has stood firm to this day, and must be considered permanent. Much more good work of this kind might have been accomplished to economize the material, had the plans been previously arranged for it.

Cross-section No. 2.—This section is taken a short distance below Moulinette, and is a fair sample of the doubtful character of the soil on which the integrity of the navigation depends. It was near this that the *first* breach occurred in December, 1843, shortly after the canal was first opened. Small streaks of sand were found in excavating the canal, which made their way in some unknown manner through the natural "*drift*" on which the embankment rests. These where discovered were cut off by a puddle trench, six to eight feet deep, another bank and canal bottom protected by an apron of puddle three feet in thickness. The *second* breach took place on the 30th October, 1850, just above the road culvert at Moulinette, after the canal has been seven years in use. The cause of the breach in this instance was attributed to a small rivulet that crossed the canal nearly at right angles, some fifteen feet below the bottom of the canal. It was a sort of blind water-course that had not been thoroughly cleared of the sand and vegetable deposits before the bank was built across it. Through this, without any previous warning, the canal water found a passage, and in a very short time, a gap 280 feet long and 26 feet deep was made, emptying the canal, and carrying away some 1500 cubic yards of the bank. The gap took the following shape. Fig. 1.



The writer at this time was Chief Engineer of Public Works, and on him rested the duty of restoring the navigation in the shortest possible time, so that the fall fleet might be passed through before the close of navigation. He at once repaired to the spot, and with the assistance of Mr. Duncan McDonald, the local superintendent, and a strong force of men and horses working night and day, the breach was made up to full height in ten days—the water let in on the 9th day—and on the 12th of November he was able to report to the Department, that the navigation was fully restored, and all the delayed vessels had passed through.

Before the canal was filled, the writer walked down the canal bank to Milleroches to make an inspection of the empty canal. He found a leak in the bottom of the canal some distance below the ***cross-section No. 2,*** when the water was running out in a considerable stream into the French drain that had been put in to drain off the springs in the natural soil. This drain was five feet under canal bottom, and near the toe of the bank; See Fig. 2. Some bad material was found

Fig 2

in the bottom of the canal through which the water found a passage to the drain in a stream the size of one's arm, and passed under the bank to the river by the French drain here shown. If the breach had not occurred at Moulinette as it did, one would most surely have happened here. The bank had a narrow escape.

Cross-section No. 3.—This section is taken 1400 feet east of No. 2, near the place where the *third* breach, the most serious of all, occurred on the 11th Oct., 1888. It will be observed that there is no excavation here. The work is altogether in embankment—an embankment that rests half on the land and half in the bed of the river, which at the end of the slope is $38\frac{1}{2}$ feet below the bottom of the canal. The river bank is 8 feet below canal bottom. The soil is clay out of which arise natural springs, which during construction were led out to the river by longitudinal and transverse French drains under the seat of the embankment. This expedient was by no means effectual, for when the bank had been raised nearly to its full height, even before the water was let into the canal, the outer slope began to slide off towards the river. The springs received into the drains rose up in the outer slope and softened the bank, and of course it must yield to the superincumbent weight of the more solid material resting against it. To remedy this evil a series of cross diagonal drains was sunk in the outer slope to carry off the leakage. A good deal of this kind of protection had to be resorted to during the progress of the work; but when all was done and the outer slope protected by rip-rap, it is evident, from the facts stated, that there could be no assurance that the bank would be permanent. A clay soil infested with natural springs, whose source is unknown, is submitted to a pressure of 22 to 24 feet head of water—the difference between the water in the canal and the water in the river. The quantity of water that leaks out through the bank may be trifling at first, but the power exerted by it for mischief is not measured by the actual volume of water that leaks through (as is well understood by what is known as the "*hydrostatic paradox*"), but is in direct proportion to the sum of the vacant spaces within the bank or area on which the pressure is applied. This power, constantly acting on the clay soil forming the outer slope of the bank, first softens it, and then it gives way to the pressure from above, causing slides.

A gravelly soil on the other hand stops its own leaks. The earth and sand and gravel rush in and close them. Herein is the great difference between the banks constructed past the Long Sault where the material is gravelly earth, and sand, and stones, and the treacherous clay soil over which the canal has been formed between Moulinette and Milleroches. The former have never failed, the latter have failed three times, and many more failures have been averted by constant inspection and prompt repairs.

The breach which occurred in this vicinity in October last, no doubt exemplified the hydrostatic law before referred to, for after it was nearly closed another slide took place and materially retarded its completion. This, with the almost incessant rains, delayed the navigation 32 days, and raised the cost of repairs to nearly $50,000.

It must be admitted that the foundation of the embankment here is by no means reliable, nor is it likely that it can be made so at any reasonable cost. Certainly it is not a foundation such as an engineer would select for the base of a dam, for while the bank of the canal must maintain the water in it from 16 to 24 feet above the river, it is in reality a dam in every part of it throughout its three miles of length.

