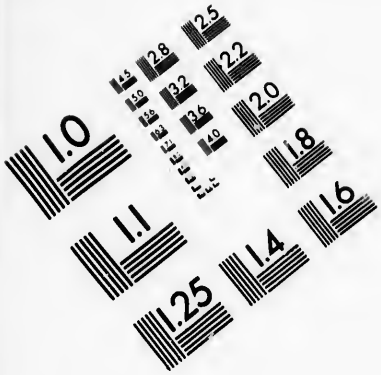


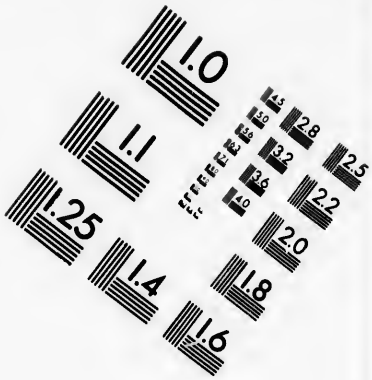
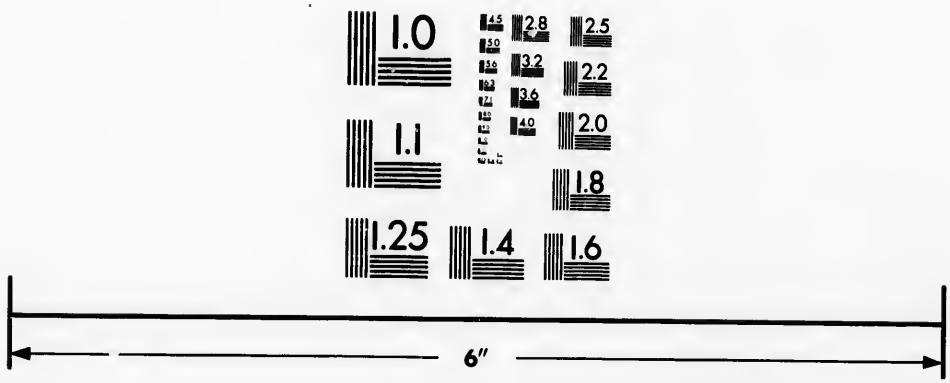
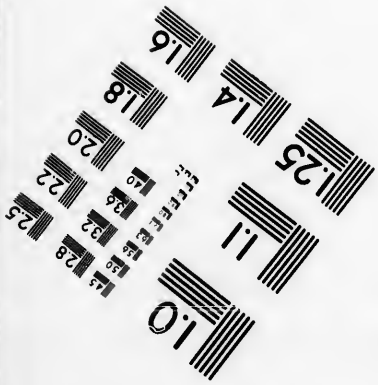
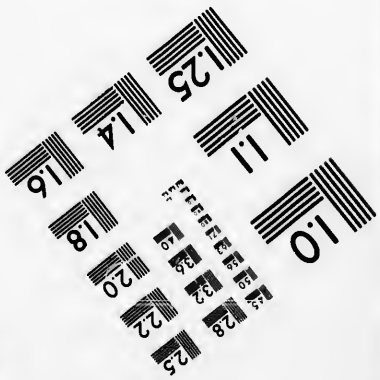


IMAGE EVALUATION TEST TARGET (MT-3)







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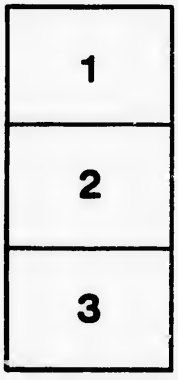

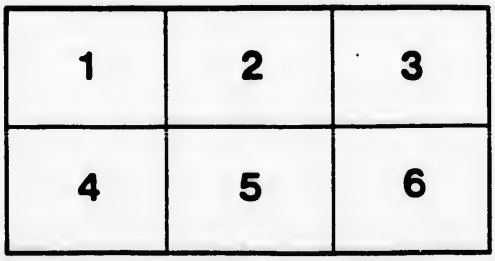

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CANADIAN JOUR

REPORTS

ON THE

IMPROVEMENT AND PRESE

OF

TORONTO HARBOU

PUBLISHED BY AUTHORITY OF THE HARBOUR CO

ERRATUM.—Page 29, for "Kivas Tully, Esq., Provincial Surveyor," read "Kivas Tully, C.E., Esplanade."

TORONTO:
MACLEAR, THOMAS & CO., PRINTERS, 16, KING STREET

1854.

1854
(38)

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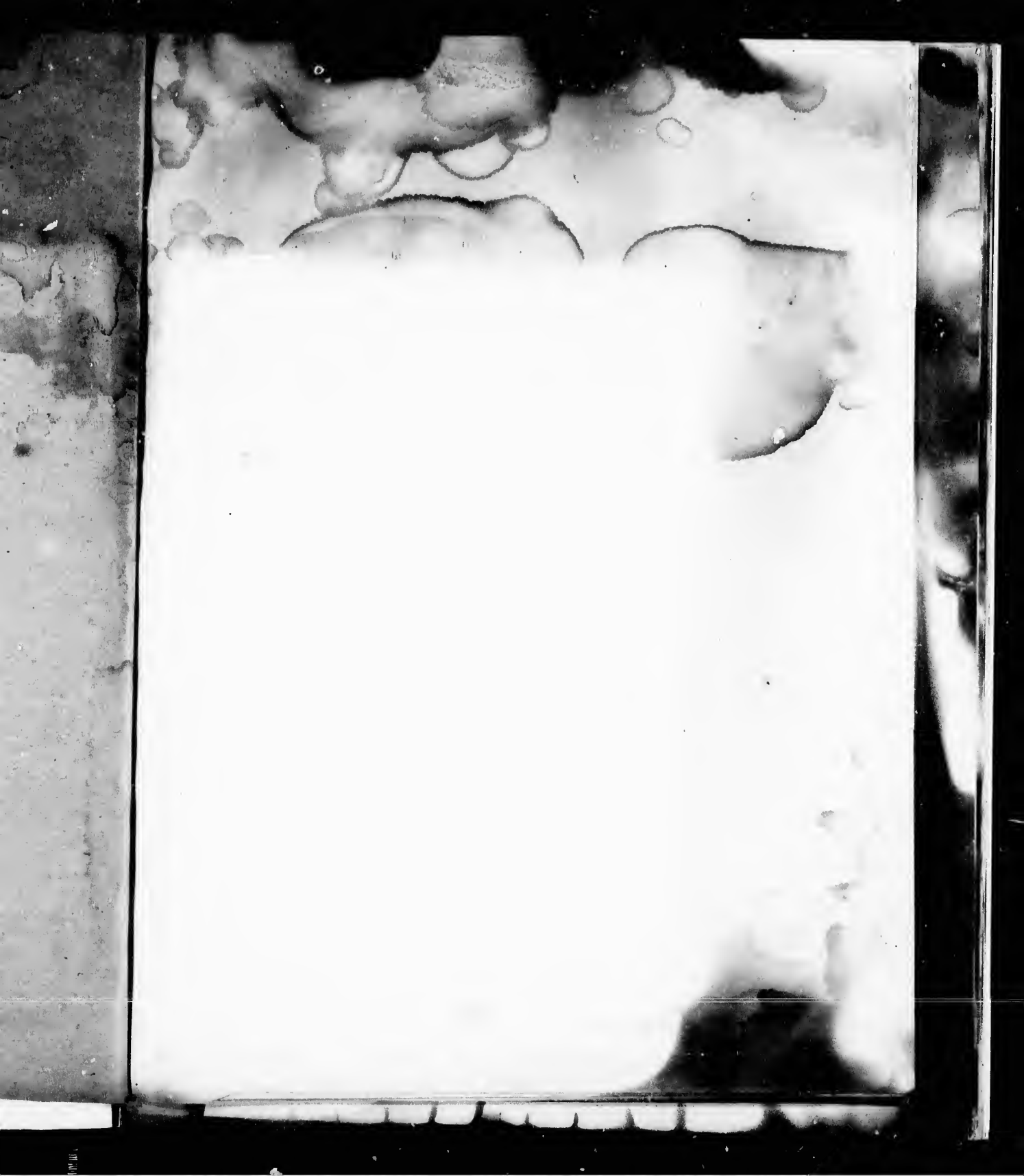
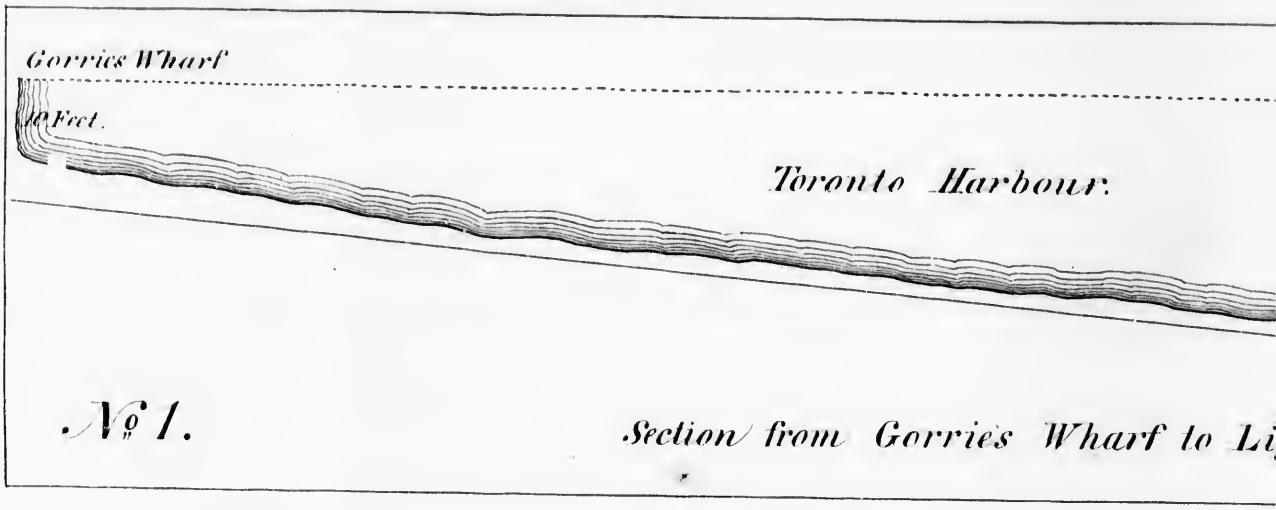
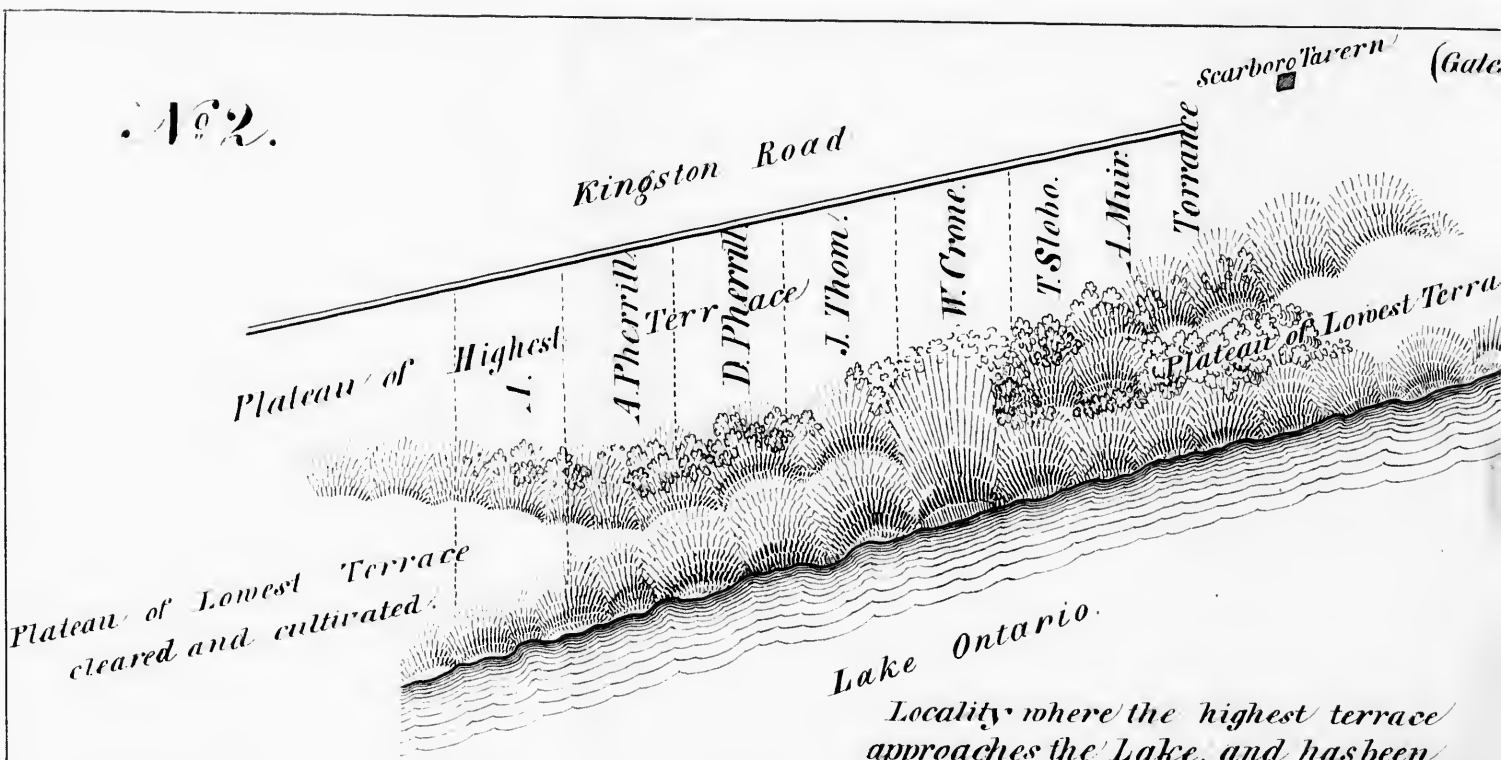




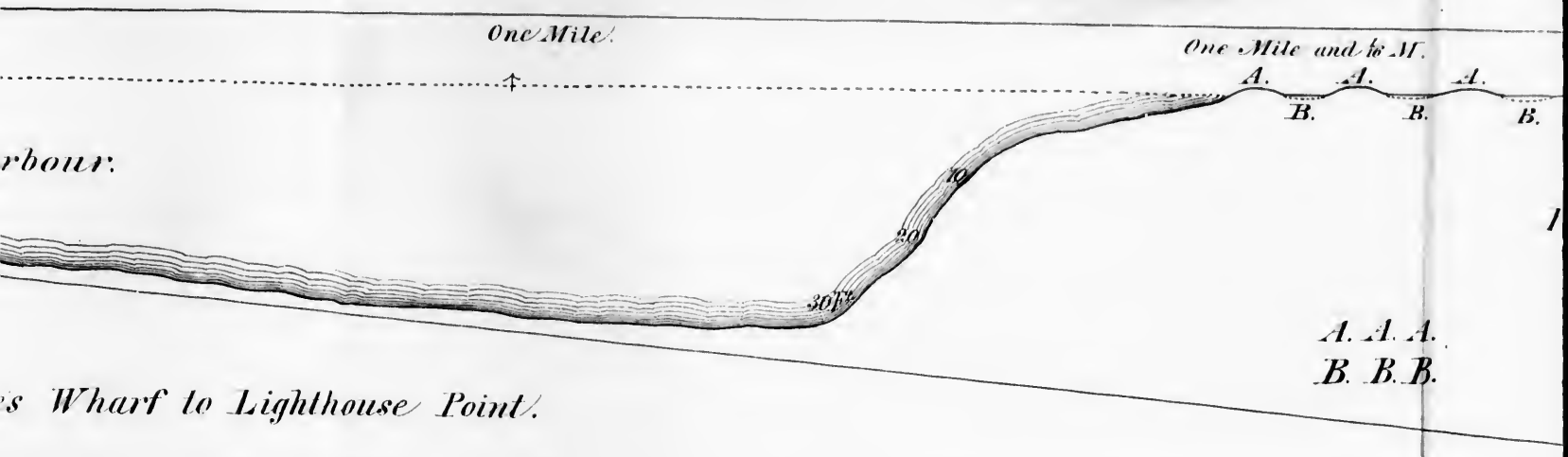
No 1. Section from Gorries Wharf to Li

No 2.



Locality where the highest terrace approaches the Lake, and has been slightly attacked by the waters of the Lake.

Diagrams to illustrate the First Premium Report.



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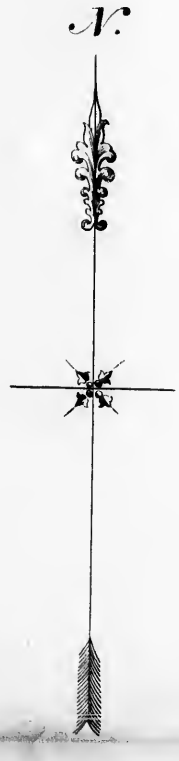
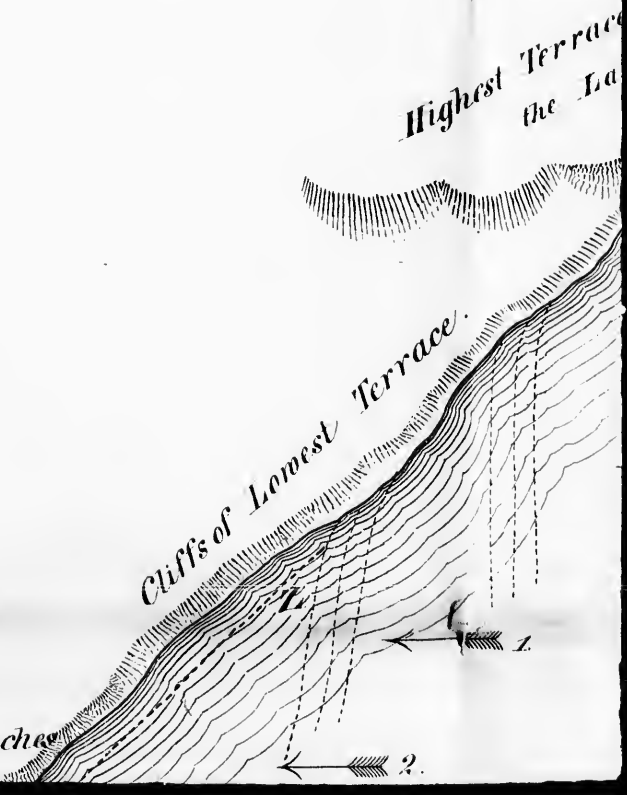
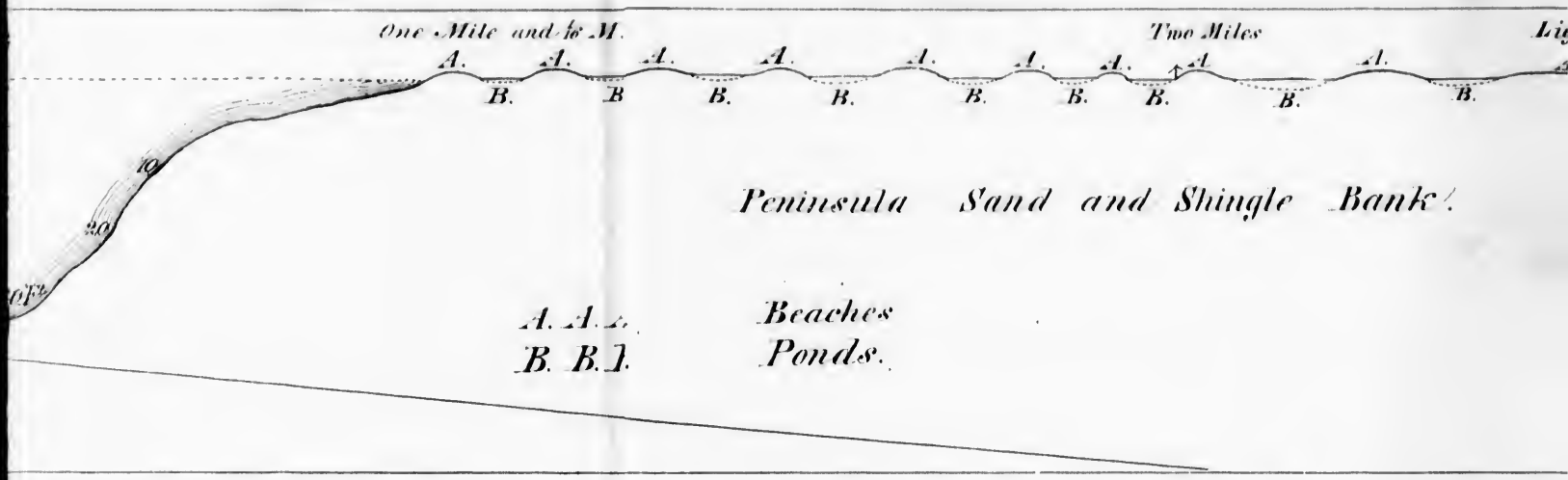
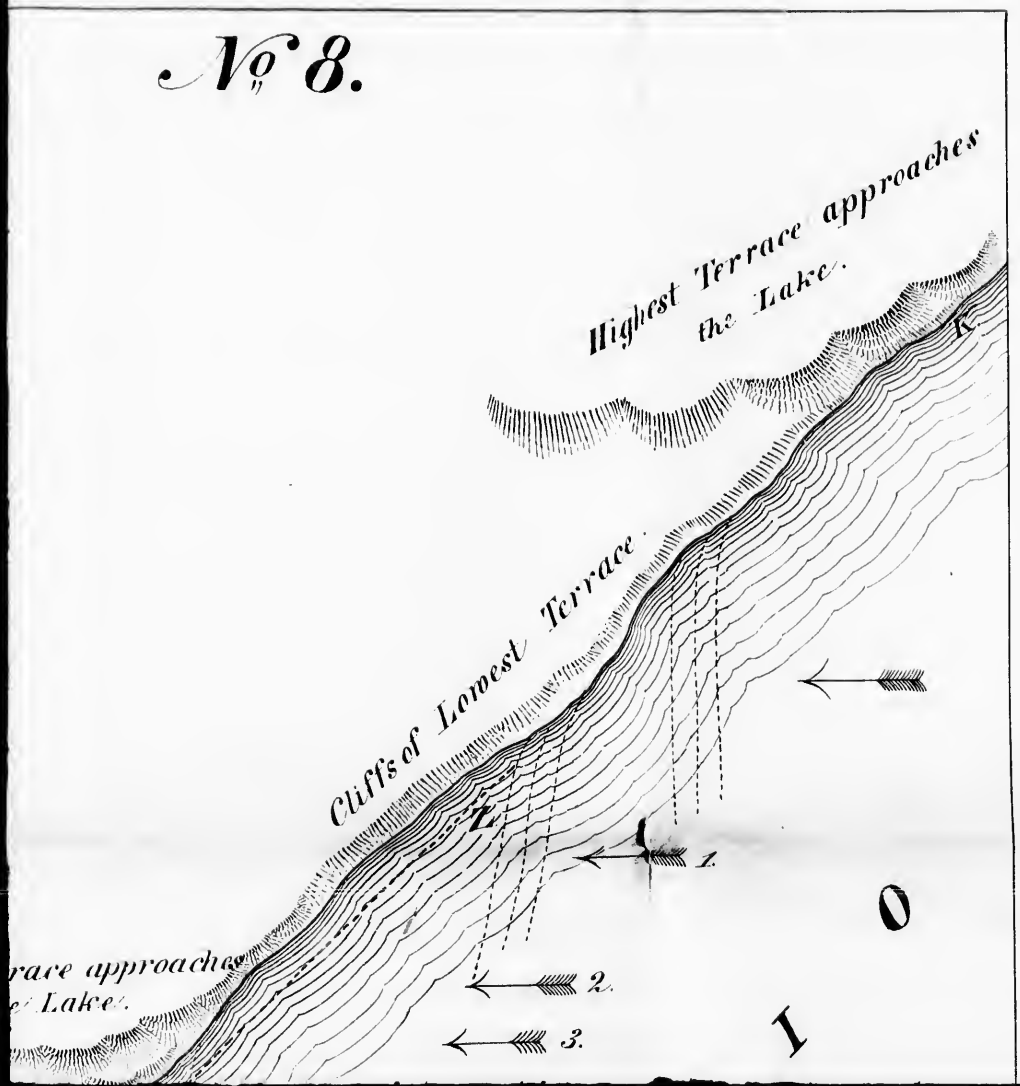
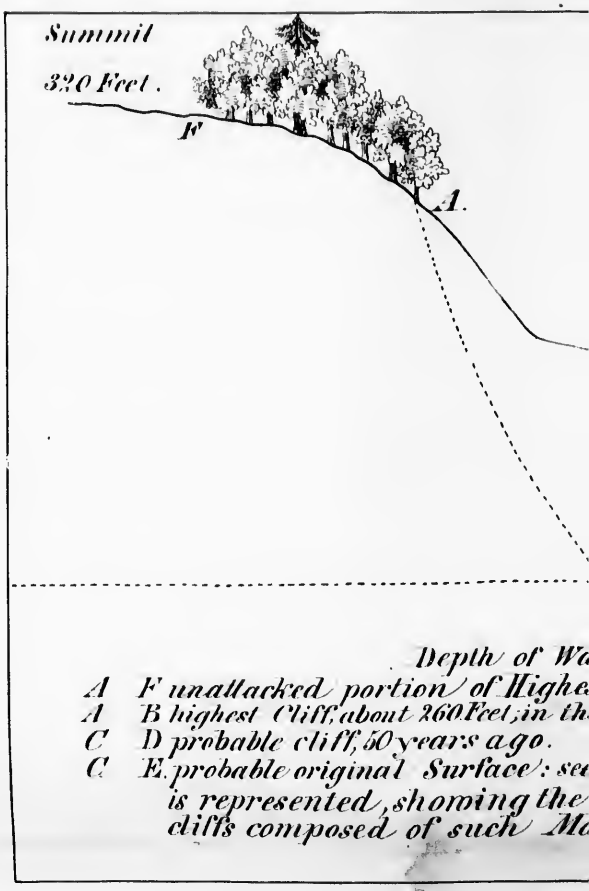