Although your attention has not been particularly directed to the character of the canal, between Moulinette and the Long Sault—or rather Brownell's Bay, it must not be inferred that this part affords no cause of apprehension. So far, it is true, no breach has happened here, but it must be observed that it rests on a clay soil, covered with a deposit of sand and loam, and the water in the canal stands 16 feet above the water in the river. A great body of this sand and clay was carried from the side cutting to form the embankment in Brownell's Bay, which had many years to settle and consolidate before the sixteen feet of pressure was put upon it. At the same time the removal of so large a mass of material from the side cutting for building this bank prepared a more secure site for the canal. Still it is a canal in side cutting, and for that reason is less secure and more exposed to accident than a canal in a thorough cut.

Cross-section No. 4. This section is taken about a quarter of a mile above the first lift lock, and represents the retaining wall built in the bank by Mr. Mills. Before the canal was begun, land slides were observed in the high bank along the river, which at this place is *forty* feet below the surface of the canal. They were caused by springs in the natural bank. As a matter of protection to the canal, a wall, as shown, was built for a quarter of a mile in length along the line of the outer edge of the towing path, founded on a solid timber platform, supported on piles. The wall is built of heavy ashlar masonry, laid dry, so as to allow the spring water to pass anywhere freely through it. The clay excavated from the prism of the canal was thrown in spoil bank in rear of this wall, and as the top of it was 3 feet under top bank it is now entirely covered in and hidden from view. It extends from sta. 335.50 to sta. 349.60 of the original survey, and contains 9,037 cubic yards of masonry.

In constructing the canal, sand streaks running through the clay were discovered in the bottom, by which the water found a passage to the revetment wall and through it to the spoil bank outside. In August, 1836, a slide took place here, which carried away part of the original bank within *five* feet of the foundation of the wall, and exposed 6 to 8 feet of the natural bank below it. From a note made at the time, it was thought that the part (A) sunk down to the place (B) and pushed out (C) before it—(B) and (C) having first been softened and prepared to slide by the water leaking through the wall. To stop the leaks a puddle trench 8 to 10 feet deep and 4 feet broad at bottom was placed along the foot of the slope, and joined to an apron of puddle three feet in thickness, protecting the bank to its top. This method of protection was entirely successful, and there have been no further slides, nor any failure of the wall up to this time.

The rebellion of 1837 interfered seriously with the progress of the works on this canal, and finally, with the financial embarrassments that followed, brought it to a stand. The writer left in 1839. In 1841 a "*Board of Works*" (afterwards "*the Department of Public Works*") was established for the united provinces of Upper and Lower Canada with the Hon. H. H. Killaly, C.E., as chairman, and the writer as Chief Engineer. Under that Board the canal was so far completed in

1842, that the steamboat "*Highlander*" was passed through in December of that year, but the formal opening did not take place until June, 1843. No important works in connection with this canal have since been executed, with the exception of the construction of regulating weirs and sluices around the locks, to supply water power to the mills at Cornwall.

The total expenditure on this canal up to the date of confederation 1st July, 1867, was $1,933,152.

THE ENLARGEMENT.

The Canal Commission of 1871 made an attempt to fix the scale of navigation for our canals. They recommended the enlargement of the Welland and St. Lawrence Canals for a draught of *twelve* feet, with locks 270′ x 45′ x 12′ in the chamber. That scale was approved and adopted by the Government; but when the enlargement was begun on the Welland, strong representations were made by the merchants of Montreal and others interested in the navigation, that the draught should be increased to *fourteen* feet, and the Welland and Lachine Canals have been finished to that depth, while the length and breadth of the locks remain the same as recommended by the Canal Commission. Skipping the Beauharnois Canal for the time, the enlargement of the Cornwall Canal was begun at each end—the middle portion was not placed under contract until near the end of last year.

Three years before this work was placed under contract, the writer ventured to lay before the Minister of Railways and Canals the facts that had come to his knowledge, in relation to the doubtful nature of the foundation on which the old canal rests. This was done by a memorandum dated 17th Feb., 1885, which has recently been printed by order of Parliament, along with the correspondence in reference to the great breach of October last, and in which will be found the reply of the Government engineer to the writer's suggestion. His letter is dated 27th Feb., 1889.

It will be observed that the chief engineer does not question the facts stated, but draws a different conclusion from them. He states that although the materials described may not be suitable for making banks in the usual way, they are yet of such a nature that, when thoroughly mixed by bucket dredging, and placed in the manner specified on the south side of the embankment, will form "*moderately good banks.*"

It will further be observed that he has learned from the last breach, and from information subsequently obtained, that it would be injudicious to cut into the north side of the embankment, and says that the widening must all be done on the landward side, the south bank allowed to remain undisturbed, and the slope on the canal side continued down to the new bottom line at the same angle as at present. Thus it appears that all the material dredged out is to be put on the south side of the bank.

On this point, the Government engineer does not speak with that confidence one might expect from this responsible officer in vindication of his own plans. He says: "It is true that placing the dredged material on the outside is not the position where it would be most serviceable to banks of the description these are represented to be, still the material will have a sectional area, and be of a nature that when fully consolidated would *almost, if not altogether*, retain the water in the canal, were the old banks opposite the respective places removed altogether."

Coupling this with the previous admission that the dredged material will form only moderately good banks, it is not easy to follow him to the confident conclusion that comes immediately after. "Of the feasibility, efficiency and safety of enlarging the present canal, in the manner described in the specification on which the works are led, the slightest doubt is not entertained by me."

In order to illustrate the effect of the *modus operandi* to be pursued in the enlargement, both on the bottom and slopes of the bank, your attention is directed to the cross-sections No. 2 and No. 3 (Plate ....), on which the bottom line and slopes of the enlarged canal are drawn.

In sinking the bottom $6\frac{1}{2}$ feet deeper, the dredge will remove the puddle trench and puddle apron on the bottom of the old canal, and will expose the streaks of sand in the original bank of No. 2 to a severe pressure. The banks at both places, being on unsound bottom, cannot be benefitted by all the spoil bank dumped on the outside of it, but on the contrary must be rendered more liable to accident than at present, by these operations.

It is perhaps necessary here to state that the *cross-section No.* 4 reveals a condition of things apparently unknown to the chief engineer, since his specification for Sec. 5 makes no reference to the revetment wall, and the puddle trench and apron in front of it. Special means will have to be adopted in order to protect the canal from leakage along the front of this wall, and thereby prevent land slides.

THE "SNYE."

The Government engineer can see no advantage to the canal whatever in the suggestion to convert the Sheek's Island channel, or "Snye," into slackwater navigation, by means of dams at either end. On the contrary, he proceeds to denounce it in most unmeasured terms. He alleges: (1) That the closing of the "Snye" may produce the most serious floods, and lead to complications with a foreign country. (2) That however insignificant this small channel may be, compared with the great St. Lawrence, it runs in the same direction as this branch of the river at the head of the Beauharnois canal, the closing of which led to a vast deal of trouble and outlay for land damages. (3) That "the St. Lawrence is on too grand a scale to admit of the probable result of interference with it, to be even approximated by the use of formulæ fairly applicable to ordinary streams." And finally, (4) That all dams are insecure. On the question of comparative cost, no opinion is expressed.

It is proper and right that an engineer's plans should be fully and fairly considered in all their bearings; but in placing his views before the Minister, the Government engineer has given a loose rein to his imagination, through which he reaches the most astounding conclusions, and by forced exaggerations has made the most and the worst of the writer's plan to serve his own purpose. He has conjured up a bugbear to frighten the Minister and divert attention from the weakness of his own position.

It is now proposed to examine his four allegations: (1) Any person acquainted with the locality would be surprised to learn that the closing of the "Snye" could possibly lead to complications with a foreign power! It seems too absurd to be seriously stated. The term "Snye" is applied in this immediate neighbourhood more particularly to the small channel at the head of Sheek's Island. It starts from about the middle of the length of the Lost Channel, nearly at right angles with the same. The banks of the St. Lawrence on either side are high, and cannot possibly be affected by the closing of the "Snye." (2) It is an unusual thing for the rapids of the St. Lawrence to be frozen over in winter. The ice jam that occurred at Weaver's Point, in January, 1887, was unprecedented. It may never happen again, but if it should, it can do no harm to the proposed dam at the "Snye," for it will be five feet above the flood, and will effectually protect the canal. As for the main river, the banks being high, they cannot suffer damage. They are nature's barrier against such disturbing forces. The reference to the dam at the head of the Beauharnois canal, which closed up a branch of the river, is altogether uncalled for and unnecessary, because, as the engineer admits, it is not a parallel case, although he thinks there is danger in closing the "Snye," from the fact that it *runs in the same direction!* (3) The St. Lawrence is indeed a mighty riven, grand and lovely in its strength. The writer, having dwelt along its borders all his lifetime, respects its magnitude, and loves its beauty and the purity of its waters. Still he considers it amenable to the laws of nature, and must not be prevented tracing out the effect of closing an unnavigable channel and turning it to the service of man. At Fort Erie, where it issues from Lake Erie, under the name of the Niagara river, its discharge, as measured by Mr. Barratt, is 24,000,000 c. feet per minute, that being the least quantity continually flowing over the Niagara Falls. At the Cascades, where it falls into Lake St. Louis, Mr. James Stewart found the discharge 27,384,640 c. feet per minute. It may therefore fairly be assumed that the volume discharged through the various channels, between the Islands at the Long Sault, is 26,500,000 c. feet per minute, and yet the St. Lawrence is not a torrential river, while from the remoteness of its sources of supply it is affected but very little by local rains or floods, and the range between high and low water is of very limited extent. It is a gently flowing stream all the way from Kingston to Montreal, except where broken by rapids. As regards the "Snye," its ordinary discharge is about 200,000 c. feet per minute. Compare this with the whole volume of the main channel, and then adopting Dr. Robertson's law, that "the squares of the discharges are as the cubes of the hydraulic mean depths," and it will be found that the only effect of closing the "Snye" will be to raise the water about *one inch* in that part of the main channel, immediately opposite Sheek's Island and Barnhart's Islands, for both above and below these islands the discharge will be constant—dam or no dam. Moreover, the main channel here is divided by an imaginary boundary line between the two neighbouring countries, and the theoretical rise of one inch will not be observable south of that line, while on the American shore, the rise will be nil. Two civilized countries are not likely to quarrel over a paltry question of this kind. (4) As before stated, the foundations for the dams, and the materials at hand for their construction, are of the best order. An engineer could desire nothing better. There is no reason, therefore, why they should not be made as permanent as the hills. If all dams are ruled out as insecure, it follows that a canal bank three miles long, every part of which is a dam, must be more liable to accident than two dams aggregating about a quarter of a mile in length, including the approaches.