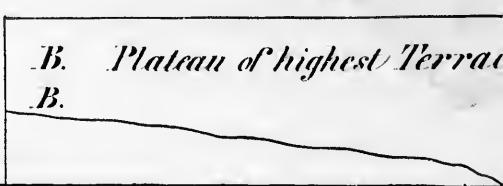


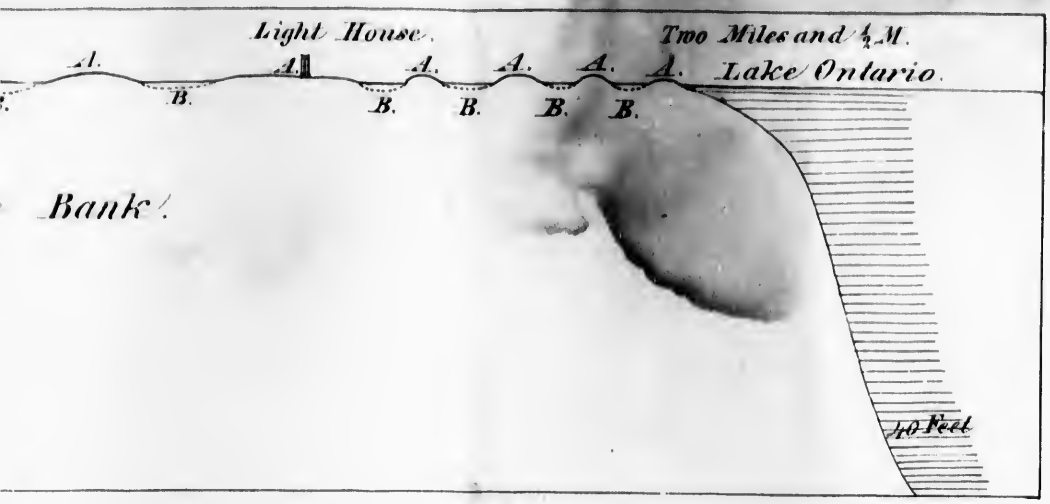

One Mile and ½ M.
Two Miles
A.
B.
Peninsula Sand and Shingle Bank.
A. A. A. Beaches
B. B. B. Ponds.

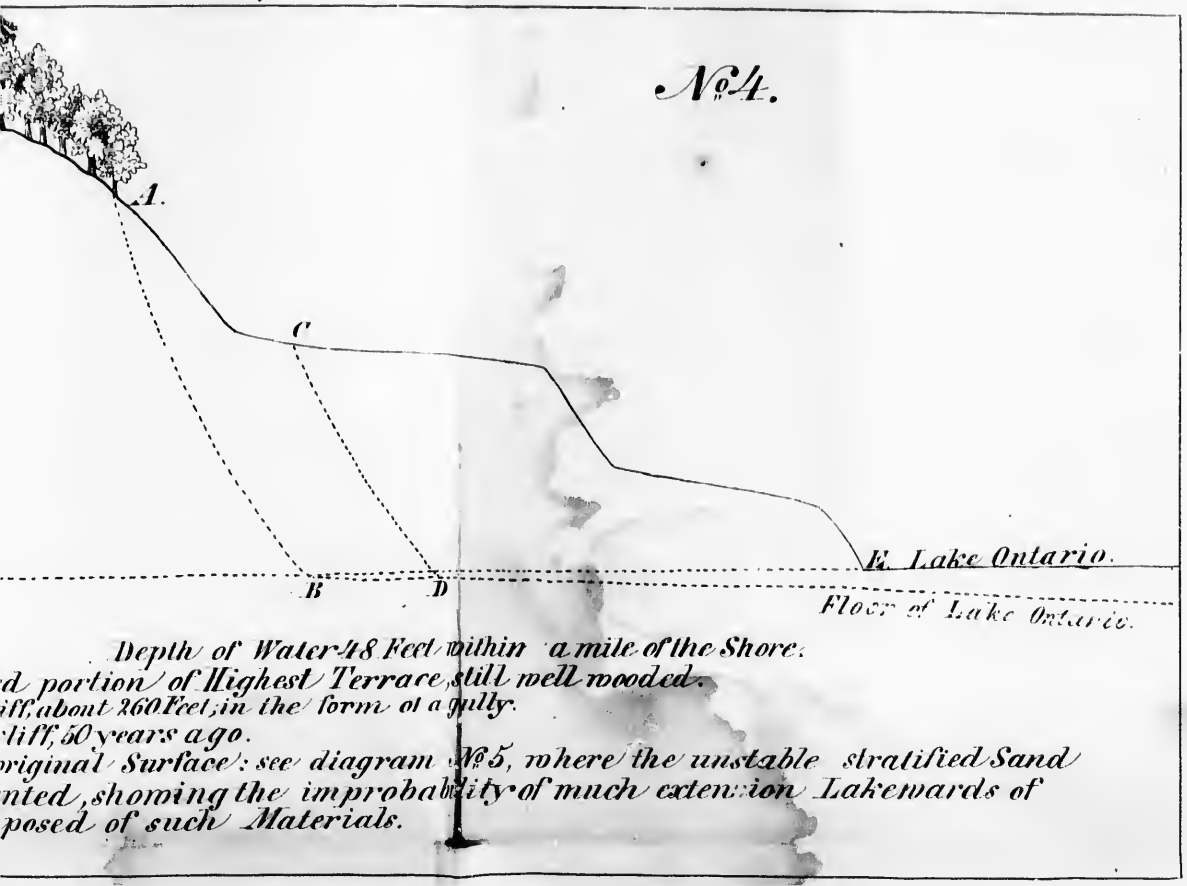
No 8.


Highest Terrace approaches the Lake.
Cliffs of Lowest Terrace.
K
L
1.
2.
3.
0
1


Summit
320 Feet.
F
A.
Depth of Wo
A F unattacked portion of Highe
A B highest Cliff, about 260 Feet, in th
C D probable cliff, 50 years ago.
C E. probable original Surface: see
is represented, showing the
cliffs composed of such Ma

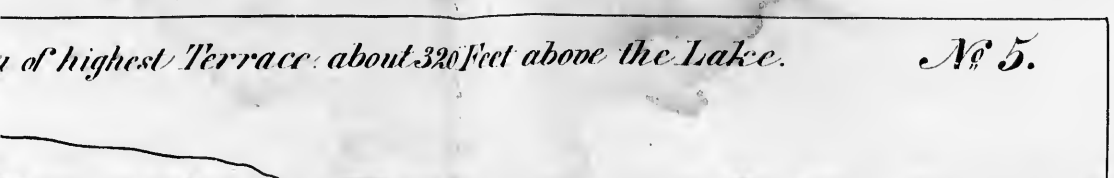

B. Plateau of highest Terrac
B.





No. 4.

Depth of Water 48 Feet within a mile of the Shore.
d portion of Highest Terrace, still well wooded.
iff, about 260 Feet, in the form of a gully.
cliff, 50 years ago.
original Surface: see diagram No. 5, where the unstable stratified Sand
nted, shoming the improbability of much extension Lakewards of
posed of such Materials.

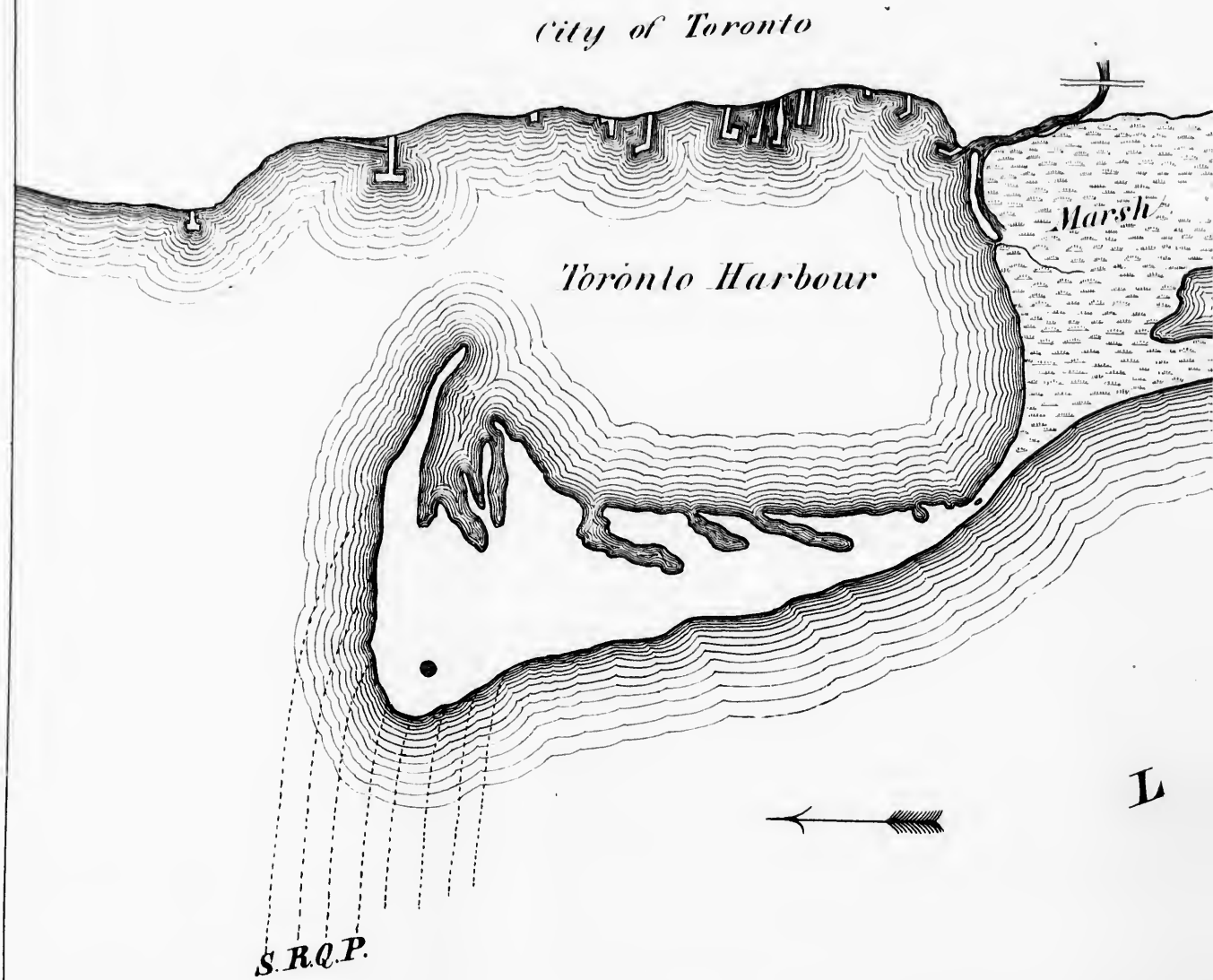


of highest Terrace about 320 Feet above the Lake. **No. 5.**

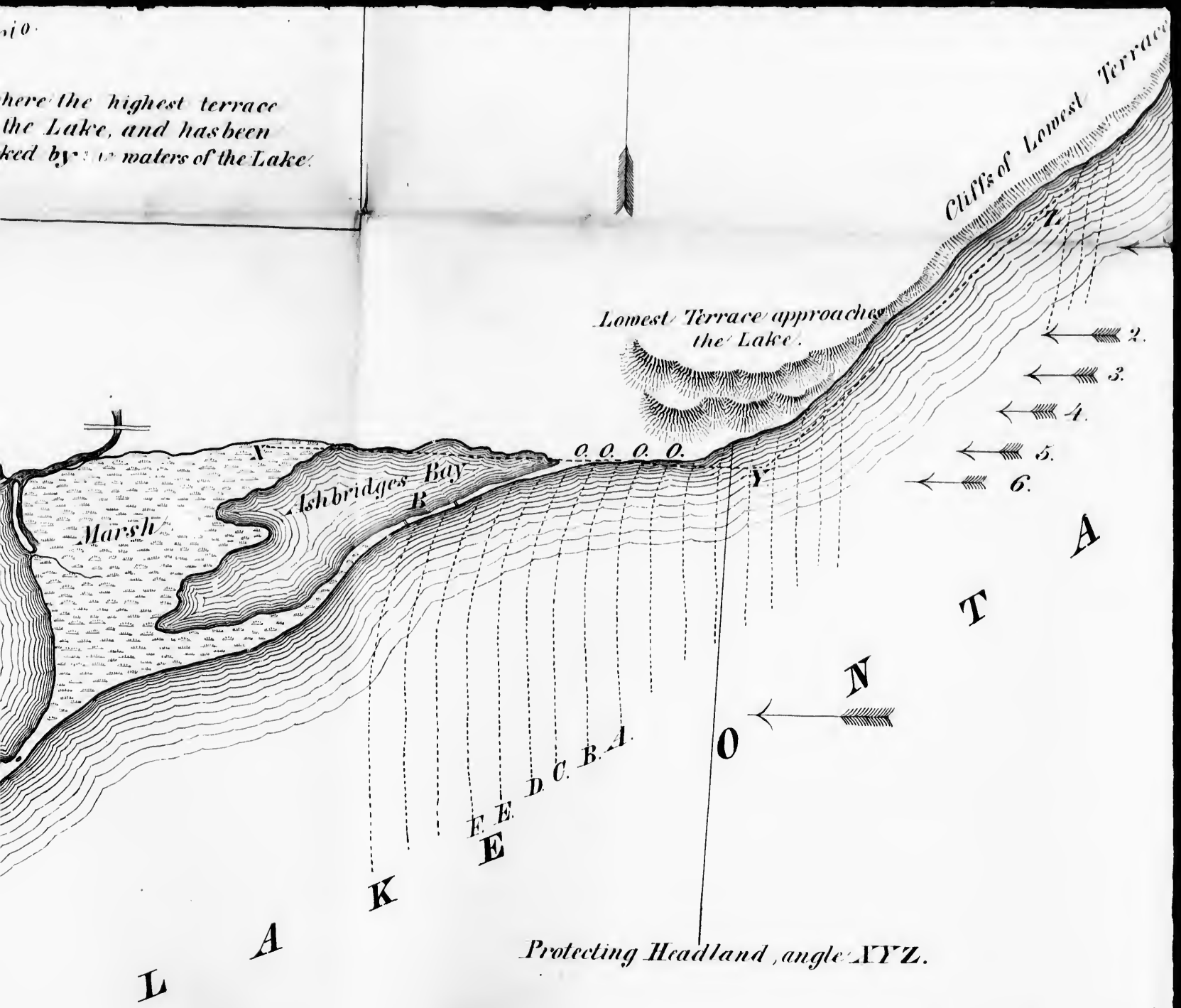
Plateau of [illegible]
cleared and cultivated.

Lake Ontario.

Locality where the highest [illegible]
approaches the Lake, and ha[illegible]
slightly attacked by [illegible] waters o[illegible]



here the highest terrace
the Lake, and has been
ked by the waters of the Lake.



Protecting Headland, angle XYZ.

B..... break in Ashbrid
mile broad, now rap

Scale a half mi

Maclear & Co. Lith. Toronto.

d, angle XYZ.

B..... break in Ashbridges Bay; a third of a mile broad, now rapidly filling up.

Scale a half mile to an Inch.

B

Depth of Water-4

A F unattacked portion of Highest Te

A B highest Cliff, about 260 Feet, in the form

C D probable cliff, 50 years ago.

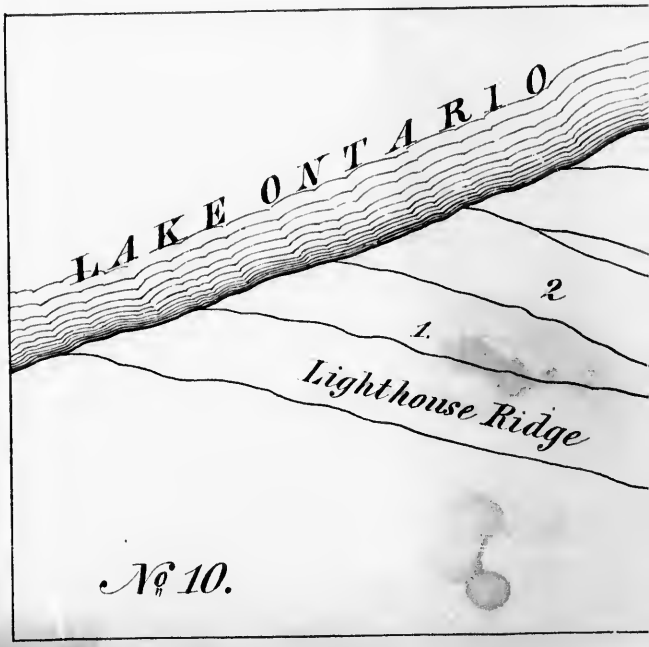
C E probable original Surface: see diag
is represented, showing the imp
cliffs composed of such Materia

B. Plateau of highest Terrace ab

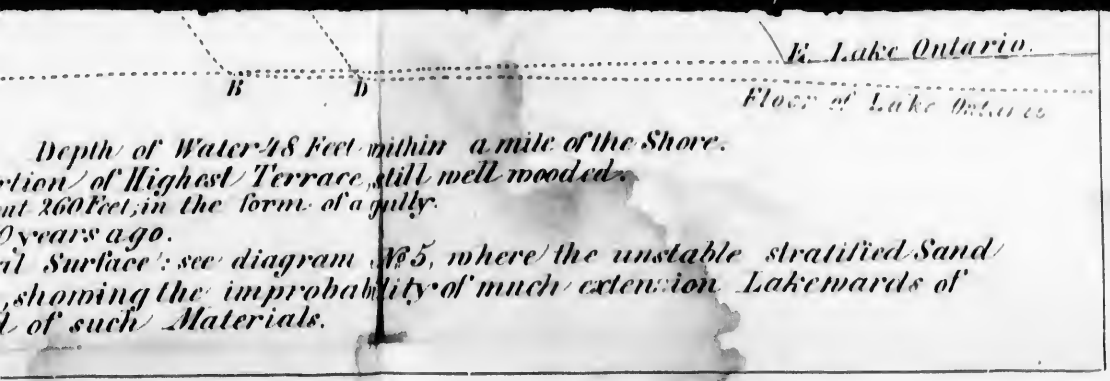
B.

Locality; Torrance's Farm

(See chart of cliffs.)



№ 10.