Practically, the best interest of the navigation will be served by the dams, for it must be observed that they can be constructed without any interference whatever with the navigation. The old canal will not be encumbered by the dredges, and the dams could be completed in half the time required for the dredging, and at less than half the cost.

Reference has been made in the printed correspondence before mentioned, to the water power that will be created by making Sheek's Island channel a portion of the canal. Incidentally this is a great advantage; for while navigable canals are not constructed to supply water power, still mill privileges have in many instances been granted wherever it was deemed safe to do so without hindrance to the navigation, and much to the advantage of the manufacturing interests of the country. For instance, at Montreal and Côte St. Paul, on the Lachine canal, and also at Cornwall. But when the water has to be passed around many locks before reaching the mills, it becomes troublesome at times to regulate the canal, and still keep up the supply to the mills. This has been the case, both on the Lachine and Cornwall canals, where the mills are established at their lower ends. Not so on the Beauharnois canal. Here the water is taken from the dam, at the head of the canal, direct from Lake St. Francis, where the supply is unlimited, and the canal itself is in no way affected by any quantity of water, great or small, that may be used for the mills.

It would be much the same for mills established at Milleroches. Here mill-races could be taken off at both ends of the dam, and run down as far as may be necessary on either side of the river, affording a clear head and fall of 25 to 30 feet, not subject, as at Cornwall, to back water from the main channel of the river, and therefore not liable to be stopped in winter or summer.

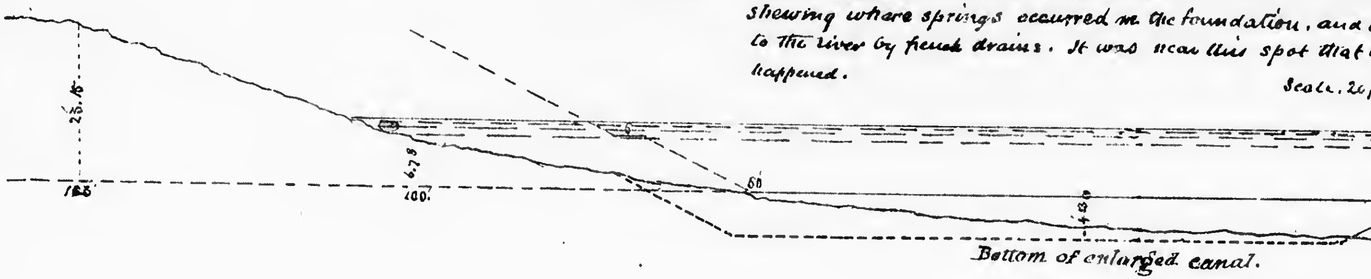
It is suggested that the dams shall be 25 feet wide at top, in order to form a good road over them. According to the Government plans, there is to be a swing-bridge at Milleroches, so that there will be complete and convenient access to the mills and the island from all parts of the main land.

C O R N W A L L C

As originally constructed in 1834.

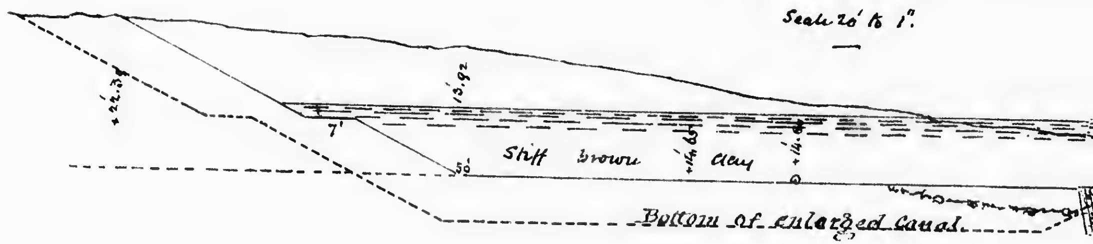
No. 3. Cross-Section of the embankment on Sec. 6. at Sta.
shewing where springs occurred in the foundation, and h
to the river by french drains. It was near this spot that a
happened.

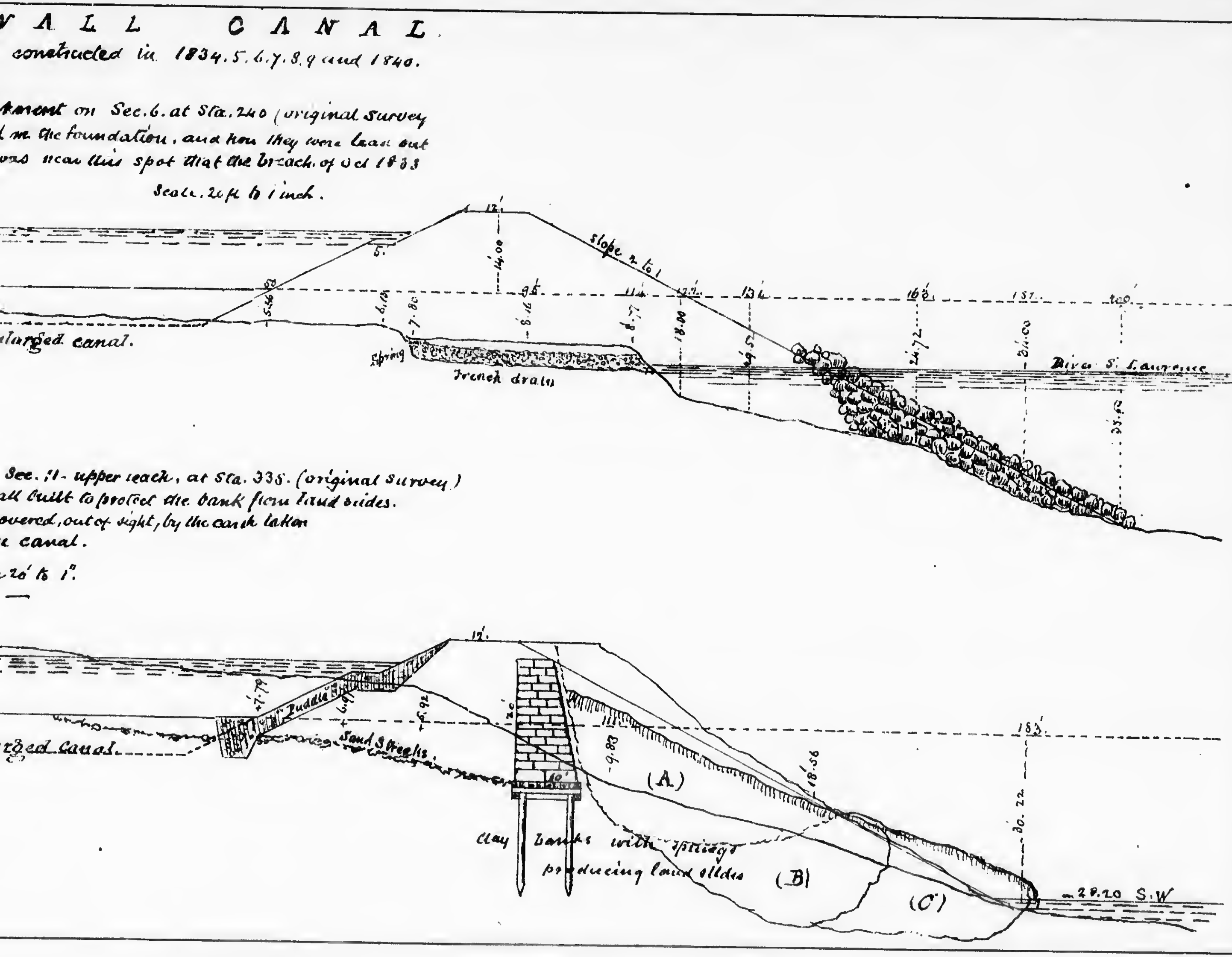
Scale. 20 f



No. 4. Cross-Section of the canal on Sec. 11- upper reach, at Sta
Shewing section of the retaining wall built to protect the bank
This wall was entirely covered, out of sight, by the can
from the canal.

Scale 20' to 1".