Depth of Water 48 Feet within a mile of the Shore.
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nt 260 Feet, in the form of a gully.
0 years ago.
il Surface: see diagram №5, where the unstable stratified Sand
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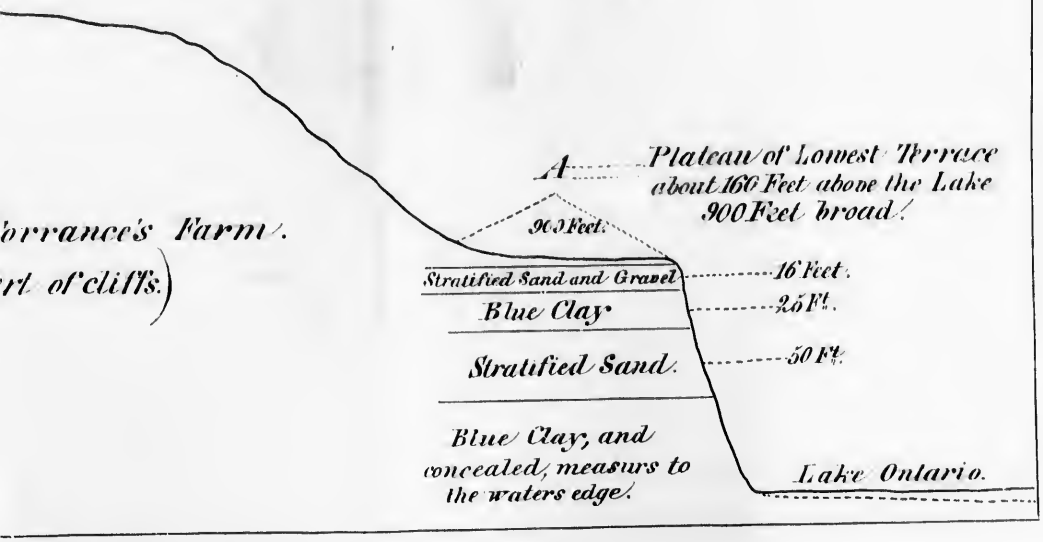
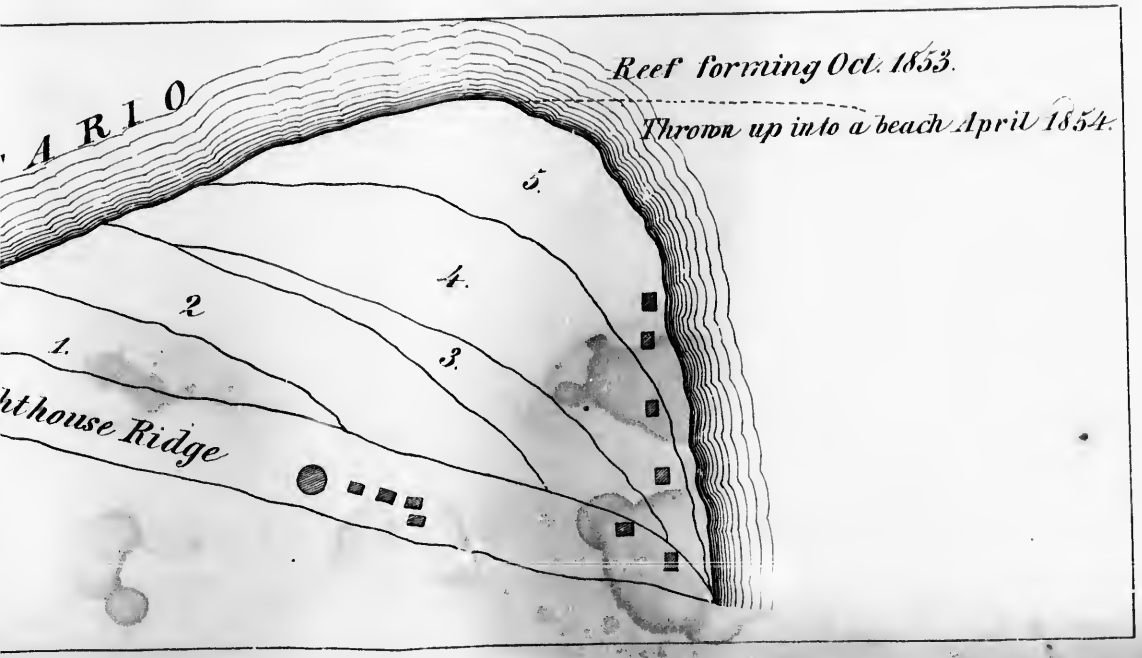
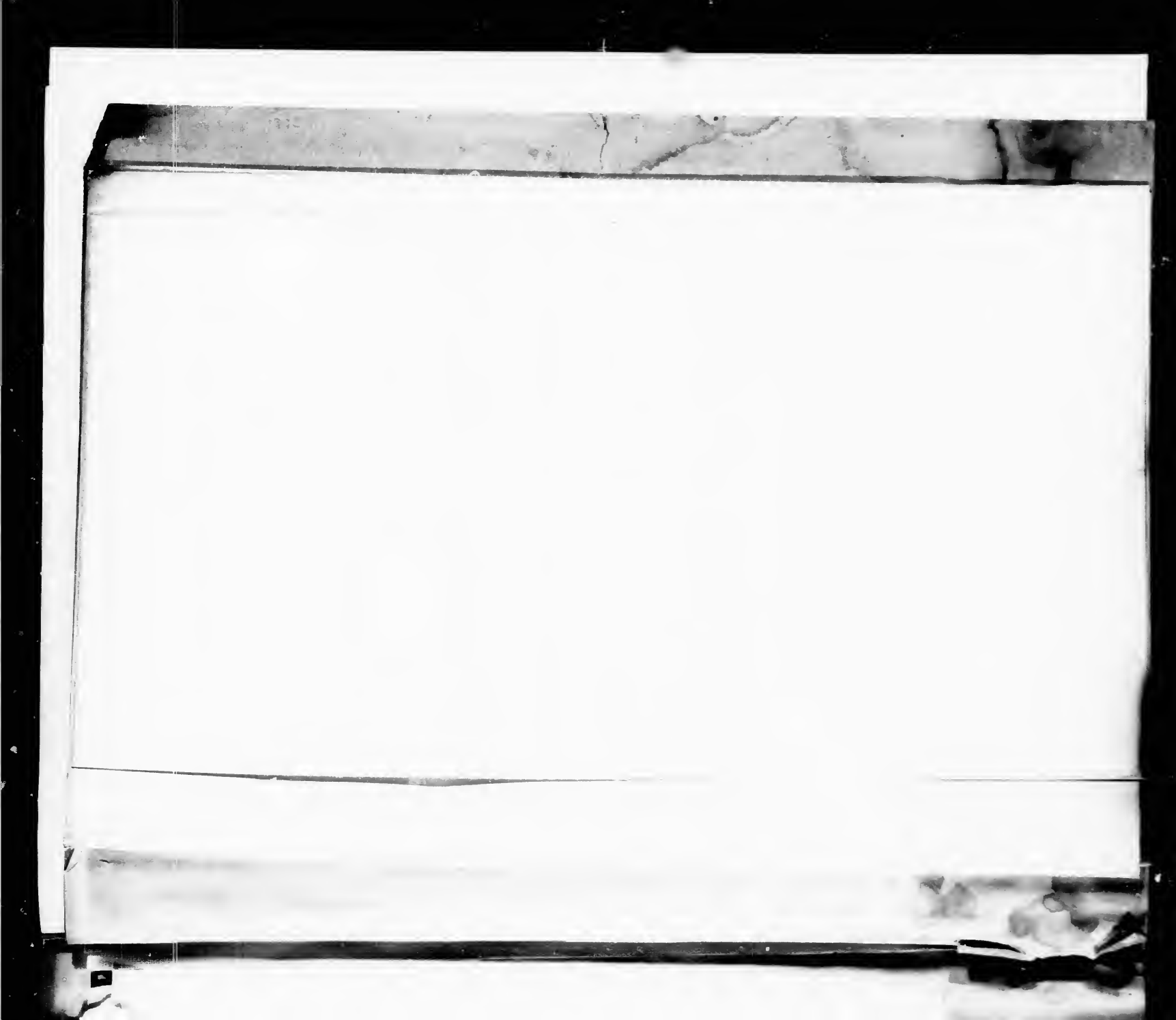


orrance's Farm.
rt of cliffs.)





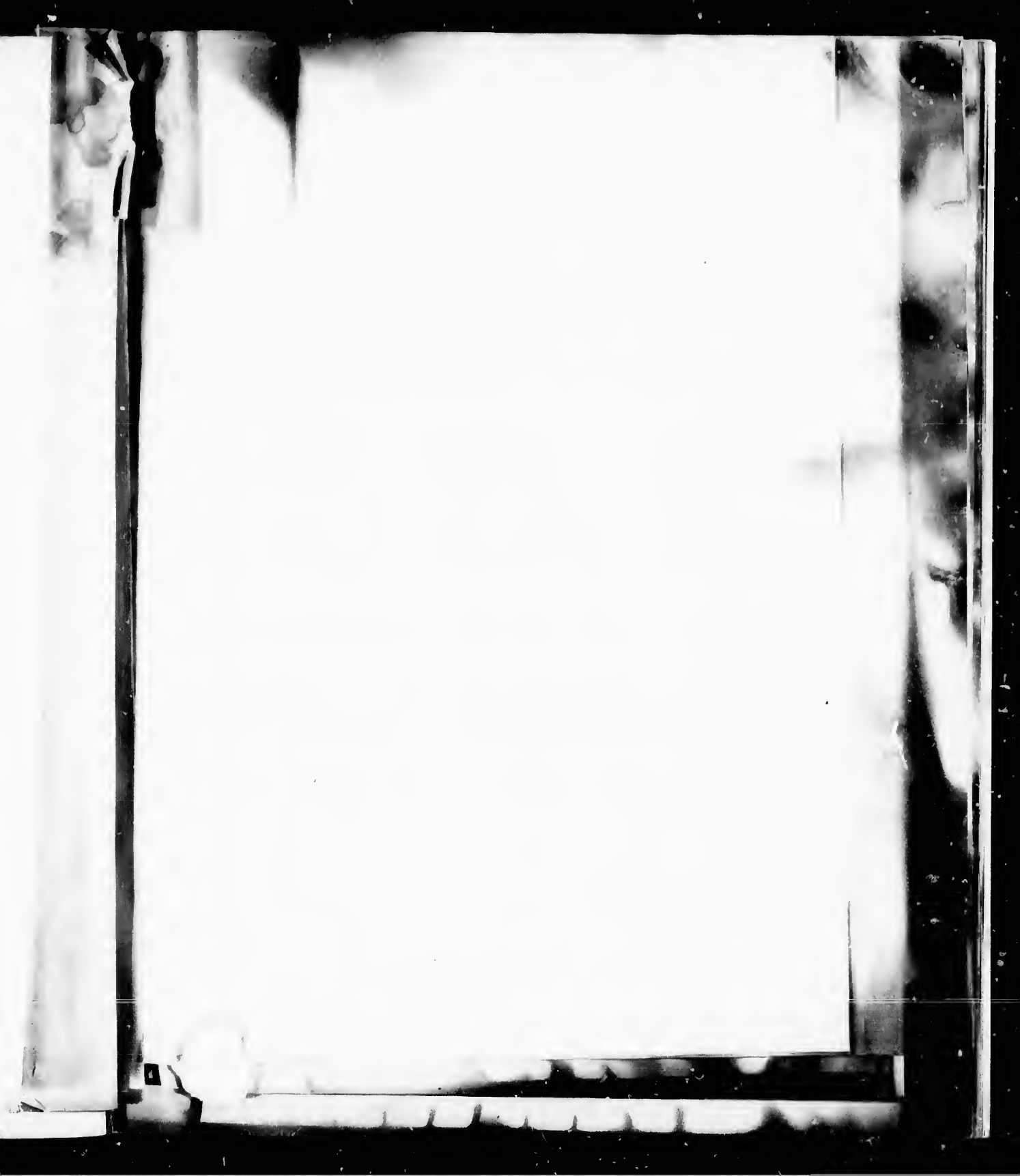
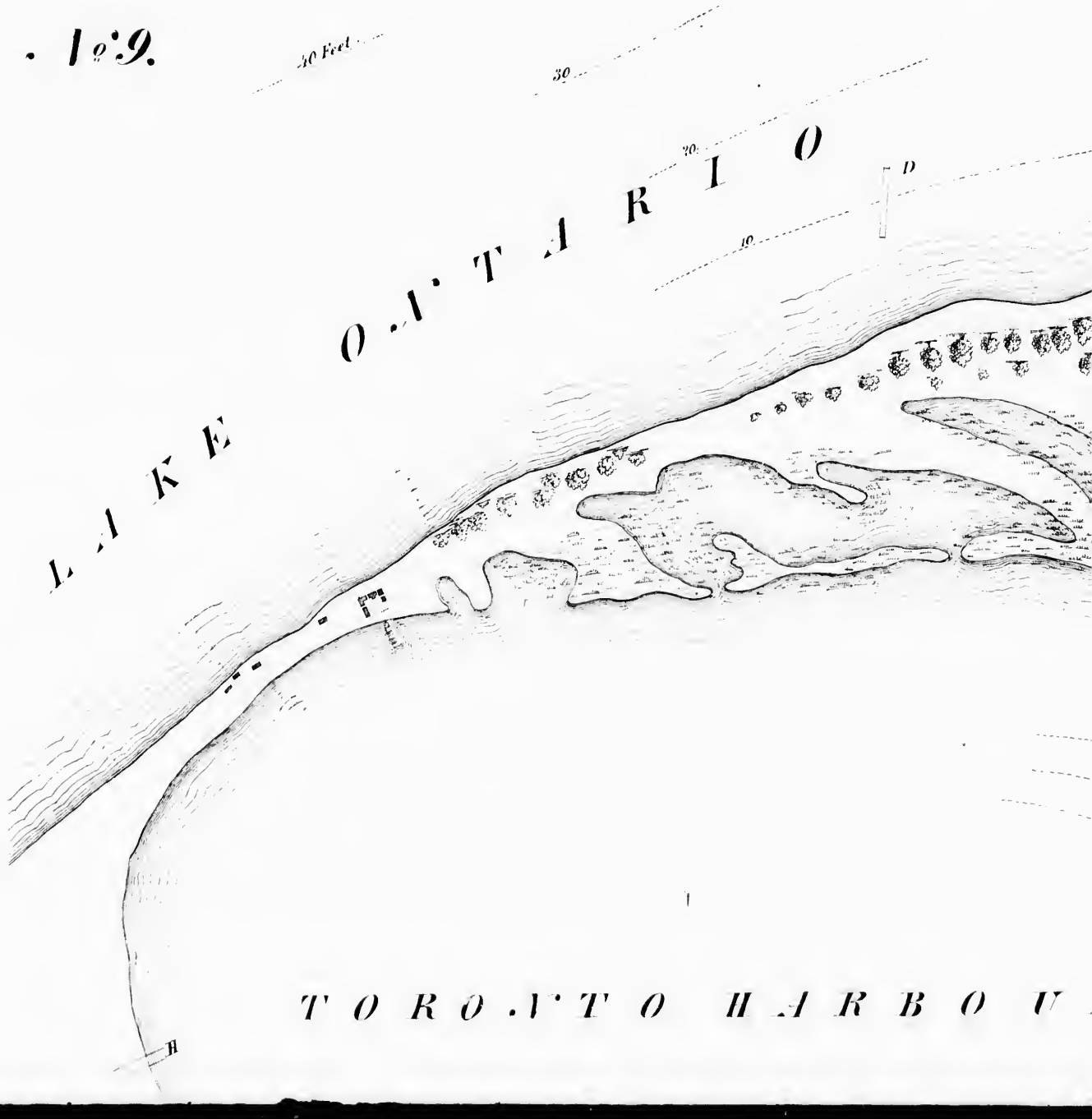


Diagram to illustrate the Firs

1 & 2.



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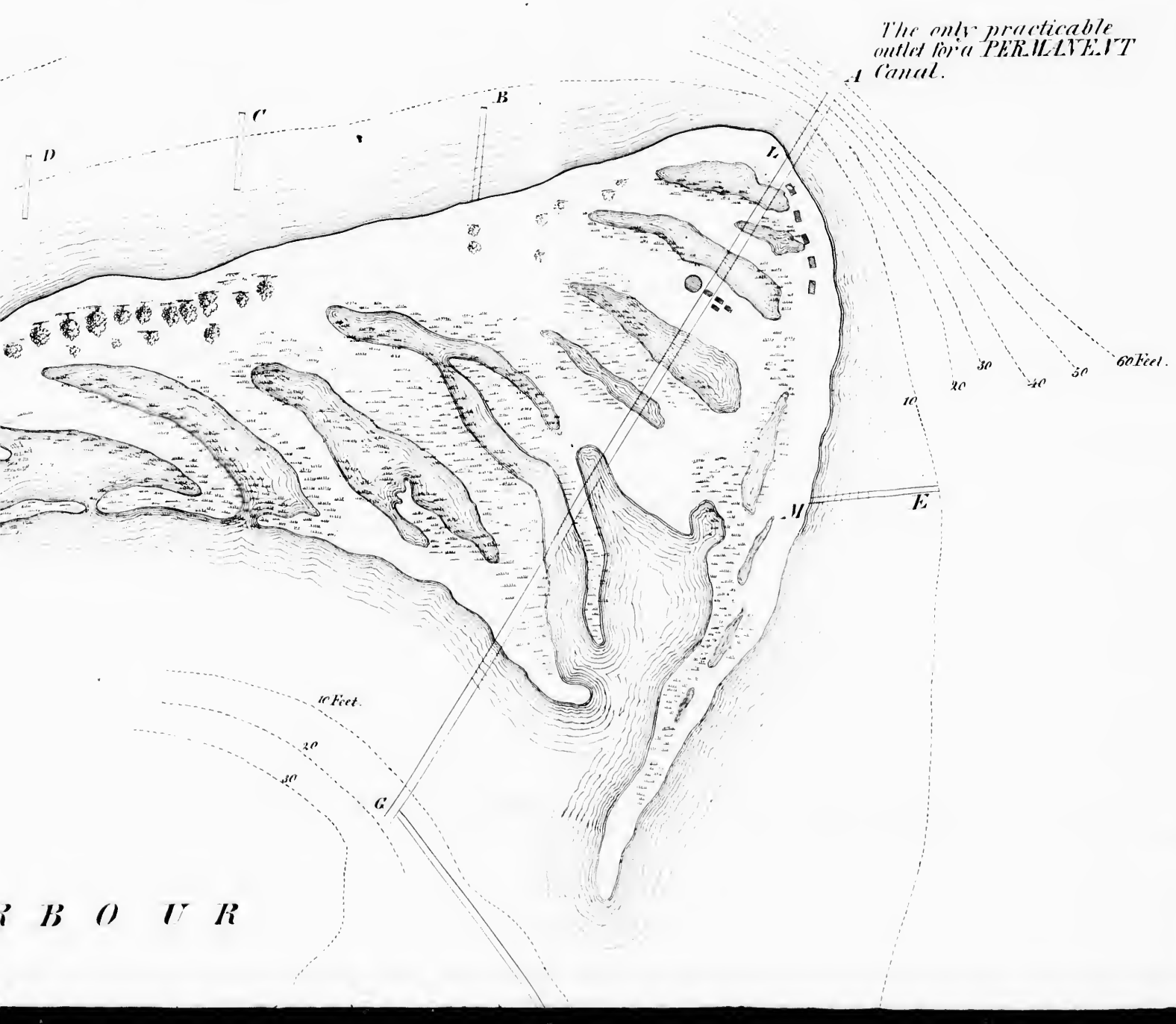
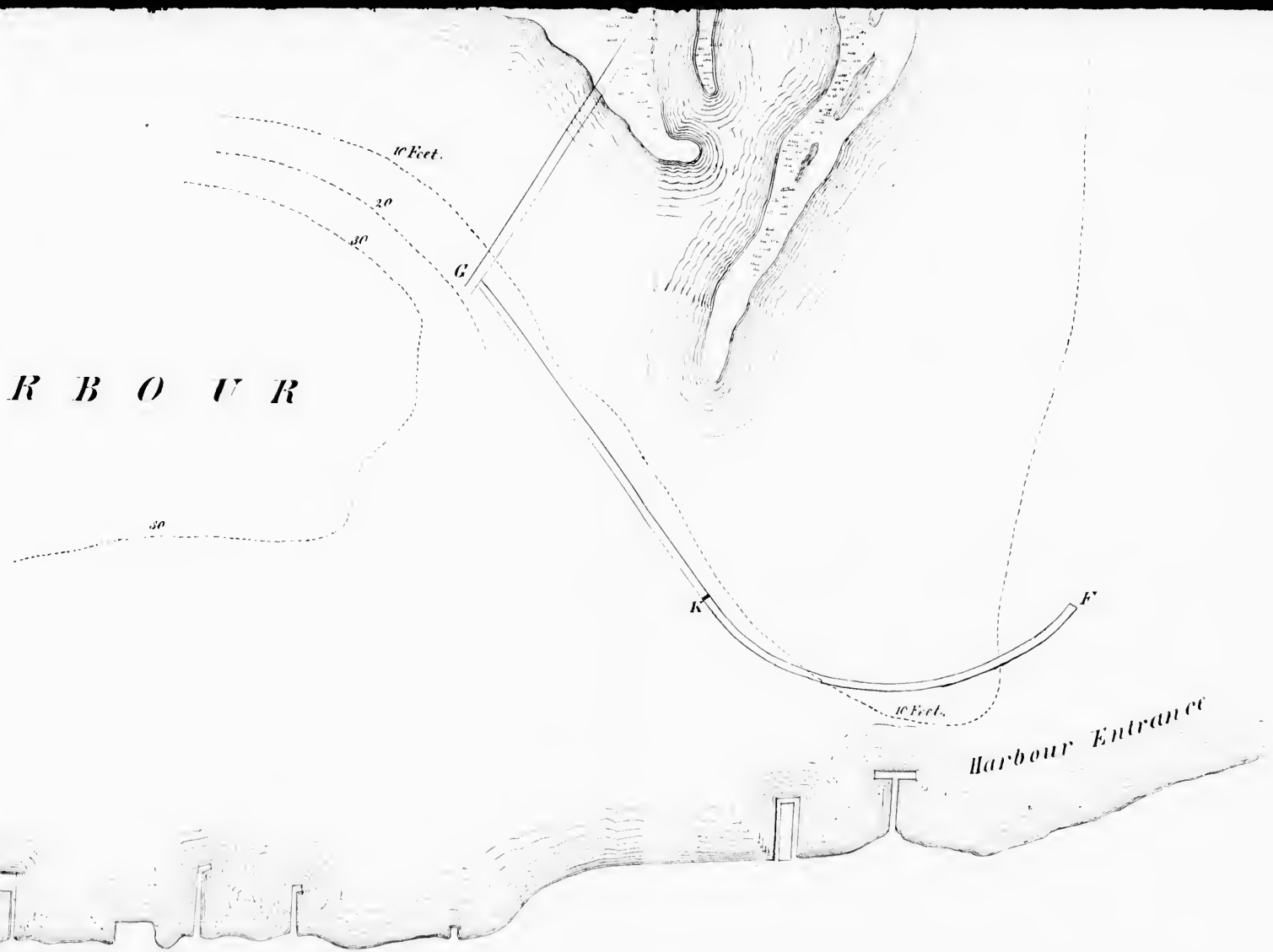


R B O U R


TORONTO HARBOU
30
H
K
J


10 Feet.
20
30
G
R B O U R
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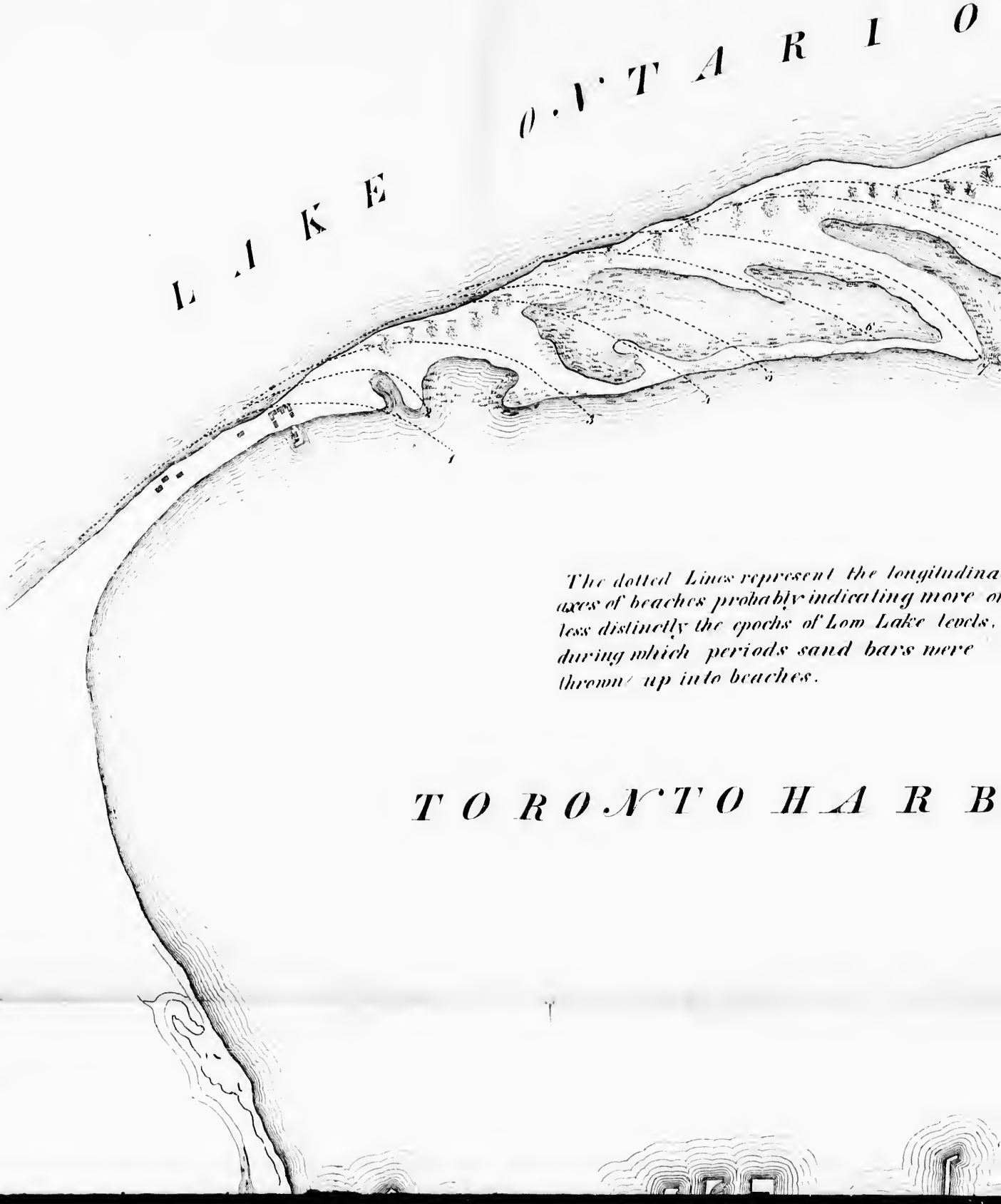
10 Feet.
Harbour Entrance

Diagra

No. 1 & 9.


LAKE ONTARIO
The dotted Lines represent the longitudina
axes of beaches probably indicating more o
less distinctly the epochs of Low Lake levels,
during which periods sand bars were
thrown up into beaches.
TORONTO HARB

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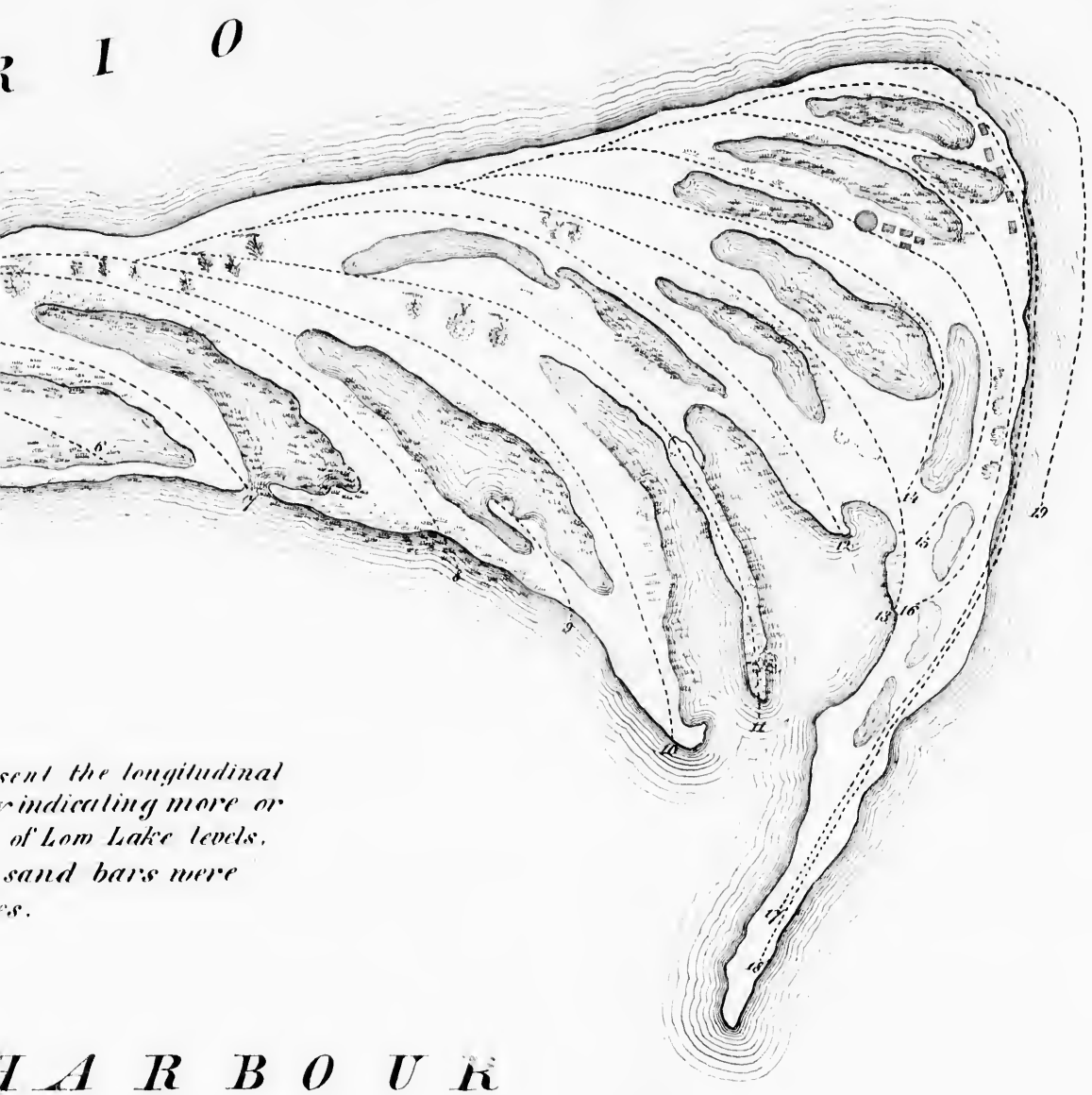

sent the longitudinal
indicating more or
of Low Lake levels.
sand bars were
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H A R B O U R

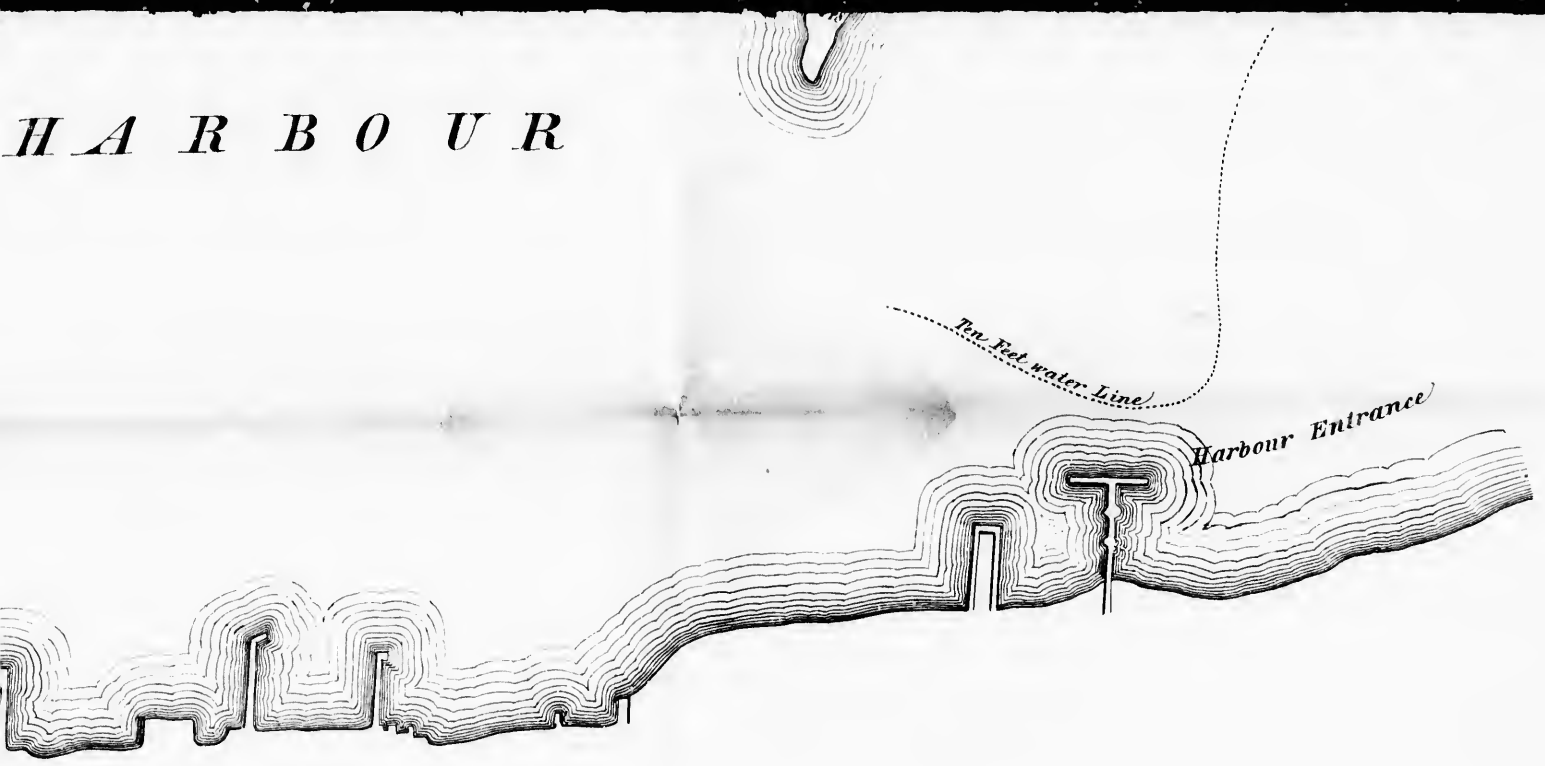
Ten Feet water Line

Harbour Entrance

TORONTO HAR

Diagram to illustrate the Fi

HARBOUR



ustrate the First Premium Report

No 6.

L A K E O

REPORTS ON THE IMPROVEMENT AND PRESERVATION

OF

TORONTO HARBOUR.

PUBLISHED BY THE AUTHORITY OF THE HARBOUR COMMISSIONERS.*

HARBOUR OF TORONTO.

THE Commissioners of Toronto Harbour, having decided upon offering premiums for the best Reports on the improvement and preservation of the Harbour, and appropriated the sum of £112 10s. for that purpose, and the Common Council of the City of Toronto having also voted a similar sum for the same object:

NOTICE IS HEREBY GIVEN,

That three premiums of £100, £75, and £50, respectively, will be given for the three best Reports on the means to be adopted for the preservation and improvement of the Harbour of Toronto.

Such Reports to embrace the following subjects:

The effects which have been produced, or are likely to be produced, by the present breach at the Eastern extremity of the Bay of Toronto, particularly with reference to the Bar, at the entrance of the Bay. If prejudicial to the Harbour, suggest the best means of closing it, and of strengthening that part of the Peninsula against further encroachments by the waters of the Lake.

Furnish also a statement as to the probable cost of such works.

If, on the other hand, a permanent opening at that end of the Harbour should be shown to be a benefit rather than an injury, furnish full particulars as to the best mode of making a Canal, and the probable cost thereof.

Also, as to the advisability, or otherwise, of enlarging the opening between the Harbour and Asbridge's Bay, or of making a permanent opening into the Lake, from Asbridge's Bay, and the cost thereof.

The Reports must be sent in not later than the 15th of April next, addressed to the Chairman of the Commissioners of the Toronto Harbour.

Two copies of all such Reports to be furnished, one for the Harbour Commissioners Office, and the other for the Clerk's Office of the City of Toronto.

Harbour Commissioners' Office,
Toronto, March 14, 1854.

TORONTO HARBOUR.

THE period for receiving the proposed Reports "on the preservation and improvement of the Toronto Harbour," is extended to the 4th of May.

The Commissioners desire it to be understood, that it is not requisite that the Reports should embrace detailed estimates of the cost of the proposed works, except in so far as will suffice to give a general idea of the comparative expense of the different plans proposed.

Harbour Commissioners' Office,
Toronto, April 1, 1854.

REPORT

ON THE PRESERVATION AND IMPROVEMENT

OF

TORONTO HARBOUR,

BY HENRY YOULE HIND, M.A., PROFESSOR OF CHEMISTRY IN THE UNIVERSITY OF TRINITY COLLEGE.

[*The first premium of One Hundred Pounds was awarded to the author of this Report.*]

The questions proposed by the Commissioners of Toronto Harbour respecting the means to be adopted for its preservation and improvement, involve as a primary consideration the origin and distribution of the entire mass of accumulated materials from near the town line of Scarboro' and York to within a few hundred yards south of the Garrison Wharf, thus embracing the whole of the sand and shingle beach enclosing Ashbridge's Bay and the swamps of the Don, together with the Peninsula boundary of Toronto Harbour and its westerly subaqueous extension towards the Humber Bay. Various theories have been advanced from time to time with a view to unveil the history of the formation of the Harbour. The citizens of Toronto are familiar with the names of Roy, Bonnycastle, Fleming, Shanly, Tully, and Richardson, in connection with this important subject. The views of these gentlemen have been brought before the public in various ways, either in papers read before the Mechanics' Institute, (Roy,—published in the Monthly Review, June, 1841), the Canadian Institute (Fleming, 1850–51), or in the form of reports and letters, (Bonnycastle, Shanly, Tully, and Richardson). Allusions are also made to the encroachments of the Sand-bar towards the Queen's Wharf in the reports of the officers connected with the Board of Works, and published in the Sessional papers of the Legislative Assembly. Notwithstanding a discussion in which so many have taken a part, and which has been extended over a period of fifteen or twenty years, the subject does not appear to be exhausted and perhaps still offers room for additional speculations. It is essentially a geological subject, involving the present active operations of those forces which, on a scale of greater magnitude, have recorded their existence and power on the shores of every tidal and tideless expanse of water. Nor can the preservation of the Harbour, with

* The Commissioners of Toronto Harbour, in addition to the liberal premiums awarded for the following Reports, have placed in the hands of the Treasurer of the Canadian Institute sufficient funds to cover the expenses of the r publication in the *Canadian Journal*

any propriety, be considered apart from the limits of geological science; the remedial measures proposed would then resemble guesses at a remedy for an unknown and dangerous disease.

The President of the Board of Works in 1844 reported to the Provincial Secretary that, "at the inlet of the Toronto Bay the sand is evidently making much, and I am of opinion, that at no remote period some work must be encountered to fix and preserve such an entrance as the rapidly increasing trade of that important city will require." In 1847 Mr. Gzowski reports (Sessional Papers, Legislative Council, 1847) to the Secretary of the Board of Works that, "from the data that could be obtained from several masters of vessels, who have certain permanent landmarks (now existing) to guide them in coming in and going out of the Harbour, it was ascertained that within the last seven years the bar had made a distance of 280 feet." Further on he observes, "there can be no doubt that the making of the bar is caused by the wash and drift of the sand and shingle from the *southern portion of the Peninsula*, which is carried when the wind is from the east, which, from want of a sufficient current in the Bay, when the wind changes to the west, is not carried out, but remains forming the bar referred to, and which, if not prevented by the construction of works, and increasing and confining the current will very soon destroy the entrance to the Harbour."

Of all the explanations which have been advanced in relation to the origin and progress of formation of the Peninsula boundary of Toronto Harbour and its subaqueous extension, the one which appears to be most complete and at the same time most consistent with observed phenomena, in many important particulars, is that submitted by Mr. Sandford Fleming, C.E. Mr. Fleming's views have been fully explained in two papers, read by him before the Canadian Institute, and since published in the Canadian Journal (Vol. II., p. 105 and 223). It appears necessary that the adoption wholly or part, of any particular theory of Toronto Harbour, out of several which have been offered to the public, should be accompanied by satisfactory reasons for the selection. In accepting the main features of Mr. Fleming's theory, the writer cannot give assent to that gentleman's exposition of the early history of Toronto Harbour, or of the Delta of the Don, or to the remedial measures for the preservation of the Harbour. It is but just to add, however, that many important features of Mr. Fleming's explanations, which will be referred to hereafter, are thought to *involve* the true history of the Peninsula as to its origin and developement, the question of time not being taken into consideration. The views submitted in a report to the Harbour Commissioner that the origin of the Peninsula is to be traced to detritus brought down by the rivers to the west of Toronto, is completely set aside, first by Lieut. Herbert's Chart of Lake Ontario, which gives a depth of ninety feet between the southern limits of the Humber Bay and the Lighthouse point; second, by Mr. Fleming's measurements, which show a depth of sixty feet about sixty chains from the Garrison Common beach; third, by the direction of the prevailing winds and their influence upon the expanse of water exposed to them; fourth, by the impossibility of masses of sand and shingle creeping along the shore in water sufficiently shallow for waves to impel them from the west, without leaving traces of their passage in the form of beaches and shoals; fifth, by the ponderous nature of the materials of which the Peninsula consists, namely, shingle, pebbles, coarse felspar and quartz sand, and black magnetic oxide of Iron;* and sixth, by the topographical conformation of the Peninsula, which shortly, will be described.

The geological conformation of this part of the country is altogether contrary to the supposition that the basis of the Peninsula in an upheaval of the Hudson River Group, upon which shingle and sand have been deposited. The Hudson River Group extends from beyond the Rouge to the Credit, and forms the basis of the drift which covers the country. Its character in this neighbourhood is any thing but consistent as shown by the uniform depths to which the Rivers Don, Humber, Mimico, &c., have succeeded in cutting it. In its exposures in all the localities mentioned, including also the Garrison Common cliffs, and the west side of the Humber Bay, it exhibits blue argillaceous shales alternating with bands of calcareous sandstone, and occasionally limestone bands. Its descent into the Bay and Lake is gradual, and within a distance of 500 yards north of Priest's Hotel it is not reached at a depth of 30 feet.† The water-worn shingle which largely enters into the composition of the Peninsula contains occasionally fossils belonging to this rock, but they do not differ from those which may easily be found in the drift clay superimposed upon it on the neighbouring shore, and which, during the deposition of the drift, have been washed out of some more northern exposure. (See the Geological Report for 1845, page 88). That shingle of the Hudson River Group forms the base or foundation of the Peninsula is quite possible, but it is more than probable that all the shingle found there has been transported to its resting-place and had its origin in the drift clay of the neighbouring shores of the Lake to the eastward.

Mr. Fleming separates the history of the delta of the Don from that of the Peninsula boundary of Toronto Bay, and he carries us back into the dim and misty ages of the Quarternary period in order to account for the deposition at the mouth of the Don of its present 'delta.' "Having thus," he says, "shewn that sufficient time may be granted, the Don therefore supplies an adequate cause for performing, and completing long since the work assigned to it; year after year during its early history, slowly but constantly hollowing out a channel and removing the former contents of its valley to the Lake, the lighter and more soluble matter being held for some time by the water, to be distributed far and wide, the heavier particles on the other hand, to be deposited near its mouth in the form of an extensive shoal or delta,—the base or ground work of the Peninsula, on which again to be deposited a drift from other causes and from another source."—(See page 107, Canadian Journal, Vol. II.)

His arguments for the antiquity of the marshes of the Don, to be hereafter alluded to, are so intimately connected with his views of the former probable extent and influence of the Scarboro' heights, that it is desirable, before proceeding further, to examine the existing phenomena of that range of hills and cliffs, and see how they agree with the descriptions which have been given of them.

The following description of the Scarboro' heights is the result of a personal visit to that romantic and picturesque range of cliffs during the present month. (April, 1854.) The Scarboro' heights consist of two distinct terraces, which run into one another on the farm of W. Crone,‡ about nine miles from Toronto. These ter-

* See Note A. in Appendix. † See Note B. in Appendix.

‡ See Map of the Township of Scarboro' for names, by J. Ellis, Toronto.

races attain their utmost elevation near Scarboro' tavern; (Gates') the elevations of the terraces, as measured by Mr. Murray, the assistant Provincial Geologist, are as follows:—

First Terrace above the Lake	161	feet
Second Terrace above the First	159	,,
Second Terrace above the Lake	320	,,

—*See Geological Report for* 1845.

As before remarked, these terraces run into one another on Mr. Crone's farm, that is to say, the second or highest terrace trends here so much to the South *that a portion* of it has fallen into the waters of the Lake, as shown in section No. 4. The slope of the second or highest terrace has been denuded by the fall of its materials to the extent of about 100 feet, so that the perpendicular altitude of this, the highest denuded portion of the Scarboro' heights, does not exceed 200 feet, upon the basis of Mr. Murray's altitudes, which, for the total height of the first and second cliffs are the same as those given by Mr. Fleming, namely, 320 feet. About 60 feet of the cliffs of the second terrace still remain clothed with heavy timber, and have not contributed any materials to increase the deposition on the shore of the peninsula boundary of Toronto Bay. It is highly probable that the present generation has witnessed the fall of the first contribution of the second or highest terrace to the sand shoals of the Lake, and it may confidently be asserted that 50 years ago the second terrace was separated from the first by a narrow plateau several yards in breadth, and consequently quite unaffected throughout its entire developement in the township of Scarboro' by the waters of the Lakes. On the next farm to the westward, that of J. Thom, the second or highest terrace has been still less subject to the effect of the encroachments of the Lake, and remaining portions of the first terrace can be seen forming projections in the sides of the crater like cavities produced by the land slips which have caused these extensive and destructive removals.