N A L L   C A N A L.
constructed in 1834.5.6.7.8.9 and 1840.
kment on Sec. 6. at Sta. 240 (original survey
l in the foundation, and how they were laid out
was near this spot that the breach of Oct 1883
Scale. 20 ft to 1 inch.
larged canal.
Spring
French drain
slope 2 to 1
River St. Laurence
Sec. 11 - upper reach, at Sta. 335. (original survey)
all built to protect the bank from land slides.
overed, out of sight, by the earth latter
e canal.
20' to 1".
Puddle
Sand Streaks
rged Canal.
(A)
(B)
(C)
Clay banks with springs
producing land slides
28.20 S.W

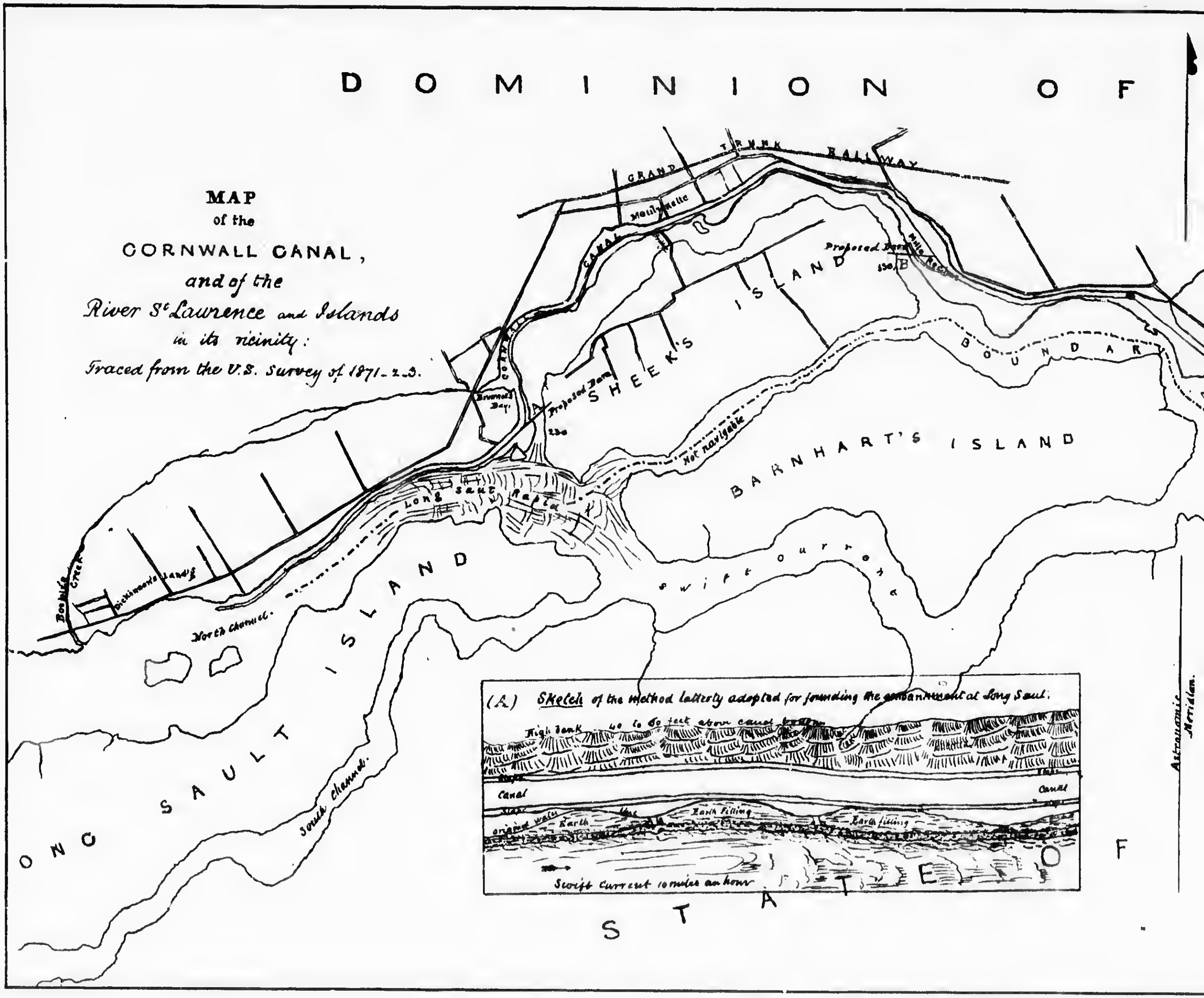
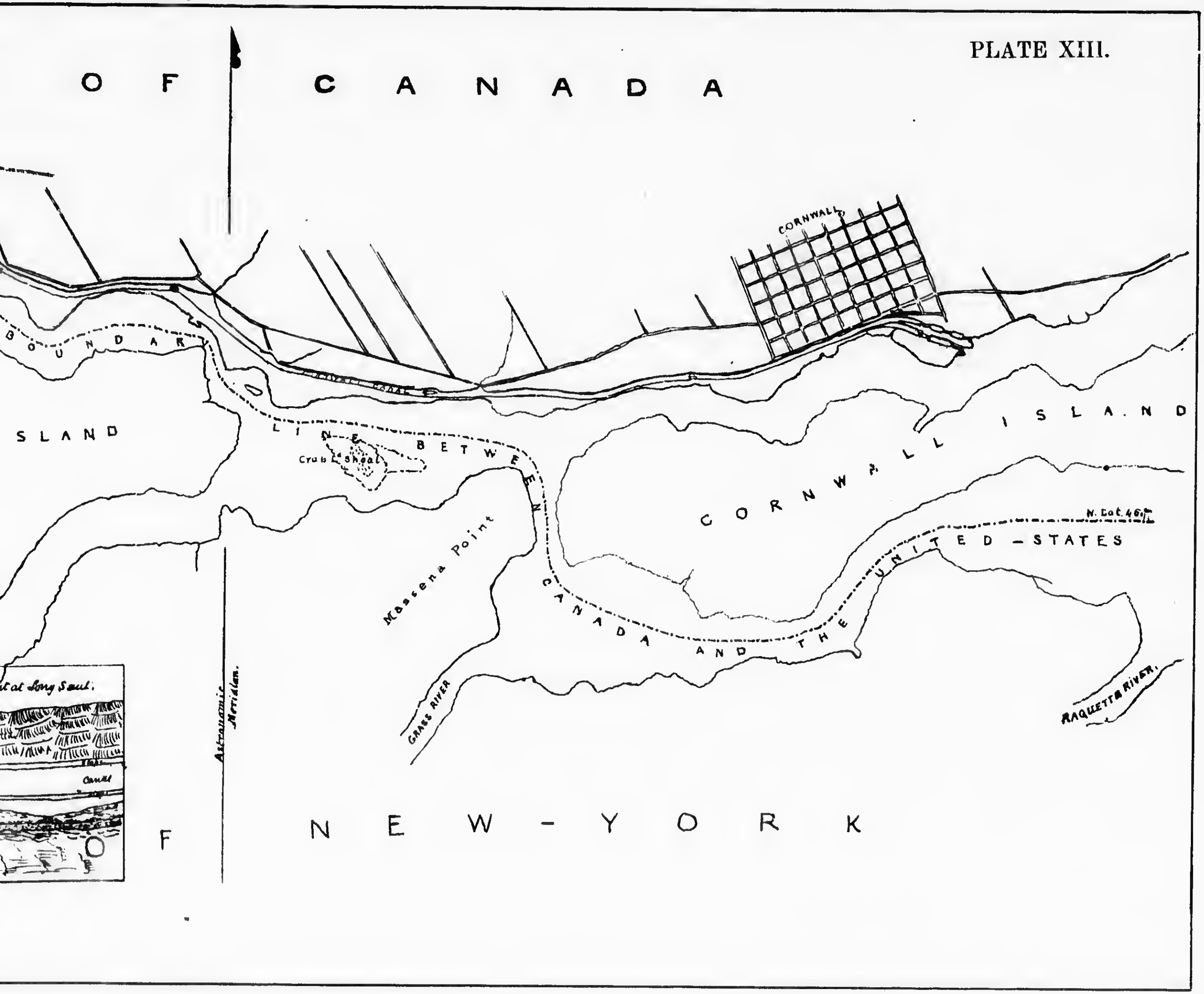
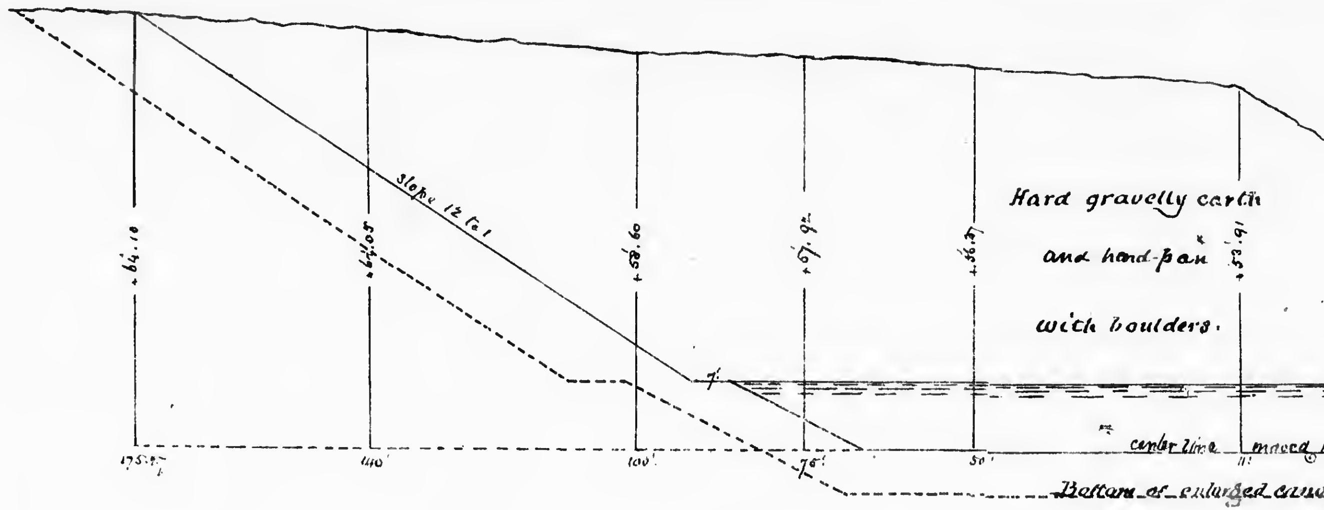