The next farm to the west belongs to D. Pherill, there the second terrace is attacked to a very trifling extent, and the projecting remains of the first terrace are more distinctly seen. On the junction between the farms of A. Pherill & A. Ashbridge (the next succeeding to the west,) the second terrace leaves the Lake, and retires into the interior, as shown in the diagram No. 2.

It thus appears that the amount of materials derived from the destruction of the second terrace is inconsiderable, and might be altogether embraced in a dozen gullies similar to that represented in fig. 3, which was sketched this spring, and of which there are great numbers equalling it in capacity, along the first or lowest terrace, between Gates' Farm and a mile or two to the east of the commencement of Ashbridge's Bay. Mr. Fleming's ingenious speculations with respect to the original form of the Scarboro' heights, and their relation to earlier developments of Toronto Harbour, as exhibited in his diagrams numbered 9, 10, 11, 12 and 16,* become imaginary, and the section number 16 assumes the probable form exhibited in diagram No. 4, in one spot only; the highest cliff contributing its materials to the Lake, not exceeding, 50 years ago, the height of 160 feet. Although Mr. Fleming's account of the past history of the Scarboro' heights, and, as will be shown hereafter, of the marshes, or Delta of the Don, is not borne out by existing topographical conditions, yet it happens that its failure in this respect does not interfere with his views of the formation of the Harbour in its *present* condition and development. The first or lowest terrace, from the nature of the materials entering into its composition, and its altitude, (in some places 160 feet) affords abundant supply of detritus to explain the formation of the sand and shingle beaches constituting the peninsula boundary of the Harbour and of Ashbridge's Bay.

The first terrace is composed of stratified sand and gravel, and of blue clay. In one of the gullies adjoining that represented in fig. 3, the following order of stratification was observed by the writer. The same order of stratification was frequently noticed along the cliffs of the first or lowest terrace:†—

Yellow clay and vegetable mould, about	2	feet.
Stratified sand and gravel	16	,,
Blue clay, ...	25	,,
Stratified sand	50	,,
Blue clay and concealed measures to the water's edge.		

Diagram number 5 shows the stratification in a gulley near Gates' farm.

A layer of two feet of small water worn boulders from one inch to six inches in diameter is very persistent about 10 feet from the surface of the lowest terrace; coarse and fine sand, beautifully stratified, occur in vast quantities; in fact the cliffs now present every requisite feature for rapid destruction.

They did not present these features fifty years ago, and there can be no question but that the operations of the settler have exercised a vast influence upon the recent rate of progress with which the destruction of the cliffs has taken place, and (as a not very remote consequence) the alarming rapidity with which the peninsula boundary of Toronto Harbour has increased during late years. In 58 years upwards of 30 acres have been added to the peninsula in deep water beyond the Light-house, on Light-house Point. The shoal towards the mouth of the Bay has increased to a very threatening extent, and has spread in the direction of Humber Bay from Light-house Point; a new reef is rapidly forming which, perhaps, this season will effect a fresh addition of 10 or 12 acres to the western limit of the peninsula, as indicated on the Map No. 6, and which only requires a period of low water to develope itself in the form of a beach. Now, all these enormous changes in so short a space of time imply the existence of no ordinary forces or supply of materials, for they have occurred in deep water, and involve the removal of many million tons of shingle and sand.

It is now proposed to consider the relation of the Scarboro' cliffs to the existing peninsula boundary of Toronto Harbour, without entering into speculations, as yet, as to its early history. The problem is not difficult of solution, and it is thought to be one of the utmost importance, as it seems to lead at once to those remedial measures which the preservation of the Harbour demands. It points to a power which has been slowly and beneficially acting for centuries, but which has suddenly become energetic and dangerous in its recent extension.

A stroll along the precipitous cliffs of the lowest terrace, from Gates's farm to where the partial union of the two terraces takes

* See "Canadian Journal," Vol. II., page 228.

† Note C, Appendix.

place on Crone's farm, then onward towards Toronto, within a mile or two of the commencement of Ashbridge's Bay, will enable the observer to comprehend the remarkable effect which has been produced by clearing the plateau of the lowest terrace of its Forest growth, and thus laying bare the crests of the cliffs. The consequence of this complete removal of the protective covering of timber is, that the cliffs being unprotected for many years by fallen trees, have lost their former terraced and wooded character, and have become (by land slips) clean, bare and shelving, exposing their loose and shifting materials to all the effects of rains and winds. When the lowest terrace was wooded, every tree which fell from the crests of the cliffs either hung by its roots, or was arrested in its fall down the sides of the cliff by underbrush and small trees, and thus became a resting place for those annual slips of earth, trees, pebbles, and even sand, which the thaws of spring set in motion. By such means minor terraces were formed, supported by the strata of blue clay before described, and on these subordinate terraces, grass and shrubs grew and gave a permanent character to the sides of the cliff. In some of the gullies, the retaining and conservative effect of underbrush is still well marked, especially where the forest growth has been permitted to protect the crest; there are, however, but few instances now remaining on the cliffs, for miles have been cleared. Another rather singular consequence is to be found in the quantities of loose sand which are blown up by every gale of wind from the South, South-east, and East, from the bare sides of the immense crater-like gullies which have been formed during the last few years. A gentle breeze suffices to transport the unstable sand of the cliffs up the clean sides of the gullies on to the plateau above. In several instances the writer measured four inches in depth of coarse and fine sand, which had been blown up upon the stubble of last year's wheat. The sand frequently penetrates into the fields for a distance exceeding one hundred yards from the crests of the cliffs, and in process of time will succeed in destroying, or at least very materially deteriorating, considerable tracts of land on the lowest plateau, if not checked in its march. When the cliffs are denuded of their protecting fringe of trees, and, as a natural consequence, of the underbrush which shields their sides, the least streamlet of water rapidly loosens and sets in motion the sand and gravel which form so large a portion of the lowest terrace. The bed of clay arrests this process of destruction for a while, but being itself underlaid by sand and gravel as unstable as that by which it is super-imposed, its conservative influence is of short duration, and in a thousand instances the bare and clean sides of enormous gullies show how rapid is the present progress of their formation and increase.

It is important to mention that occasional traces of long continued persistence are observable in some of the gullies. Beds of bulrushes of gigantic growth may be seen in some of those whose sides are still partially protected with underbrush and small trees. These occur on the lowest bed of blue clay. The blue clay itself sometimes presents precipitous tower-like prominences, which are best seen east of Gates' farm, where the forest still affords its protection to the cliffs. It is not, however, only the plateau and the cliffs which point to the destructive effects which have been produced by clearing away the timber, the beach itself shows by its encroachments how much its boundaries have been increased by the absence of that annual supply of fallen trees which once checked the inroads of the surges of the Lake. In many parts the sand and shingle present the same features as those which distinguish the peninsula. Formerly the progress of the breaking waves was arrested by multitudes of those natural groynes which Mr. Fleming has so faithfully delineated and described.

The present high waters of the Lake have of course exerted their influence in removing many of the trees which afforded long resting places for shingle and pebbles, but the absence of a continued supply of these protective barriers has enabled the beach to attain and the waves to wash the foot of the cliffs, thus accelerating their downfall. It is also probable that the removal of the boulders and larger pieces of shale washed out of cliff detritus, for building and other purposes, has exerted its influence in assisting the encroachments of the breaking waves of the Lake. Sketch No. 7 may afford an illustration of the appearance and power of these breakers as they dash at an acute angle on the beach during the continuance of easterly and south-easterly winds.

A question of much interest and importance suggests itself with respect to the first or lower terrace. It may be urged that a plateau of the altitude of 160 feet, extending in gradual surface lines in the form of a promonotory, would be a sufficient source of materials and afford the necessary topographical conditions to produce modifications of Mr. Fleming's hypothetical early development of Toronto Harbour as shown by his diagrams No. 9, 10, 11, 12, and 13, and thus in part give countenance to his view of its remote history. Mr. Fleming says, "On the subsidence of Lake Ontario from a high to its present level, the land fell in easy slopes to the water's edge, and the gradual descending surface lines were continued outward under water; the abrupt terminations of the land along the boundary of the Lake having been formed by its encroachment through a long course of ages, the promontories which formerly projected have been rounded off by the destructive influence of the elements."—(Can. Jour., p. 226, Vol. II.)

That an arm of the sea did occupy the region of Lake Ontario and Lake Champlain during the Tertiary epoch there is little reason to doubt. The occurrence of marine shells and skeletons of marine fish (Mallotus Villosus) 540 feet above the sea or 310 feet above Lake Ontario, at Montreal, in the valley of the Ottawa, near Bytown, in the valley of Lake Champlain, and in many localities in the valley of the St. Lawrence, afford ample proof of this vast phenomenon. (Lyell's 1st voyage to the United States, page 119, vol. 2, New York Edition. See also Provincial Geological Reports, Ottawa valley). It has, however, been shown that the phenomena of the highest terrace can have nothing to do with the formation of Toronto Harbour, seeing that it has only been attacked to a trifling extent and probably within the last 50 years. It becomes necessary, therefore, to advert to the period when Lake Ontario, probably as an arm of the sea or a fresh water estuary, stood at an altitude of 160 feet above its present level, or in other words washed the base of the second or highest terrace. There is every probability that this event extended over a long period of time.

Ridges corresponding to the plateau of the lowest terrace have been described by Mr. Hall in the Geology of the fourth district of New York: "One of the most interesting of the superficial deposits of the district is the Lake ridge, which from Sodus in Mayne County with some trifling exceptions is a travelled highway, nearly as far as the Niagara River. Beyond this it can be traced quite to the head of Lake Ontario, and I have been informed that it exists upon the northern side of the Lake." In a note attached to the remarks of Mr. Hall on the Lake ridges we find the follow-

ing: "To the geological reader it will require no attempt to prove this the ancient beach of Lake Ontario, or a body of water, perhaps an arm of the ocean, which once stood at this elevation; such occurrences are well known elsewhere; but there are many persons in western New York, and some grave critics among the number, who prefer to explain this by supposing some stupendous uplifting of the strata in this line from Sodus Bay to Niagara River." Further on (page 351) Mr. Hall states that "The elevation of this ridge above Lake Ontario has been variously estimated from one hundred to two hundred feet. In 1838, through the kindness of Mr. Barrett, I obtained the elevation of the ridge north of Lockport, which is about *one hundred and sixty feet* above Lake Ontario."

It is probable that the formation of the New York ridge above described was contemporaneous with the lowest terrace of the Scarboro' heights, and may not the persistant layers of water-worn pebbles described before, as being about ten feet below the surface of the plateau, be the ancient beach of Lake Ontario at its former altitude? Is it reasonable to suppose that when by a slow upheaval of the country, the level of Lake Ontario became comparatively lower and lower, the strata of alternating sand and gravel and blue clay forming so large a portion of the cliffs of the lowest terrace, would have remained persistant, and permitted the land to fall in easy slopes to the present level? Is it not rather to be supposed that its shores would have been terraced and abrupt like those descents which are to be seen about four miles from Toronto, where the lowest terrace leaving the Lake crosses the road from Toronto to Kingston? If this were the case, and there does not appear to be any reasonable objection to the hypothesis, the lowest terrace instead of descending in easy slopes when the land became elevated would form at least two distinct terraces abruptly bounded by declivities of sand, precisely like the abrupt declivities seen on the Kingston road near the eastern extremity of Ashbridge's bay, which are nothing *more* or *less* than the abrupt *sandy shores* of the ancient Lake as the land slowly rose from beneath the bed of a Tertiary estuary or ocean.

Under such circumstances the existence of any promonotory becomes very doubtful, and the coast line would appear to assume an extension commensurate with the former extension of the whole northern coast of Lake Ontario, which in its earlier development extended probably nearly uniformly a short distance Lakewards. The protection afforded by Lake beaches during periods of low water is so great that it may truly be said that the cliffs or bluffs of the coast are only submitted to the denuding action of atmospheric forces during those epochs, an action which tends to give them the form and conditions essential to the growth of vegetation, which, in not a few instances, extends without the occurrence of cliffs or even of quarternary formations to the very shores of the Lake.

Other objections might be advanced against the existence of a promontory or even a considerable extension of the coast of the Scarboro' heights Lakewards since their emergence. Such for example as the great depth of water which exists in the Lake to the south of the Scarboro' heights.

Lieutenant Herbert clearly shows soundings to the depth of 48 feet *within* a mile of the coast, and in one locality, west of the Highland Creek, the great depth of 120 feet is recorded *within* two miles of the coast; what denuding operations can have produced these great depths since the assumption of the present level of Lake Ontario if the land extended Lakewards to a considerable distance, even half of the distance assigned by Mr. Fleming (about two miles—see section and scale) during that epoch? The occurrence, it is said, of tertiary blue clay within two or three hundred yards south of Ashbridge's Bay is another objection which, combined with the known dip of the Silurian rocks in that locality, suggests grave doubts as to the former extension of the land to a degree consistent with the idea of a promontory.*

Mr. Fleming's views of the origin of the delta of the Don are also scarcely consistent with the probable topographical condition of the country, when the Lake assumed its present level. The supposition is not admissable that the country rose from beneath a tertiary ocean (see Geological Reports for 1845–6) in a sudden and violent manner. It occupied, most probably, a vast epoch of time; if it emerged at twice the rate at which Sweden is now becoming elevated, namely at the rate of five feet in a century near the North Cape, and a few inches in a century near Stockholm, (see Lyell's second voyage to the U.S., Vol. II., page 194, New York Edition), it would have required 32 centuries for the hills in Scarboro' Township to have emerged; or if we take the lower and perhaps best defined sea beach, the one of the lowest plateau, 160 feet above the present lake level, it would still have embraced 16 centuries, and this too upon the supposition that the rise was continuous, which is known not to have been the case, as lower beaches testify. During that period, how would rains, snows, and dews drain away from a country "totally devoid of water-channels for surface drainage," as Mr. Fleming supposes when he assumes that the Don *began* to exist when the Lake had acquired its present level (Can. Jour., Vol. II., page 106). The Don, together with all the rivers and streams of any magnitude which now flow into Lake Ontario, *began their existence with* the uprising land and grew with its growth, excavating the valleys through which they now flow to within a few feet of their present level, during the successive epochs of the subsidence of the Lake from its former vast extension. The detritus of the Don and other streams, brought down during higher Lake levels, forming sand-bars and mud-flats, which are now pine clad ridges and the cleared farms of thriving settlers. On the south shore of Lake Ontario the valleys of streams which fell into the Lake when it stood at an elevation of 160 feet higher than at present are plainly visible. Mr. Hall says, "The interruptions in the continuity of the ridge, from the passage of small streams are numerous throughout its whole extent. Many of these streams were doubtless discharging their waters into the Lake at the time of the formation of the ridge, and have thus kept an open passage, others have been closed up during its deposition and formed little ponds upon the inland side, which, subsequently becoming more powerful, have burst through the barrier and carried away large portions of it." (Geology of the 4th District, page 350.)

It is suggested that the term 'delta' is altogether a misnomer, leading to the idea that the River Don has brought down materials from its excavated valley and deposited them at its mouth, and elevated them above the surrounding waters, like the Nile and the Mississippi, only on infinitely smaller scale.

Now, the banks of the Don at its mouth are of tertiary yellow and blue clay, and there was a time no doubt, not very far removed

* See Appendix, Note E.

from us now, when those banks were washed directly by the surges of Lake Ontario. It is abundantly evident that the Don, within the limits of the Christian era, poured its waters directly into the Lake, as the absence of *made land*, which alone constitutes a delta, well proves, without reference to the deep waters of the Marsh, and the absence of that evidence of antiquity which one would expect to find, if the Don had for many ages contributed its detritus to fill the space intervening its mouth and the opposite, though somewhat far removed shore of the Lake boundary of the Marsh.

It is, however, important to inquire what phenomena exhibit themselves at the mouths of rivers pouring their waters directly into the Lake, such rivers, for instance, as the Rouge, the Humber, the Mimico, and the Highland Creek, which are severally larger and smaller than the Don, consequently comprehend either extreme in point of dimensions. It is important to know whether it is probable, or even under ordinary circumstances of wind and weather, possible for the Don to have formed a *bar* (the proper term) as far from its mouth as the south sand beach of Ashbridge's Bay.

The testimony of Mr. Hall is peculiarly appropriate in the present instance. Speaking of bars at the mouths of rivers and streams, he says, "The bar is formed by the influence of two forces—the waves washing in, which carry forward the sand and deposit it in long beaches; and the opposing power of the steady current, which neutralizes that of the waves, and the sand then falls down in a broad curve. The force of the current is principally expended in opposing the waves of the Lake, and becoming diffused, it flows quietly over the bar. This continues while there is no more than ordinary force in the waves, but on the occurrence of a violent north-east storm (i. e. near Genesee) the whole of this bar and perhaps ten times as great an amount of matter is thrown upon the beach, closing the outlet. This remains so long as the wind continues, but as soon as it subsides and the water in the pond is able to force a passage through the beach, the old order of things is resumed to be again subverted and again renewed. Such, simply, is the operation of one stream, as it has existed for the last four or five years, and such would be the history of hundreds of large and small streams along the Lake shore." (Geo. of the 4th District, p. 356.) The knowledge acquired by the inspection of any stream pouring its waters directly into Lake Ontario, shows that it is impossible for a small river like the Don, even if it were ten times as large, to form a bar a mile from its mouth and water to the depth of 18 and 20 feet intervene. Nor is there reason to suppose that the Don was ever a stream much larger than it is at present. Those who are familiar with the cutting action of rivers, first attacking one bank, then by landslips or fallen trees, driven to the opposite bank, will feel fully satisfied that the Don in its present development is abundantly sufficient to explain the denuding action it has exercised since it began to flow with the slowly receding waters of a tertiary ocean.

We may, however, gain some clue as to the age of the marshes of the Don, and the beaches which confine them, by examining other marshes and beaches which have been long under observation. In geological investigations every thing is to be learnt by *comparison*, and he who speculates upon an incident without taking cognizance of similar occurrences must expect to be called upon to furnish a separate theory for every phenomenon, differing in externals from the class to which it belongs.

In describing the ponds, marshes, and beaches which lie to the west of the Genesee river, Mr. Hall mentions a few facts which will enable us to form some idea of the probable age of the 'Delta' of the Don.

"The beach before alluded to between the Lake and these ponds, is nearly a mile long (near Genesee, see Lieut. Herbert's chart,) before coming to the outlet, from fifty to one hundred feet wide, and generally not more than five or six feet above the Lake. *For the last few years** it has been wearing away (1842) and the roots of large trees growing upon it are becoming exposed, and some of the trees themselves are thrown down."

"Farther westward the space between the Lake and the marsh is five or six hundred feet wide. This is occupied by three distinct ridges, running parallel with each other, and with the Lake. Near the western extremity these three ridges divide into four, but continue equally well marked. Their summits are from six to eight or ten feet above the Lake, and the vallies between them are from four to six feet below the tops of the ridges. The materials of which they are composed are similar to the recent lake beaches, consisting of pebbles and sand covered with a light sandy loam. They are over-grown with large trees of oak, elm, beech, and button-wood, which shows their antiquity. Their form is distinct and well marked, while the cause which gave rise to them *more than a hundred years since* is still active, producing other similar ones before our eyes."

Mr. Hall is contented to limit the duration of the existence of Lake beaches separating marshes from the Lake, and containing far stronger evidence of *antiquity* in the form of large trees of "oak, elm, beech, and button-wood" than any portion of Toronto Harbour beaches, to a period of "more than one hundred years," —(Geol. of the 4th Dis., page 357.)

Further on he says, "I might go on to illustrate the condition of the beaches and outlets further to the west, but these few examples are applicable to the whole. The ridge of beach west of Long Pond is undivided, and in many places from ten to twenty feet high, showing that a variation of a few feet in height can be no objection to the mode of formation."

"For many years previous to 1835 the Lakes were all at a lower elevation, and *this allowed the formation of bars and beaches* at the outlet of streams, which before opened by a deep channel into the lake." Mr. Hall here hints at a condition of things which will be shown hereafter to have exercised a remarkable influence upon the conformation and stability of the marshes of the Don and Toronto Harbour.

One more example will suffice to illustrate the comparatively modern formation of beaches and marshes on the shores of Lake Ontario. "Some of the Bays along Lake Ontario formerly admitted vessels for several miles, while at the present time they are partially or entirely closed. The beach formed at the mouth of Irondequoit bay has a narrow opening of three feet deep, while formerly it was a quarter of a mile further east, and of a depth sufficient to admit sloops which took in freights at the head of the bay *three miles* distant. The bay is so situated that it receives the abraded materials of the banks of the Lake, both from east and west. It is one mile and a quarter wide, gradually narrowing southward; and is separated from the Lake by a sand-bar or

* High water of 1838 equal to that of 1858.

beach, from fifty to two hundred feet wide, and rising from three to twenty feet high. The *greater part* of the beach has accumulated within the last *fifty* years. At that distance of time it was very low, and scarcely covered with grass; it is now overgrown in some places with large trees. The sand and silt brought down by the streams into this bay are gradually filling it up, and eventually it will become a marsh, with the stream winding through it to the Lake."

From these quotations it is evident that extensive formations, such as beaches from four to twenty feet high, swamps with vast accumulations of vegetable growth far exceeding the Don marshes, have sprung into existence during the last few centuries, adopting a wider margin than Mr. Hall, who merely says, "more than 100 years ago." Now in the absence of any evidence of greater antiquity than that which may be embraced within a period of a few centuries, it does not appear reasonable to *assume* such antiquity, when every existing phenomena may be accounted for by comparison with surrounding and nearly contemporaneous events. It is again urged that the great depth of water (12, 16, and even 18 feet) between the main *boundary* and the mouth of the Don, together with the great distance by which they are separated, are geologically, quite sufficient to exclude the idea that any connection whatever has existed between the formation of the one and the detritus of the other. The peninsula beach would have existed in nearly its present form and extent if the Don had never begun to flow. A perfect type of the peninsula, only of larger extent and more complete growth, is found at the Rondeau, Lake Erie. It embraces an area of 6,000 acres of water. The shallowness of Lake Erie readily explains the giant size of this and other similar formations in that Lake; the long swells and tempestuous waves which distinguish that easily agitated Lake are due to its small depth.

It now remains for the writer to explain the views he entertains of the formation of Toronto Harbour, and then proceed to the discussion of those remedial measures which the conditions of the case appear to require. These views are not submitted without due acknowledgement of the great interest which distinguishes the theories of Mr. Fleming and other gentlemen who have recorded their opinions; and the writer would never have publicly appeared in this controversy, if he had not thought it the bounden duty of every one whose thoughts had been turned to the subject, to discuss, to the best of his ability, a question involving the very existence of the City of Toronto as a commercial emporium.

The subject of '*Travelling Beaches*,' is one which has long engaged the attention of Geologists, and is in the present instance of peculiar interest. Sir Henry de la Beche, in the Geological Observer, points to the action of the Sea on coasts in the driving forward of shingle, in a particular direction, by breakers produced by the action of prevalent winds, under the influence of HEADLANDS.—(Geological Observer. page 83. Phil. edit., 1851.) The illustrations given by that eminent geologist, are perfectly applicable to the great North American Lakes, due allowances being made for the height and length, and, consequently, the force of the waves, as well as to the difference in the specific gravity of fresh and salt water.

Mr. Fleming has correctly described the *effect* produced upon the Scarboro' beach, as regards its westerly motion, under the influence of winds impelling waves or undulations over the greatest expanse of the Lake. It is believed, however, that a few points of material importance may be added, by way of illustrating the action of waves on the coast, and the subsequent distribution of the beach they transport. Any wave raised by winds blowing in a direction east of a perpendicular drawn to the general direction of the coast, (see Mr. Fleming's Chart, also, Chart No. 8,) will begin to curve inwards the moment the wave become retarded by the increasing shallowness of the water. The time when this influence on the direction of the wave begins to be appreciable is entirely dependent upon the height of the wave; for it has been ascertained that a wave *begins* to *break* when it reaches water of a depth *equal to its own height*. (See Reports of the British Association for 1837—Report on Waves.) Its influence upon the bottom is exerted before it attains a depth of water equal to its own height, and the retarding effect of a shoaling coast is felt at some considerable distance from the Shore—dependent, of course, upon the depth of water. These effects give to all waves the curved form shown in fig. 8. But there is another and a far more powerful influence which gives a curved form to waves as they approach the coast (Scarboro') when the wind is blowing in an easterly direction, or to the North of East. The influence of *protecting Headlands*. The shallowness of the water induces the waves to break when they approach the shore, which they do in the form of a curve, but the influence of a protecting headland is felt long before the wave reaches shallow water on a shoaling coast like that of Scarboro.' The influence of a protecting Headland is extended to waves in water of any depth. By reference to the chart, No. 8, several systems of waves will be seen, some merely curving inwards by their approach to a shoaling coast, others (A, B, C, D, E, F,) curving to a much greater extent under the influence of the protecting headland shown on the Chart. The same argument applies, though in a far less degree, to the waves, P, Q, R, S, which, although coming from the East, will have a *tendency* to move the sand, of the west shore of the peninsula *northwards*, where one would suppose it to be entirely safe from the effect of easterly waves. Sir Henry de la Beche is very precise on this subject, he says "The lines of waves are shown by dotted lines made to curve inwards by protecting Headlands." (page 84, Geo. Ob.) It is urged by the writer that waves driven by belts of winds acting in the direction and position of the arrows, 1, 2, 3, 4, (Chart 8) would be obstructed by the headland at Y, which, when clothed with pine forests, was far more influential than it now is, although now it affords protection to small craft anchoring outside Ashbridge's bay from all winds to the *North of East*. It is well known that the influence of headlands is manifested every where on the sea coast and often gives to certain harbours their value against the destructive effect of particular winds. It appears manifest that a travelling beach from K to Y, would be arrested after it had passed Y, and begin to be deposited at O O O, (See note C. Appendix;—remnant of an ancient Beach.) Belts of wind 1, 2, 3, 4, could have no effect upon the beach at O O O O, nor would belts 5 and 6, as they would act under the lee of the land. The argument applies, *a fortiori*, to ALL winds blowing from the *North* of *East*.

The origin and formation of the peninsula appears to the writer to have been as follows. At a period far within the Christian era limits, the coast line of the township of Scarboro' and York was continued without interruption round the north shores of Ashbridge's Bay and Toronto Harbour. The Don

flowed then, directly into the Lake like the Humber, Mimico, &c., at the present time, without depositing any more 'Delta,' or bar, than other rivers of its class are observed to do, and exercising no influence whatever upon the formation of any portion of the sand beaches and shoals under consideration. Sand bars would frequently be formed under the influence of the protecting headland, about four miles from Toronto, and as frequently be washed away by storms during periods of high water, their materials being distributed far and wide. With these sand bars pebbles and shingle would be occasionally mingled, and time after time might be deposited from their great specific gravity to form a basis for a permanent sand bar. A period of high water arrives like the one just terminating, like the period of 1838, or of 178[illegible] and during that period a sand bar of larger growth was deposited under the protecting Headland—a period of low water follows, like that of 1819 or that of 1848, and during that period the sand shoal was washed up into a sand beach similar to the sand beaches before alluded to, as described by Mr. Hall, near the mouth of Genesee (see Herbert's Chart,) and of which thousands of their kindred are to be traced on the shores of all the great Lakes, formed under similar circumstances, "more than a hundred years ago."

This beach would undergo numerous modifications according to the height of water, which fluctuates in Lake Ontario to the extent of five feet (some authorities say eight feet), but as soon as its western extremity had progressed beyond the influence of the protecting headland it would be swept round to the north shore, forming the 'spit' from the Peninsula beach to near the wind mill. Now all this might have occurred during one period of low water (a few years), or it might have occupied several periods. It is, however, probable that the beach surrounding Ashbridge's Bay and the Marsh was thrown up and round during one period of low water in the Lake. Now begins the existence of the Marsh, which is described as consisting mainly of a floating bog, but which has been making rapid progress of late years, as a few illustrations will prove. About 250 or 300 yards south of the bridge over the Don, now being built by the Grand Trunk Railway Company, an old brick-yard is seen. (April, 1854.) The clay has been dug out to a depth below the present level of the Don, and the hollows are occupied with reeds, rushes, and swamp plants. A farmer who has resided near Ashbridge's Bay, not two miles from the City Hall (next to Leslie's), stated to the writer that he considered he had lost about five acres during the last thirteen years by the encroachment of the Marsh, but he expected he should regain some of it *when the waters fell*. The remains of a fence at least 60 yards distant from the present boundaries of the rushes is distinctly visible in one portion of the Marsh. These encroachments have been made during periods of high and low water, and arise from the invasion of the land by the rushes and other swamp plants. They are merely presented as modern instances of rapid encroachment, but without relation to the main question.

Chart No. 6 represents a plan of the Peninsula. The dotted lines indicate the longitudinal axes of the beaches which were thrown up one after the other during the progress of the formation. The dotted line No. 19 represents the bar now in the act of being thrown up into a beach by the lowering of the waters of the Lakes, which are now (April 20th) *two feet lower* than in *June last*.

The materials of which the beaches are composed have travelled along the beach of Ashbridge's Bay, impelled by winds and waves before alluded to. The materials originated in the continued destruction of the Scarboro' cliffs. *This portion of the theory of Toronto Harbour is entirely due to Mr. Fleming, to whom the credit of having first given it to the public is unquestionably due.*

It is with some degree of confidence suggested that the several beaches denoted by the dotted curved lines on Chart 6 represent the successive epochs of additions to the Peninsula, and that they are the visible and permanent records of the periods of low and high water which have distinguished the recent history of Lake Ontario. Five beaches are distinctly seen between the lighthouse and the utmost south-westerly extension of the Peninsula.* These may correspond to such periods of high and low water, as are known to have occurred in 1788, 1838, and 1852, and in 1819 and 1848, and probably in 1854 or 5. The question is one of much interest and deserves further investigation.

The history and mode of formation of the Peninsula having been pointed out, it is now proposed to discuss the question whether a permanent opening at the end of the Bay would be a benefit, and first of all, whether such an opening in the form of a canal could be maintained at a reasonable expenditure.

It is manifest that in order to make such an opening permanent, which is evidently the first point to be considered; sand and shingle must be prevented from 'travelling' into it from the east, which would without doubt be the case if no preventive measures were adopted. We are not, however, permitted to assume that an opening in any one part of the Peninsula would *suspend* the operation of those forces which have given a local habitation to the whole beach from Ashbridge's Bay to Gibraltar Point. Assuming that an opening were made, say near the Peninsula Hotel, and that by groynes or other devices sand and shingle were prevented from closing it. It is perfectly clear that in order to effect this result the first object would be to retain the sand and shingle *east* of the opening. Suppose this to be accomplished, what, it is asked, would become of the remaining western portion of the Peninsula? would the sand and shingle there cease to be a travelling beach? would it cease to move westward as heretofore? There can be no doubt that if left unchecked it would progress onward, being still subject to the same controlling forces as before. But if it progressed, the beaches to the west of the opening would be rapidly moved away and form an extensive natural breach, seeing that no advance of materials to *supply their place* could take place, they being preserved to the eastward of the opening for the sake of maintaining it. The Peninsula, under such circumstances, would rapidly become an island, and its extremity near the canal gradually assume the form of the western extremity, throwing out tongues and spits in a northerly direction. But, it may be urged that the sand might be prevented from 'travelling' by means of groynes. It is true that the construction of groynes from the canal all the way to Lighthouse Point at short distances apart, would have that effect for a time, but without they were made very high the sand would mount over them and form dunes, according to laws painfully recognizable in many parts of Europe and especially in the 'Landes' of France as well as on the shores of Lake Huron. (See Sir Henry de la Beche, on this subject, page 84, Geo. Ob.) Again, the groynes would have to penetrate into deep water beyond the influence of waves upon a shoaling

* See Note G. in Appendix.

coast, or how would they check the progress of the shelving beach which is disturbed by the long waves of an easterly gale to a greater depth than fifteen feet?

The Peninsula in its subaqueous extension is an enormous sand and shingle shoal, very shelving on the Lake side, and, where it has not been remodelled or disturbed, very precipitous on the Bay side.*. The testimony of the fishermen of the present day in relation to it is the same as when Sir Richard Bonnycastle wrote, it consists Lakewards of immense fluctuating shoals. These shoals extend Lakewards 1500 yards before they attain a depth of 30 feet, except in one spot, and that is near the Lighthouse or Turning Point. Baywards the shoals are in general precipitous, and the openings which have from time to time been made in Asbridge's Bay and the Peninsula, have scarcely changed the precipitous character of the Bay sides. They have merely succeeded in shifting the boundary a little northwards, but they have not materially changed the form of the coast or its subaqueous extension in either Bay. The writer took pains to examine the effect of the waves breaking over about a third of a mile of the coast of Ashbridge's Bay this season (April, 1854), and found along the Bay side of the Beach 6, 6½, and 7 feet water *within* 15 or 20 feet of the bar over which the waves broke furiously, and had been breaking for weeks, under the influence of the easterly gales which have distinguished the present spring. (See Note B. in Appendix.) It is well known that the late breach near the Peninsula Hotel is wholly filled up, and that its effect upon the Bay has been comparatively insignificant.

It will be seen that the arguments against the construction of a permanent opening apply with greater or less force to every portion of the beach from its western to its eastern extremity. A canal from Ashbridge's Bay into the Lake would, *a fortiori*, be still more objectionable than one near the Peninsula Hotel, as it would involve the strengthening of the whole of the beach as far as the Light-house Point to prevent its westward motion. The next question which suggests itself, *assuming* the preservation of the beach provided for, is the possibility of keeping an artificial canal open anywhere between a few hundred yards east of the Point and the most remote extremity of Ashbridge's Bay, without continued and expensive dredging. When we remember that many million tons of sand and shingle have passed along the beach from Scarboro' shore to form in 58 years the 30 acres in deep water beyond the Lighthouse Point, when we glance at the new beach which has recently been thrown up west of the Point, when we consider the changed character of the Scarboro' cliffs, unprotected as they now are, is it probable that a canal could be maintained within the limits before mentioned? Is it not rather to be supposed that the sand would accumulate on its eastern side with a rapidity before unknown and defy the most energetic efforts to preserve a passage during the winter season? The rapidity with which natural breaks fill up, as shown repeatedly in Ashbridge's Bay, and recently near the Peninsula Hotel, furnishes also a safe answer in the negative to this question.

It appears manifest that the integrity of the Peninsula must be preserved; that no artificial Lake communication situated between the Light-house Point and the eastern extremity of Ashbridge's Bay could be maintained under the existing conditions of the Scarboro' cliffs, without an enormous outlay at the commencement and an annually increasing expense in maintaining it.

It is urged that the chief objection to the construction of groynes into only eight or ten feet water is the nature of the sloping beach, the fluctuating shoals, which in places are not twenty feet below the surface of the water seven hundred yards distant from the shore. Mr. Fleming's own measurements opposite his proposed canal give a distance of nearly 700 yards before the shoaling coast reaches a depth of twenty feet water. The whole question of the construction of groynes is involved in a distinct and exact knowledge of the depth to which the surges of the Lake affect the sand and shingle of the shoal. It is manifest that if a groyne were not constructed into water deeper than that in which the waves have the power to move the sand at the bottom, it would be of little avail. Let us suppose for instance that groynes were constructed on the sand bars to the depth of twelve feet water, and that the high waves of the Lake affect the bottom to a depth of fifteen feet.* The sand during storms, namely those which produce the longest and highest waves (the easterly storms) would be disturbed to the depth of fifteen feet and pushed round the projecting groyne, other sand from above or the east, falling down by gravity or pushed along by the impelling waves would fill the place of that which had been removed, and be in turn swept westward, and so on repeatedly. A really useful groyne must penetrate into water of a depth *beyond* the ordinary influence of the waves upon the shelving bottom during storms, which certainly extends on the Peninsula shoals to a depth exceeding fifteen feet. There is a spot on the Peninsula where a groyne can be constructed to serve every purpose required. Mr. Fleming has justly recommended a groyne at the Lighthouse Point (the south-western point of the Peninsula), and it appears to the writer that THAT spot is the first which should be selected for the construction of a groyne. But Mr. Fleming's suggestion that the groyne should be carried out into eight or ten feet water, is altogether incompatible with the effect produced on the sand at the bottom below that depth by the long swell of the waves.

The writer, while duly acknowledging Mr. Fleming's appropriate selection (as it appears to him) of the locality, would suggest that one groyne should be carried out there into 40 feet water. When the peculiarity of the beach and shoal at the Lighthouse Point is considered the magnitude of the work will not appear so imposing as it seems to be at first sight. The boundary of the Peninsula at its south-west extremity is extremely abrupt, so much so, that at the point A on the Chart No. 9, the depth of water is not less than 40 or 50 feet within 400 feet of the beach, (leaving a wide margin for recent changes, possible, but not probable.) The soundings on the Map are taken from personal observation, and Mr. Fleming's Chart, and they indicate a steep and abrupt boundary at the turning point of the shoal. This peculiarity in the conformation of the Light-house Point in its subaqueous extension, will necessarily be maintained for a long period of time, as every successive step in advance is into deeper and deeper water. A few hundred yards to the west of the Point, 90 feet water is recorded. (Lieut. Herbert.) All progress of the beach, therefore, in a south-westerly direction must be made by vast accumulations in deep water. This point serves as a protecting headland round which the travelling beach is rapidly moved by easterly winds and as rapidly forwarded northward by south and south-westerly winds.

A groyne at A, bisecting the segment of curvature would, if

* Note H. in Appendix.

* Note B. in Appendix.

run out into 40 feet water, arrest all sand and shingle for a considerable period of time, and as the accumulating materials encroached upon the protecting limits of the groyne, further increase could be arrested, and the materials FIXED, by placing a second groyne at B; in process of time the travelling beach would encroach upon the protecting limits of B, a third groyne placed at C, on a smaller scale, would arrest further progress and FIX the sand between C and B; a fourth after a few years would be required at D, and so on, as materials accumulated. The results of this system would be the establishment of the Peninsula upon a firm basis, adding year by year a large quantity of what might become valuable property if properly taken care of and embellished with, as well as sustained by, appropriate trees. The western extremity of the Peninsula is also subject to the inroads of travelling beaches as not only its formation but the extension of the sand bar sufficiently shows, and has shown, for many years. (See Gzowski's report, noticed before.) A groyne at E, would, if made to penetrate into 15 feet water, effectually retain the moving beach, and preserve the integrity of the distance between A and E, and finally a groyne at F K, as mentioned by Mr. Fleming, would establish the channel, and if curved sufficiently far in the direction of K, a permanent beach would be thrown up during the next period of low water, which would secure a current in one channel of at least 12 feet water, sufficient to preserve it from possible inroads of sand, which might be deposited in the form of Bars, *within it*, during summer currents, hereafter to be noticed.

In the mean while, what, it will be asked, is to become of the more easterly portions of the peninsula; is there no danger of any part of that narrow strip between the Peninsula Hotel and the extremity of Ashbridge's Bay being swept away? Nature herself supplies an answer to this question, which, when duly considered may be correctly interpreted. Nature has made and repaired one breach during the past year at the eastern extremity of Toronto Harbour; she has made and is now repairing at the rate of an acre a week another breach in Ashbridge's Bay, of a third of a mile long. There is not a doubt that during the whole epoch of the existence of Toronto Harbour, from its first washed up beach to its present imposing magnitude, breaches have been made during all periods of high water, and repaired during periods of low water. The writer is of opinion that several remains of breaches can be recognised in various parts of the coast between the Hotel and the eastern extremity of Ashbridge's Bay—these remains distinguish themselves by two projecting spits, precisely like those which are now seen where the recently closed breaks existed at the east end of the Harbour. Four years ago—during the period of low water in 1849—several of these remains of breaches could be distinctly seen, bordering the swamps and east of it. It is desirable that breaches should not be made, as by slow degrees they limit the dimensions of the Harbour, but under certain circumstances, they are of immense importance, as will be shown hereafter. The writer submits, with respect, that no works whatever are required to preserve any portion of the beach from destruction. It will be asked, why not? and it will be urged that the diminution of the beach near Privat's Hotel and elsewhere, in an easterly direction, to less than one half its width in about two or three years, is cause for serious doubt as to its stability. The writer would beg to call attention to the circumstances under which the beaches became diminished: their diminution is only *apparent*, and where real (if anywhere) it will be rapidly repaired; the beaches expose less surface in consequence of the *unusually high water of the Lake*. The average annual fluctuations of Lake Ontario are about two feet, but the difference between the levels of the Lake in October, 1849, and in June, 1853, was four feet, five inches. (See Canadian Journal, page 27, Vol. 2.) Now it is suggested that these great differences in Lake Levels are of the utmost importance, not only with respect to the general appearance of the Peninsula, but with regard to its subaqueous development. An observer in 1849 would see a broad beach at the Peninsula Hotel some fifty or sixty yards broader than an observer in 1853, solely on account of the difference in the Lake levels, without the necessity of one particle of sand being removed. An observer in 1853 would say the beach is but two feet three inches above the waters of the Lake, while an observer in 1849 would say, it was six feet eight inches above the same level, and yet the real altitude of the beach might be precisely the same. So with respect to Soundings. The bar which in 1853 had four feet water upon it would be two inches above the water in October, 1849. These are important items, they show the absolute necessity of exact scrutiny into all measurements relating to the Harbour, and the reduction to the same standard of Lake level of all observations, before a fair conclusion can be arrived at. The influence of difference in lake levels, in other words, of periods of high and low water upon the Peninsula is all powerful. This difference has enabled sand bars to be thrown up into sand beaches, and has, in a word, been the great *formative* cause of the whole Peninsula. It is beautifully shown even in this tempestuous weather, (April, 1854); at Lighthouse Point the writer noticed in October last the slow deposition of the spit now protruding itself above water at the western extremity of the Point. The Lake was then 3 feet 3 inches above its lowest level in 1849, and the spit was just covered with water in calm weather, and not to be seen from the shore, but easily discernable from the Point.* Now it is decidedly a narrow sand beach, but the Lake is about a foot lower than in September last. During the present, or rather coming summer, as the Lake falls, it will be washed up into a stable, prominent beach, sweeping round to the north, and enclosing some additional acres, to mark the present rapid increase of the boundary of Toronto Harbour.

One more aspect under which the fluctuations in the level of the Lakes may be viewed, is in the relation of those changes to the construction of groynes.

It may be supposed, for instance, that during a high lake level a groyne is constructed into 10 feet water—it is known, however, that the difference between the maximum and minimum levels of Ontario exceed five feet (some authorities say 8 feet). It is clear that a groyne penetrating into 10 feet water during high lake levels would penetrate into only five feet during minimum levels, which would have the effect of neutralizing the purposes for which the groyne was constructed. †

This argument becomes perfectly applicable when we consider the nature of the shoals east of Lighthouse Point. There is an immense distance between the lines of 10 feet water and 15 feet water, when reduced to the standard of the Lake levels; this distance exceeds in many instances the total length which would be required for one groyne at Lighthouse Point, penetrating into

* See Note G, Appendix, (referred to before.)

† See Note I.

40 feet water, (between 390 and 400 feet) thus involving for the construction of effectual groynes east of Lighthouse Point, where the water shallows, an outlay which, if judiciously incurred, would serve to arrest permanently the progress of the sand, give stability to the Peninsula and distribute the expense of future works over a great number of years. It will, doubtless, be becoming in the writer to express more fully the reasons he entertains for the opinion that it is unnecessary to protect the weaker portions of the Peninsula.

1. Vast bodies of water in the form of waves may break upon it, and over it, without carrying any considerable quantity of materials into the bay, as before noticed. This arises from the very *gradual sloping* conformation of the shoals lakewards. They may carry away the crests during high water, but they rapidly repair the breach. The sloping character of the shoals being always maintained by the mode of their formation, and waves always *breaking* when they reach water *equal* to their own *height*, their force is destroyed before they reach the shore. During low water levels, the waves break nearer the shore, the re-arranged materials of the beach are then more precipitous, but during this period the breaking waves exert no force on the crests of the beach, because the emerged land due to falling of the Lake *protects itself*.

2. It is submitted that we have *passed* the maximum period of high water; but, if not, it will occur in June, and before works (supposing they were necessary) could be constructed to protect the weak portions of the beach. It appears quite probable that all period of danger from high water is passed, if we may permit ourselves to be guided by the experience of the past. Mr. Hall, in quoting Mr. Higgins, the Topographer to the Geological Survey of Michigan, embodies in a single sentence the probable state of the case. "He considers it probable that the minimum period continues for a considerable period of time, while the maximum continues only for a single year." * (Geo. 4th Dist.) This summer, doubtless, we shall see the Peninsula apparently extending itself in all directions (as it is already doing) by the subsidations of the waters of the Lake, and then will begin to appear and to be thrown up into beaches, the vast accumulations which have been progressing during the last two years of high water from the unprotected naked gullies of the Scarboro' cliffs.