DOMINION OF
MAP
of the
CORNWALL CANAL,
and of the
River St. Lawrence and Islands
in its vicinity:
Traced from the U.S. Survey of 1871-2-3.
GRAND TRUNK RAILWAY
CANAL
SHEEK'S ISLAND
Proposed Dam
BOUNDARY
BARNHART'S ISLAND
Not navigable
Long Sault Rapids
LONG SAULT ISLAND
North channel
South channel
Swift current
Dickinson's Land'g
Hoople Creek
(A) Sketch of the method latterly adopted for founding the embankment at Long Sault.
High bank
40 to 60 feet above canal bottom
Canal
Earth filling
Earth
Swift current 10 miles an hour
STATES OF
Astronomic Meridian

PLATE XIII.



OF CANADA
CORNWALL
BOUNDAR
SLAND
LINE BETWEEN CANADA AND THE UNITED STATES
Crab Shoal
CORNWALL ISLAND
N. Lat. 45°
Massena Point
GRASS RIVER
RAQUETTE RIVER
Astronomic Meridian
OF
NEW-YORK

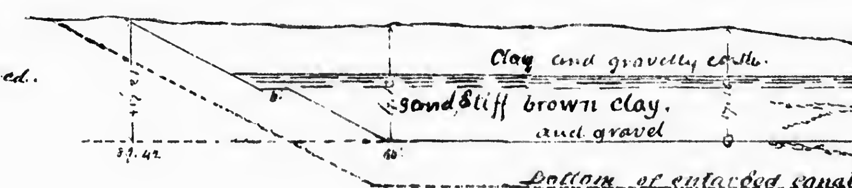


C O R N W A

As originally construc

Cross-Section. **No. 2.**
taken below Moulinette on Section No 6
at Sta. 226 (original Survey)

It was here the first breach occurred.

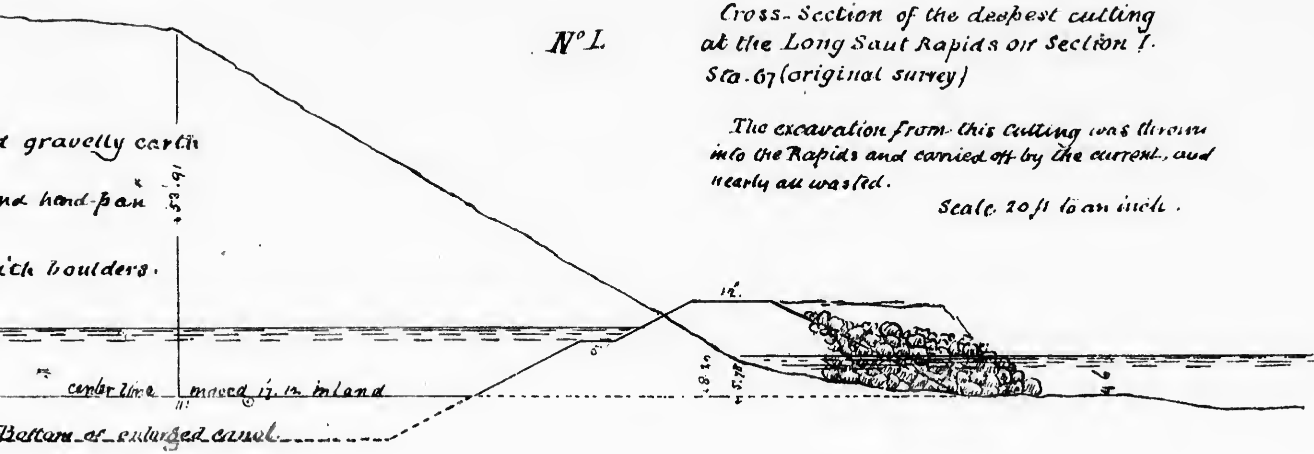


Nº 1.

Cross-Section of the deepest cutting at the Long Saut Rapids on Section 1. Sta. 67 (original survey)

The excavation from this cutting was thrown into the Rapids and carried off by the current, and nearly all wasted.

Scale 20 ft to an inch.



N W A L L C A N A L

originally constructed. 1834 to 1840.