The answer to the question proposed by the Harbour Commissioners respecting "the effects which have been produced or are likely to be produced by the present breach at the eastern extremity of the Bay of Toronto, particularly with reference to the bar at the entrance to the Bay" becomes very materially simplified by recent events. The first event being the natural closing of the breach, the second event the occurrence of another breach of far more imposing dimensions in Ashbridge's Bay. Assuming that the breach had not been closed, it is manifest that the question of its influence upon the bar at the mouth of the Harbour would involve the action of the *currents* which modify the form of the bar at the mouth. The currents will be noticed hereafter. The question of the breach being *prejudicial* to the Harbour is also involved in the general question of the influence of the currents, and the necessity for strengthening that portion of the Peninsula where the breach existed has been already discussed. It has also been shown that a permanent opening could not be maintained at that end of the Bay without immense outlay, and is consequently not to be recommended. The question of "the advisability or otherwise of enlarging the opening between the Harbour and Ashbridge's Bay" is subordinate to the general question of the currents and will be noticed in the sequel. The construction of a permanent opening into the Lake from Ashbridge's Bay, has been shown to be infinitely more objectionable than the construction of a canal near the late breach east of the Peninsula Hotel, as involving an enormous outlay for the purposes of protecting its mouth and preventing, by groynes, the beach *west* of it as far as Lighthouse Point from continuing to 'travel' under the influence of the same forces as those which called it into existence.

It is submitted by the writer that it is quite impossible to separate the effect of the breach at the east of Toronto Bay on the bar at the mouth of the Harbour from the simultaneous and posterior effect of the breach in Ashbridge's Bay.

Whatever beneficial or baneful results were produced on the bar by the opening near the Peninsula Hotel, have been entirely obliterated by a power of much greater magnitude acting unceasingly during the last five or six weeks, and there seems to be no reason to doubt but that 99 per cent. of the good effects produced by any openings or breaches on the bar, are due to those which have recently occurred in the Lake boundary of Ashbridge' Bay. We can only *suppose* the effect produced on the bar by the opening near the Peninsula Hotel; it cannot now be measured. Observations made in the autumn might have recorded its effect, if any were noticeable, but since the breach was made in Ashbridge's Bay, those effects have been annihilated, or, at least, so greatly remodelled as no longer to be appreciable. The reasons for this statement are as follows:—

1st The opening in Ashbridge's Bay, when the writer's attention was first particularly drawn to it, at the beginning of April, was a third of a mile long, and the waves swept through it with terrific violence, producing a current so strong in Ashbridge's Bay towards Toronto Harbour, that all expectation of distinguishing the effects produced at the bar by the opening near Privat's, (then closed,) were entirely dispelled. At another time, towards the end of April, when a few days of calm weather permitted a close examination of the breach, it was found that the waves still breaking over it, although there was very little wind, produced a violent current, which drove the boat in which the writer was seated, with rapidity towards the swamp. A calculation was then made of the amount of water projected into Ashbridge's Bay by the rolling of the waves over the beach. The distance exceeded 1600ft., over which the waves broke. The height of each wave was estimated at two feet, the breadth between fifteen and twenty feet. Assuming the length, 1600 feet, the height, one foot, the breadth, ten feet, a quantity of water exceeding 16000 cubic feet would be thrown into Ashbridge's Bay by each system of rolling waves. This occurred, on an average, once in twelve seconds, or five times in a minute, which would give 80,000 cubic feet of water every minute.

If the Don were 100 feet broad, ten feet deep, and moved at the rate of one foot a second at its mouth, it would throw into the Bay, 60,000 cubic feet a minute; while the breaking waves over the breach, at Ashbridge's Bay, would, in a comparative calm, throw 80,000 cubic feet at the lowest estimate, into the same general receptacle, during the same time. This number does

* See also Note I.

not, it may be very reasonably supposed, represent one-fourth part of the mass of water projected into Ashbridge's Bay over the low beach, during the long continued easterly storms which distinguished the month of April. It is therefore urged, that any attempt to pronounce an opinion upon the effect produced upon the entrance to the Harbour by the late opening near Privat's Hotel, must be entirely theoretical, as it cannot be fairly represented by soundings taken in April of the present year. It is important, to ascertain, how this mass of water projected into Toronto Harbour by the Don and through the breach at Ashbridge's Bay, distributed itself in passing out of the Harbour entrance. The temperature of the water determines the solution of this problem. Six or eight trials showed the temperature of the water to vary from 38 to 42 degrees, both in Ashbridge's Bay, the Lake, and the Harbour. This is within two degrees both above and below the temperature of water at its greatest density, (39° 6,) consequently, the density of the water may be regarded as uniform, and hence, the current would be equally distributed over the bar at the entrance to the Harbour, modified by a current produced by the easterly gales, noticed hereafter. In summer, it is probable that the surplus water would have escaped, almost entirely, over the bar at the mouth of the Harbour, and would have had little effect upon the channel in deep water. The effect of temperature is beautifully shown in the currents which are established during the summer months at the Harbour entrance, and requires a detailed notice. The most permanent current in the Bay, having an outward direction, is, of course, due to the Don; but the waters of the Bay and Don, being shallow, rapidly acquire an elevation of temperature, by exposure to the sun's rays; their specific gravity is therefore diminished. The deep waters of the lake do not attain the same elevation of temperature, and are, consequently, heavier than the surface waters of the Bay. The warm and light waters of the Bay are pushed out over the bar by the colder and heavier waters of the Lake, irrespective of the current of the Don. The cold Lake water enters at the deepest part of the mouth of the Harbour, and during the summer months establishes an inward current, often remarked. Two other currents of importance are to be noticed;—1st. An under, outward current, which is occasioned by *westerly* winds impelling the waves of the Lake over the bar into the Bay: the same influence, however, pressing upon the waters of the Lake, raises them at its eastern extremity and lowers them at its head. In order to establish equilibrium between the level of the waters in the Harbour and those in the Lake, an ontward undercurrent is established, which, in prolonged westerly gales, is very marked. 2nd. An inward under current at the mouth, when easterly winds are blowing, which have the effect of driving the waters *out* of the Bay, and at the same time, raising the level of the water at the head of the Lake; in order to preserve equilibrium, a powerful under inward current is established in the deepest water at the mouth of the Harbour.

It is evident that these currents have given to the sand-bar now threatening the mouth of the Harbour its peculiar conformation, as shown in Mr. Fleming's chart. These *currents cease* to exist during the maintenance of an opening, either in Ashbridge's Bay, or at the east end of the Harbour. Their conservative influence in retarding the progress of the shoal northwards, and its invasion of the entrance of the Harbour, cannot fail to be noticed: they form another objection against the construction of permanent openings in the localities named. The late Mr. Roy, C.E., who, as before stated, paid much attention to the phenomena of the Harbour, well describes the influence of these currents in his paper published in the *Monthly Review*, for June 1841.

It is sufficiently clear that the currents just described, irregular and accidental as they are, and *deriving their very existence* from the conformation and growth of the Harbour, can only be supposed to exercise an influence, (and moderate in its effects,) upon the *form* of the sand-bar which threatens the mouth of the Harbour.

An effect requires a cause: the cause of the currents is the presence and form of the peninsula, without which they would not have existed; the currents are destroyed by destroying the integrity of the peninsula. It follows, as a matter of course, that the currents could not have produced that which has given birth to them; an hypothesis which, in spite of the contradictions it involves has yet found supporters.

The writer presumes that the Harbour Commissioners will permit such an interpretation of their words, "Means to be adopted for the improvement and preservation of the Harbour," as to allow the introduction into this Report of remedial measures which have not been specially referred to in their published notice.

The suggestions which the writer begs leave to submit are introduced, without present comment, into the following recapitulation of the statements advanced in relation to the history, formation, and preservation of the Harbour.

1. The Harbour, in its utmost extension, is altogether a modern formation.

2. Its formation is due to the present existing PROTECTING HEADLAND of the west commencement of Scarboro' Heights.

3. Its original form was a sand-bar, or shoal, deposited under the protecting headland, in a position a little to the south of its present situation. The materials of which the sand shoal was composed were derived from the east, being impelled by easterly winds during a period of high water, and then washed up into a beach during a period of low water.

4. The Don exerted no influence whatever on the original formation or extension of the sand beach, but the beach was extended westerly, under the headland, by the same causes which originated it, until it advanced so far as to be removed from the influence of the protecting headland. Subsequently, it was swept round in a northerly direction, more particularly by south and west winds, until it enclosed the space now occupied by the marshes of the Don and Ashbridge's Bay.

5. The whole valley of the Don was excavated ages before the enclosure took place, and the marshes have been produced by the same vegetable growth which now converts the ponds of the peninsula into reedy swamps. (Witness the ponds south of the Lighthouse, during the present generation). The detritus of the Don has accelerated the formation of its marshes, but that detritus consists only of the fine mud which can be mechanically suspended in water.

6. The peninsula proper has been formed by "travelling beaches," impelled along the boundary of the present Ashbridge's Bay and its westerly extension. There is every probability for supposing that each successive beach, as shown by the dotted lines on Chart 6, and Sketch 10, are permanent records of *Low Lake Levels*.

7. The boundaries of the Peninsula have been immensely extended during the last 58 years, and the addition of so many acres in deep water beyond the Lighthouse implies the *subaqueous extension* of the shoals forming the sloping Lake sides of the Peninsula to a very considerable degree southwards.

8. The materials have been obtained by the destruction of the Scarboro' cliffs. (Mr. Fleming.)

9. The operations of settlers during the last forty years in clearing the crests of the cliffs in Scarboro' have occasioned the immense recent destruction there visible, and have produced to a great degree the alarming progress of the Peninsula boundary of the Harbour.

10. Previously to the settlement of the country the cliffs were much protected from atmospheric influences by trees, under-brush and grass growing on their crests and down their sides, and the beach by natural groynes of fallen timber, also by the large fragments of shale and boulders washed out of the drift, which have been removed for building purposes.

11. The progress of the travelling beaches may be arrested by groynes. (Mr. Fleming.)

12. The groynes must penetrate into a depth of water beyond the influence of the great waves of the Lake upon the bottom, and the maximum and minimum level of the Lake must be taken into consideration in ascertaining the depth to which they ought to be constructed.

13. The effect produced upon the beach by waves washing over it, or in some instances creating openings, is merely to change its position and move it a few yards to the north; this is a consequence of the vast extension of the sloping beach southwards.

14. There is no danger of a *permanent* breach being made by the waves of the Lake.

15. Breaches are due to the concurrence of storms and high Lake levels, and no breach would have been made near the Peninsula Hotel during low Lake levels.

16. Evidence tends to show that the maximum level of the Lake lasts for one or two years only, whereas the minimum lasts for several years. The maximum level of Lake Ontario for the present period was attained very probably in June last, when the level was 4 feet 5 inches above the level recorded by Captain Lefroy in October of 1849 at the Queen's Wharf. There is a remote probability of the level this year being equal to what it was last year, owing to the late severe winter. This is a point which will soon be ascertained. The level (end of April, 1854) is now two feet one inch lower than in June last.

17. In order to preserve the Harbour from closing, a groyne must be constructed at Lighthouse Point into 40 feet water, which will cause the sand to 'back up' against it and extend the dimensions of the shoal southwards; in a few years a second groyne must be constructed at B on the Map, and after another interval of time a third groyne at C, then at D, (each groyne being smaller than the preceding one), and so on. The effect of this system of groynes will be to extend the shoal southwards into deeper and deeper water, and gradually 'back up' the progressing materials TO THEIR SOURCE, thus immensely strengthening the Peninsula and making it a permanent and stable tongue of land. The sand may be prevented from forming dunes by planting trees, beginning with the formation of new land and planting as the *land forms*. (If groynes were to be constructed first, say at the Hotel and then westward, it would be necessary to plant the whole coast at once, which would be a difficult matter).

18. Simultaneously with the construction of a groyne at A, a groyne into 15 feet water must be constructed at EM, and simultaneously with this a groyne at KF. (Mr. Fleming.)

19. It is most desirable to produce a current between the Queen's Wharf and the groyne. In order to effect this object the Don must still be permitted to enter the Bay, but not by its present mouths. They should be closed and a mouth opened at H, and a channel cut for the Don south-east of the Railway Bridge. Two or more channels would be better, for the purpose of preventing the cutting of a deep passage by the waters of the Don; the channel might be conveyed to different parts of the Marsh. The progress of consolidating the Marsh by this means would be very rapid. The waters of the Don would then percolate through the Marsh, and if they cut a deep channel they would have time to deposit much of the mechanically suspended matter with which they are charged during freshets, and if they did not cut a new deep channel, the reeds would act as filters, like the reeds in the swamps bordering the Mississipi, (see Lyell's 2nd voyage to America), and effectually arrest all silt. The sewage of the town should be made to flow into the Don; in the Marsh it would become inoffensive, being rapidly consumed by vegetation. The waters of the Bay would thus be greatly purified. The passage of the Don through Ashbridge's Bay *could not be maintained*.

20. Any permanent opening in the form of a canal between a few hundred yards to the east of Lighthouse Point and the eastern extremity of Ashbridge's Bay could not be kept open, without the construction of works into deep water, and of groynes into deep water *east and west* of it.

21. But ONE POSITION for the mouth of a *permanent* canal exists on the Peninsula, and that is at Lighthouse Point, where it should be carried out side by side with the groyne into 40 feet water. The groyne might form one side of the canal. A canal from the Bay terminating there would retain a permanent opening for ages, if groynes at B, C, D, &c., were constructed as the 'land made' time after time.

22. A canal constructed from the point G to A, and the continuation of the groyne at K to G, would soon inclose a piece of land which would amply pay all the expenses of the undertaking, (to be used for the sites of warehouses, storehouses, &c.,) and maintain the integrity of the Peninsula, and the preservation of the permanent opening into the Harbour throughout the year. See Section No. I.

23. In process of time, which might be materially shortened by the construction of simple works, a junction from A to E would be advisable, and thus form a permanent island.

24. If the entrance at the Queen's Wharf were narrowed simultaneously with the construction of the canal from A to G, both openings would remain permanent and unobstructed by bars.

APPENDIX.

NOTE A.

The materials of which the Peninsula beach consist are derived almost altogether from the drift clay and sand of the Tertiary epoch. Precisely the same materials, as regards their mineralogical character, are found to compose a very large portion of the Scarboro' cliffs. The materials consist of—

1st. Very coarse quartz sand.
2nd. Red Felspar.
3rd. Black magnetic oxide of iron.
4th. Comminuted calcareous shale, derived from the breaking up of larger fragments found in the blue clay.
5th. Pebbles of quartz, syenite and various other kinds of granite, such as are found in abundance in the drift sand and clay of the Scarboro' cliffs.
6th. Water-worn and rounded fragments of shale, containing fossils belonging to the Hudson River Group; some of these fragments are four and five inches in diameter, and one inch thick.

The shale and pebbles constitute a very considerable proportion of the materials composing the Peninsula and are found in abundance at Lighthouse Point. They must have come from the East and 'travelled' along the beach. The specific gravities of some of the sand materials are given below, the figures will probably be conclusive as to the possibility of such heavy substances, and of a magnitude which may well confer on them the appellation of 'very coarse sand,' being transported from the *west*, in the absence of powerful currents to propel them through water from 30 to 40 feet deep. (Between the Humber bay and the west frontier of the Peninsula:—)

Gneiss	2.72
Syenite	2.74
Granite from	2.62 to 2.74
&c.	&c.

Out of 40 kinds of rocks mentioned by Sir Henry de la Beche in his "Researches in Theoretical Geology," only *four* have a specific gravity less than 2.50, or two and a half times heavier than water.

The fossils of the Lower Silurian rock found on the Peninsula are derived from the drift clay which reposes immediately above the rock itself. They may be seen, *in situ*, in very many situations near Toronto.

Ice cannot have transported the Peninsula materials from the west, for then we should find *boulders*, of which none are to be seen.

But one rational conclusion remains, which is that they have come from the *east*.

NOTE B.

The late Mr. Roy, C.E., of Toronto, paid considerable attention to the phenomena of Toronto Harbour. He describes it as follows: "The Harbour of Toronto is about 2¾ miles in length from the Government Wharf to the Peninsula Hotel, and about 1¾ miles in breadth from the end of Church Street to the southern Peninsula. The water deepens gradually from the North Shore. At the distance of 1000 feet from the shore it is about 15 feet deep, and at the distance of about half a mile from the shore it is 30 feet deep: further out it deepens to 33 feet, and continues to maintain these depths for about a mile further, when as we approach to the southern Peninsula, the depth suddenly declines from twenty-eight and thirty feet water to five, six, and seven feet water. The greatest depth at the entrance is 14½ feet, and the width of deep water from the Government Wharf to the buoy is about 800 feet." This was published in the Monthly Review, June, 1841.

NOTE C.

The writer would respectfully suggest to the Harbour Commissioners the propriety of a personal inspection of the Scarboro' coast from the east corner of Ashbridge's Bay to Gates' Farm. The wild and romantic beauty of the scenery will well repay the fatigue of the trip. It must be accomplished on foot, and in order to obtain a clear insight into the phenomena of the coast as connected with the formation of Toronto Harbour it must be commenced at the east end of Ashbridge's Bay.

The points to which the writer would respectfully direct attention are,

1st. The nature of the beach at Ashbridge's Bay, and in many instances the very regular *attitude* assumed by the shingle under the influence of the late easterly gales. That attitude consists in the inclination of each piece of shingle with respect to its neighbour, the one to the east reposes as it were on the one to the west of it, and so on, as exhibited in the diagram. In several instances the writer lately observed this arrangement, evidently made under the influence of easterly breaking waves.

2nd. Attention is called to a remarkable *remnant* of an ancient beach, about a mile east of Ashbridge's Bay. A fence of a cleared field is in one part placed upon it. Trees of considerable growth are still remaining on it, showing its antiquity. The beach or spit has the form indicated in the diagram.

3rd. Natural groynes of fallen timber occur in this locality and afford a good idea of the extent to which the fallen timber may protect the cliffs.

4th. The configuration of the coast is especially to be noticed where the first or lowest terrace approaches the Lake. It will be seen that this terrace, especially when fringed with the tall pines which once covered it, would serve all the purposes of a vast protecting headland from north-easterly and easterly gales, to the present Ashbridge's Bay, and, in the writer's opinion, the first origin of the peninsula was due to this protecting headland.

5th. The enormous gullies are to be particularly noticed, their recent formation, the unstable nature of the materials of which the cliffs are composed, and the certainty of an immensely rapid yearly increase in the quantity of material precipitated into the Lake by the falling of the sides of the gullies.

6th. The identity of the mineralogical character which exists between the sand of the cliffs, the beach sand, and the sand of the peninsula.

7th. The influence of the total destruction of protecting forest growth on the rapid formation of gullies.

Other subjects worthy of note are embodied in the accompanying Report, and do not require to be noticed here.

NOTE D.

"From the experiments made by the Committee appointed by the British Association, in 1836, it was found that with a depth of water equal to twelve feet, waves nine inches high, and four or five feet long, did not sensibly affect the water at the bottom. Waves from 30 to 40 feet long, oscillating at intervals of six or eight seconds, produced some effect, but much less than near the surface."—(See Article *Waves*, in the *Penny Cyclopedia*, vol. 27).

"The agitation of the sea is felt at different depths, in proportion to the magnitude of the waves raised by the friction of the wind. During heavy gales of wind, the depth at which this agitation has been observed, sufficient as it were to shake up fine sediment enough to discolour the water, is about 90 feet."—*Geological Observer*, page 112,

"The depths at which the disturbing action of a sea wave can be felt has been estimated even so high as 500 feet on the Banks of Newfoundland."—*Emy. Mouvement des Ondes.* Quoted by Sir H. de La Beche.

The writer is persuaded that the long waves of Lake Ontario, formed by the friction of the wind on an expanse of water equal to 180 miles, are sufficient to move sand at a depth of fifteen feet, especially on a shoaling coast. The construction of groynes on a shoaling sand beach is open to the objection that the groyne itself may occasion such a *reflex* action of the waves as to bring sand from depths where it is affected into deeper water, thus producing *secondary shoals*.

NOTE E.

The writer does not advance this statement as founded upon indisputable authority, but has heard it stated by persons employed in collecting stone [illegible] from the Scarboro' coast, that blue clay is found in ten or twelve feet water, outside Ashbridge's Bay, and affords good [illegible] ground. On questioning the fishermen in that locality,

they said they had *not* observed it. The question is not one of importance, nor has the writer had any opportunity of verifying any statement by personal inspection.

NOTE F.

During the present spring the writer endeavoured to discover the ancient beach of Lake Ontario, alluded to in the text. At the depth of two feet, on the borders of the marsh, he found, repeatedly, a washed sand, but did not succeed in finding shingle and pebbles. The high state of the water prevented any search being prosecuted far in the marsh, at a depth of three and four feet.

NOTE G.

In October, 1853, the writer sketched the appearance of the ridges and new reef, at Lighthouse point, from the summit of the lighthouse, of which, Diagram No 10, is a representation. The diagram does not pretend to the accuracy of measurement. It was sketched at that time with a view to illustrate, at some future period, the theory of the formation of the Harbour advanced in this Report.

NOTE H.

The Bay subaqueous extension of the peninsula has been remodelled and disturbed in many parts, this arises from a circular current which sweeps round the south shore of the Bay, towards the bar at the mouth, when westerly and south-westerly winds press the waves on to the north shore. Equilibrium is established by means of this current, which is, of course, dependent upon the force of the gales from the quarters mentioned. The late Mr. Roy, C.E., notices this current in the paper before alluded to.

NOTE I.

The late Dr. Houghton, State Geologist of Michigan, took the level of Lake Michigan, in 1819, as his Zero of Comparison, and he noticed, in subsequent years, the following variations in the level of that Lake:—

LEVEL OF LAKE MICHIGAN.

Years.	f.	in.	
1819	0	0	Zero of Comp.
1830	2	0	
1836	3	8	
1837	4	3	
1838	5	3	
1839	3	11	
1840	2	7½	

(*Report of the State Geologist of Michigan*, 1841.)

Approximate Estimate for the construction of Works for the preservation and security of Toronto Harbour.

	£
Groyne at Lighthouse point, about 400 feet long, into 40 feet water	3000
Groyne at E. M., into 15 feet water, estimated length, with allowance for Low Lake Levels, 50 chains	2000
Groyne at mouth of Harbour, 100 chains	4000
Total	£9000

	£
Estimated Expense of constructing a *Canal*, into 40 feet water at A, and 20 feet water, at G; approximate length, 1900 yards, width 200 feet	15000
Construction of Groyne from K to G, 100 chains	4000
Total Expense, including Canal and Groynes	28000
Amount of available Land enclosed by works between the points A. G. F.....250 acres: 250 acres at £100 per acre	25000
Difference	£3000

REPORT
ON THE PRESERVATION AND IMPROVEMENT OF TORONTO HARBOUR,

BY SANDFORD FLEMING, CIVIL ENGINEER.

[*The second premium of Seventy Five Pounds was awarded to the author of this Report.*]

TO THE CHAIRMAN OF THE COMMISSIONERS OF TORONTO HARBOR:

SIR,—A public roquisition has been made for information as to the means which should be taken for the preservation and improvement of your Harbor, by a notice dated March 14th, 1854, and a pecuniary reward has also thereby been offered. This last, although perhaps insufficient in itself to an elaborate examination of the subject, is doubtless an additional incentive to all who may chose to compete for it; but to one who is proud of, and takes delight in, those pursuits collaterally related to his profession, the pleasure derived from an enquiry so interesting as the formation of that singular breakwator bounding your harbor is in itself inducement sufficient; and I am fortunately in possession, by previous and independent researches, of information enabling me to approach it with some degree of confidence, and I accordingly submit the accompanying copy of a paper laid before the Canadian Institute about four years ago, which you will be pleased to consider as preliminary to this report.

Toronto Harbour—Its Formation and Preservation.

Read before the Canadian Institute, June 1st, 1850;
BY SANDFORD FLEMING, C. E.

The origin of the now wealthy and flourishing City of Toronto is, in common with that of many other cities and towns, clearly traceable to certain natural advantages possessed by their localities. A waterfall or rapid stream, the navigable termination of a river, or its junction with a lake or other open navigation, will frequently account for the position of a town or village in an agricultural or manufacturing district; but a natural harbour of easy access will generally, if not universally, point out the locality of a thriving commercial nucleus, in all countries open to settlement and civilization.

To none of these circumstances except the last can we attribute the origin of Toronto. We have no waterfall,—no navigable river—even the soil itself is comparatively barren, and for several miles around, with a few isolated exceptions, unsuited for agricultural purposes. To the last, therefore, must we ascribe the beginning of Toronto, and to the unequalled excellence of this harbour forming on the north shore of Lake Ontario, the most facile outlet for the productions of the back country, is principally due the rapid and uninterrupted progress in commerce and wealth of the western capital. To maintain this harbor

in its original state, or, if practicable, to improve thereon so as to ensure a continuance of prosperity, becomes, therefore, of the utmost importance.

The natural basin formed by a sandridge extending from the western boundary of the township of Scarborough, embracing in its arms a portion of the great Lake, possesses many of the requisites for a good harbour; it encloses about 1200 acres of water, entirely free from rocks and shallows, and averaging from 15 to 35 feet in depth, on the wide expanse of which the whole shipping of *all* the Canadian Lakes might safely ride at anchor. During the prevalence of certain winds, however, the basin is not of easy access to sailing craft; and not only is the channel scarcely sufficient to admit the entrance or departure of large vessels, but it is even fast closing up, and, astounding as the assertion may appear to some, will, ere many years, unless efficient means of prevention be taken, put a complete stop to all navigation—a bold enough statement, but from ascertained facts a proper inference.

That the entrance to the harbour is fast closing up, I have been led to discover, by comparing a series of careful measurements recently made, with old charts of various dates. In the sequel, this important fact will be clearly shown, and an attempt made to account for it; in the meantime, it may be sufficient to state that a bar has encroached so much on the channel, as to make it not more than half the width it was fifteen years ago. With the view of prescribing an efficient mode to prevent the further accumulation of shoal calculated to prove so detrimental to the future prosperity of the city, it is first requisite to ascertain the cause of the evil, from whence it arises, and investigate the manner of its action—hence the following inquiry into the formation of the Peninsula and Harbour.

Few persons visiting Toronto for the first time but are struck with the singular appearance of the neck of land or peninsula stretching out into the lake in front of the town, so low that the few small trees growing at wide intervals on its surface appear almost springing from the water, and on a nearer approach, so long, so curiously shaped, and so different from the land on shore, that many are doubtless led to theorize a little on its formation. Some, who have probably arrived in the province by way of Niagara, and crossed over with their minds filled with contemplations of the mighty cataract, at once, and without much consideration attribute to the descending torrents of that river, the power of elevating from the depths of the lake, or of carrying across in suspension, the drift deposited here—a theory wild and incapable of defence, though some are bold enough to venture it.

Others again, who have probably arrived from the west, or whose business takes them frequently in that direction, and from the steamer generally calling at the mouths of the various small rivers emptying into the lake between this and Hamilton, may be induced to think that these streams have had the effect of drifting the debris of the uplands outward, which, with the assistance of an imaginary eastward current of the lake, is carried until meeting a contrary current, supposed to be of the Don, then the matter held in suspension is supposed to have been deposited at their junction line, opposite Toronto. The advocates of this theory have yet to prove that such currents of the lake as these exist in reality: although it is true that currents outward and inward, over the bar, are found, occasionally resembling a slight half hourly tide, yet, if they have any effect on the bar at all they must have a tendency rather to diminish than increase the deposit. All these streams, with the exception of the Don, enter the lake nearly at right angles, and it is impossible that they can flow into a large and deep body of water, such as exists between their mouths and the point in question, without being entirely diffused; nor could the drift brought down by them be carried wholly or chiefly in one particular direction without a most powerful current, but would, if ponderous, be deposited at their outlet, and if light, would be distributed far and wide. More especially is it reasonable to infer that the Peninsula is neither now affected in any way by these western streams and the imaginary currents in conjunction with them, nor *has* been formed by their drift, since the material composing it, sand and gravel, could not, in accordance with existing laws, be held in suspension and transported for miles over still water, 60 and 100 feet deep. Were the deposit or any part of it of an argillaceous nature, there would have been some slight reason to think that these streams might have been auxiliaries, but such is not the case.

Others, again, suppose that the Peninsula is merely a narrow ledge of rock, slightly covered with the sand and gravel which we find on the surface, but this opinion is quite at variance with the general geological features of this part of the country, and to local investigations.

A little consideration of the subject will show that these opinions can only be advanced by those persons who have merely been enabled to make cursory observations, and by those who, knowing the wonderful transporting power of running water when confined, as in a river, are inclined to attribute to its agency more than is justly due, and overlooking the change of circumstances, class effects universally which can only be produced by causes under particular conditions. They being anxious to account for certain results, are contented with a superficial and fallacious reasoning, and assign to the most conspicuous agents of nature, that, which after a more careful and deeper search would be ascribed to a power less easily observed, but not less active, or less potent.

Sir Richard Bonnycastle, in an elaborately drawn up Report, dated 1835, gives it as his opinion that the Peninsula "was one of the many ridges deposited at the bottom of a vast lake which existed before the present Ontario and Erie were formed out of its drainage," and "that it had not materially altered for a vast length of time, probably not since it emerged from the waters."

It may be thought presumptuous in me to present anything in opposition to the judgment of that respected and eminent gentleman; but from careful observations and measurements, and a comparison of these with surveys made at different times by others during the last half century, having found that the deposit both above and under water has received additions so extensive, and which so closely resemble in character its older portions, I may be permitted to suggest, instead of the Peninsula being a sedimentary deposition of the tertiary periods, as thought by Sir R. Bonnycastle, that the whole of it belongs to the present era, and that at least one of the agents of its formation, is at this day as actively engaged in changing and enlarging the outline of the deposit in question, as it has been hitherto in gathering together the materials, and modelling them into its present shape.

I shall first endeavour to show that the inferior portion or base of the Peninsula has been washed from the valley of the Don by that river at an early date; second, that the materials composing the superior and more recently formed portions have been gradually transported along the shore from the eastward, and that this westward progressive motion of the sand and gravel beach is now the sole cause of the extension and enlargement of the Peninsula, and of the danger at present threatening the entrance of the Harbour.

First—That the groundwork of the Peninsula enclosing the Harbour is, or has been, a delta of the River Don.

It is generally believed that at one time Lake Ontario stood at a higher level, and covered a far greater area than it at present occu-

pies. A barrier may have then existed at its outlet, where probably the Thousand Islands are now seen, over the top of which the primeval St. Lawrence flowed; this great river, rushing over the barrier with tremendous velocity, would, through course of time, wash away its softer parts, and leave standing those numerous isolated rocks and picturesque islands which, now covered with foliage, adorn so much the landscape of that section of the country. If this be not the approved way of accounting for the lowering of the level of the waters, a gradual upheaval of the land generally, or even a subsidence of the ocean may be brought forward; it is unnecessary for our present purpose, however, to enter into a geological disquisition on this point, if we allow that the whole of the country bordering on Lake Ontario was at one time submerged under the same extensive sheet of water; and that the level of this great lake, or it may be this arm of the ocean, was through course of time depressed, and its outline contracted until it was reduced to the present Ontario. A supposition so strongly supported by the discovery of several ancient beach lines, terraces and parallel ridges in the vicinity of Toronto and other parts of the country, at various, but corresponding levels, that it may, without much difficulty be admitted.

As the land gradually emerged, its appearance would be bleak in the extreme; a flat or but slightly undulating surface unbroken by rivers or ravines, and uncovered, for a length of time with vegetation; on the ancient shallows of the great lake various kinds of plants would, through course of time, take root, grow up and wither; the continued reproduction and decay of which would gradually coat the surface with organic matter, and thus enriching the soil, enable it to produce more luxuriant vegetation. Now, (prior to the settlement of the country,) after a lapse of many centuries, we find the great hardwood forest growing over soils of an argillaceous character, and the ancient *sand shoals* of the great lake clothed with lofty pine.

We can easily imagine the general character of the present shores of Lake Ontario, when they first became dry land—a vast undulating plane ascending as at present from the Lake into the interior, but totally devoid of water channels for the surface drainage—here a bed of clay—there a tract of sandy soil; and as it is only reasonable to suppose that rains fell in those days as at present, the water produced by them on the surface, in flowing from a higher to a lower level, would most easily wash out channels in the softest material; and these little streams, collecting together in their downward course towards the Lake, would form the commencement of a river course.

The newly formed rivers, having the same fall towards the Lake as the surface itself, their beds being but slightly under it, would be much more rapid than they are now, and rushing down with violence after thaws and heavy rains, would, proportionally with their greater rapidity, during the first years of their existence, be more effective in scooping out the sand drift, and transporting it to the Lake; from year to year the water channels would thus grow larger and larger, and although the rivers, as they were depressed, lost much of their force and rapidity, yet continually undermining the banks and transporting the debris downwards, would, through course of ages, form these deep ravines in which many of them now flow.

That the rivers in this section of the country have originated in this manner, is inferred from the fact, that they are found almost universally to flow in flat-bottomed vallies or ravines, the banks of which are the abrupt terminations of the level country on each side; and that these ravines are generally found where the drift is of a light and sandy nature.

The accompanying section across the River Don, taken a little above the Cemetery, will show clearly the first proposition; the second also is established by the well-known character of the soil of which the banks are composed. The surface of the country extends for miles to the right and left of the river without any material change of level, except where broken by a secondary ravine of a tributary stream. Doubtless, then, the inference is correct as far as regards the Don, and that the dotted line stretching from bank to bank on the drawing, was the surface prior to the scooping out of its channel.

Section across the Don abt. 1½ miles from its mouth.

a. The valley of the Don about a ¼ of mile wide, and upwards of 100 feet deep—the river here is on a level with Lake Ontario.

b. A tributary of the Don, running through Yorkville, it is cut obliquely by the section and forms a junction with the Don about ½ a mile further down.

The dotted line is about 120 feet higher than the Lake, and the surface maintains very nearly the same level for a long distance on either side in a direction parallel to the shore, with a gentle slope at right angles to it—on part of this slope the City of Toronto is built.

Nor is the Don singular in these respects; of all the streams I am acquainted with to the east and west of Toronto, the same scooping out of the ravines can be shown, and generally the same sandy character of the country immediately traversed, as indicated by the dark green belts of pine running into the interior of the country through the hardwood forest which flourishes better on the heavier soils. And here, without digressing much from the subject, one can scarcely avoid observing very apparent marks of design—the adapting of the pine to grow on soils unfitted for cultivation, and the leading of rivers through pine-bearing soils, thus enabling the settler to take advantage of the various properties of running water in conveying and preparing the most useful of all timbers for his manifold purposes.

The valley of the Don is from a quarter to half a mile in width, with abruptly rising banks, from 100 to 200 feet and upwards in height, the scooping out of which implies the removal of many hundred millions of cubic yards, a quantity so immeasurably great when brought into comparison with the agent of removal—a stream (when not dammed up) only about 50 feet wide, that it appears altogether irreconcilable with the inference drawn; more especially is it so, when we know that the annual quantity of matter brought down by the Don is at present inconsiderable. If, however, we bear in mind that, without assuming a greater volume of water to have flowed in its channel than now, the transporting power of the Don must formerly have been very much greater by reason of its greater descent and rapidity; and, if it can be shown that many ages have elapsed since it first came into existence, the conclusion come to may be taken as rational and correct.

It may seem difficult—nay, almost impossible—to estimate, however roughly, the time which has elapsed since the Don commenced to flow; but if we can arrive at the age of any other river emptying its water into Lake Ontario from a source equally high, the problem is solved. When the great Lake already mentioned, subsided from its high level, then, and not till then, did the Niagara, the Don, and other cotemporary rivers make their appearance. Since that epoch the Niagara has cut a deep channel for seven miles through the solid rock; its annual recession has been ascertained approximately, and from these data its age has been roughly determined. "We may turn to the deep ravine," says Lyell, "and behold therein a chronometer measuring rudely, yet emphatically, the vast magnitude of the interval

of years which separate the present time from the epoch when the Niagara flowed at a higher level."

Thus, then, the Don, coeval with the Niagara, has flowed, according to this great Geologist, for a period far too great for the imagination to comprehend, and which one can scarcely venture to name by years;* even allowing that our historical knowledge of the present condition of the Falls is far too meagre to estimate with any precision, the rate of their retrogression in former times, we cannot but arrive at the conclusion that the chronological age of the Niagara and consequently of the Don, must be so enormously great, that one would think even its fractional part would suffice for the removal of the hundreds of millions of yards of matter by the latter river to the Lake, without calling to its aid any unusual phenomena.

Having thus shown that sufficient time may be granted, the Don therefore supplies an adequate cause for performing and completing long since the work assigned to it; year after year during its early history, slowly but constantly hollowing out a channel and removing the former contents of its valley to the lake, the lighter and more soluble matter being held for some time by the water, to be distributed far and wide, the heavier particles on the other hand to be deposited near its mouth, in the form of an extensive shoal or delta—the base or ground-work of the Peninsula, on which again to be deposited a drift from other causes and from another source.

Second, That the Peninsula proper has been formed solely by the mechanical action of the waves, that the sand and gravel of which it is composed have been by this action gradually transported from the eastward and deposited on the deltaic shoal of the Don, and that the delta has thus been raised above the surface of the water and extended westward far beyond its original limits.

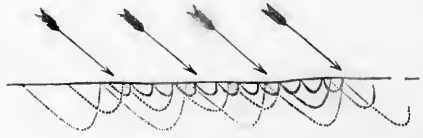
The effects produced by waves on a shore exposed to their action are of various kinds, depending in a great measure on the nature of the beach, the direction of the waves, and their mechanical force: if the shore be of clay the action is entirely destructive, the banks are undermined and continually caving in, the fine argillaceous particles are taken up by the water, carried out and deposited after a time at depths unaffected by the motion at the surface; if the shore be of sand or gravel the effects produced are quite different. When the direction of the waves is not at right angles to the beach a progressive action results, and when the waves break point blank on the shore line with sufficient force the action is destructive, in which case the banks are broken down and the spent wave returns loaded with sand to be deposited outside of the breakers in the form of a shoal generally parallel to the coast; if the soil of which the banks are composed be a mixture of clay and sand the action is both destructive and progressive, the clayey particles are washed out and deposited in still water, while the sand, gravel, and stones are left behind to be moved forward either in one direction or another, and at a rate depending solely on the strength of the impinging waves, and the gravity of the materials themselves. On a rocky shore the effects produced are precisely similar, although of course to a much more limited extent; by continual exposure to the wearing action of water and weather a mass is undermined and tumbles down, a portion of the debris is put in progressive motion during every storm when the waves impinge otherwise than at right angles to the shore line, and is moved, according to the locality, in a certain prevailing direction, until meeting a projecting point or other hindrance to its onward progress; thus forming those shingle beaches seen at many places on all rocky shores.

The effects of the destructive action on banks of clay can be traced wherever the shore is entirely of that material; the owners of property along many parts of Lake Ontario can bear testimony to its annual encroachments; and, to come nearer home, many citizens of Toronto must have witnessed the gradual alteration in the form and recession of the clay banks between the old and new garrisons.

The effects of the progressive action can also be witnessed at many places on all the lakes; but at none in a more remarkable degree than at Toronto, although at other places to even a much greater extent. And since to the peculiar motion of sand and gravel beaches will be attributed not only the extraordinary changes the Peninsula is at present undergoing, but even the greater part of the entire formation, it will be necessary to explain fully the nature of it, and give the reasons why the beach should have a tendency to move in one direction in preference to another.

Let us take an example when the direction of the wind forms an acute angle with the shore, a particle of sand resting on the surface is driven forward up the inclined plane of the beach in the direction in which the wave itself moves, the particle either remains at its now elevated position or (as is more usual) sweeps along in a small curve and rolls downwards with the expended wave to a new position, the distance of which from the first will be in proportion to the mechanical force of the wave and its direction; another and each successive wave drives the particle forward in a similar manner, unless by accident it finds a resting place behind some obstruction or be buried by other particles on the same mission as itself. If we take instead of a grain of sand, a small pebble, we find that the same wave, or a wave having the same force, moves it a less distance than it does the sand; that larger pebbles being heavier make proportionately less progress, and that stones still heavier are moved only when the waves have considerable power. All of these bodies, however, when within the impinging force of the wave and placed in positions fairly exposed to its direct action, seemed to be governed by the same law, and are moved forward a less or greater distance according to their weight and gravity.

Fig. 2.



The arrows denote the direction of the waves; the dotted lines show the paths of grains of sand and pebbles.

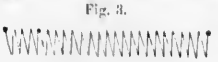
The zig-zag direction taken by the sand and gravel on the beach is indicated by the various dotted lines on Fig. 2, the smallest one is intended to show the course of a grain of sand, and the two largest lines that of pebbles varying in size. The progressive motion is slightly suspended between each wave, but although intermittent is continued so long as the seas break on the shore from the same quarter, and until the moving mass meets with an obstruction, or by reason of a

* "Mr. Bakewell calculated that, in the forty years preceding 1830, the Niagara had been going back at the rate of about a yard annually, but I conceive that one foot per year would be a much more probable conjecture, in which case 35,000 years would have been required for the retreat of the Falls, from the escarpment of Queenston to their present site, if we could assume that the retrograde movement had been uniform throughout. This, however, could not have been the case, as at every step in the process of excavation, the height of precipice, the hardness of the materials at its base, and the quantity of the matter to be removed, must have varied. At some points it may have receded much faster than at present, at others much slower, and it would be scarcely possible to decide whether its average progress has been more or less rapid than now."—*Lyell.*

sudden bend or other peculiarity of the shore line is deposited in a position beyond the influence of the waves.

When the waves impinge at right angles to the shore the progressive motion of the beach is theoretically nothing, the various particles of sand are rolled upwards and downwards, changing position only laterally or in the line of direction of the waves; when the waves impinge somewhat less than a right angle the grains of sand move along in a sharp zig-zag line, as

Fig. 3.



In Fig. 3, when much less than a right angle the particles move onward in a long undulatory line as in Fig. 4. The distance between the points of each indentation being in proportion to the cosine of the angle formed by the direction of the waves and the line of the shore.

Fig. 4.

Granting that the direction of the waves is governed by that of the wind, it follows that whenever the wind blows from a quarter to the right of a perpendicular to the shore, the beach sand is moved to the left, and *vice versa*. If, therefore, the wind blew with equal strength and during equal times from all points of the compass throughout the year, and the waves also had at all times the same mechanical force, the sand would at one time move to the right, and at another time an equal distance to the left; but, to speak in general terms, the beach would remain ever as it was (excepting the effects of the destructive action). Since the forces never could act simultaneously, we would have, it is true, a constant repetition of complicated motions, zig-zag, undulatory, lateral, progressive, and retrograde; but, from their assumed equality and the equal times of their application, there could be no resultant. The mean velocity of the wind may properly enough be taken as equal throughout the year from all points of the compass, since the actual difference, as obtained by observations, will effect the results inappreciably; but the mean force of the waves will not in consequence be equal, as this is greatly influenced by the locality. It is found that the mechanical force of a wave depends chiefly on the strength of the wind and the extent of open water traversed; allowing then that the wind blows equally from all points, it will follow that the resultant of the aggregate forces of the waves impinging at any particular place, will be a line lying in a direction opposite to the largest area of open water.

In applying this conclusion to the beach in front of Toronto we find that the greatest extent of Lake Ontario passed over by winds blowing from any point westward of the perpendicular A B, Fig. 5, does not exceed forty miles, nor is the area of water over twelve hundred square miles, while to the East of A the

Fig. 5.

waves have a fetch of as much as a hundred and eighty miles over an expanse of water measuring nearly nine thousand square miles; hence then (the duration of the action being taken as equal in both cases) the intensity of the collective forces of waves impinging at A from the eastward is many times greater than those from the westward, and the motion of the beach at A must therefore be westerly; it must of course move with a variable velocity because the forces are not constant; its path, or rather the path of each particle, undulatory, since the forces act impulsively on the plane of the beach in combination with gravitation: it must sometimes retrograde since the direction of the forces is ever changing, and they never act simultaneously; but aggregately, the beach sand, subject to many complicated motions, and acted on by innumerable and incalculable forces, must move absolutely from east to west, and (taking the forces on each side of line A B respectively as positive and negative) with a velocity proportionate to their algebraic sum.

On that portion of the beach successively washed by the waves only, can the progressive motion be proved ocularly, yet doubtless a similar action must be produced between the breakers and the main land all along the shore, and when we consider that the lake is seldom or never entirely at rest, that even during perfect calms, unless continued for several days, a gentle ripple capable of moving sand is found on the shore, throughout the whole year, therefore, must the materials composing the beach be continually changing place, and although sometimes moving easterly, yet generally, as proved above, in the contrary direction.

Fig. 6.

The accompanying drawings of natural groynes very strongly confirm the conclusion here come to. They are copied from sketches recently taken (1850) on the spot, between Privat's Hotel and the Scarboro' Heights. Fig. 6 was formed by the falling of a tree opposite a fisherman's hut east of the Narrows on the passing log: the outer end of the tree was supported by its branches: about one half of the log was floating, but kept stationary by the tree; the remaining half rested on the surface, and enabled the sand to accumulate at its easterly side. Figs. 7 and 8 appear also to have been formed in a similar manner. They were found on that part of the shore between Ashbridge's Bay and the Scarboro' Heights. The dotted lines indicate what

Fig. 7.

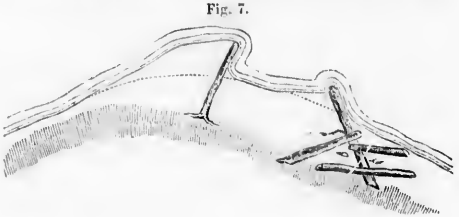
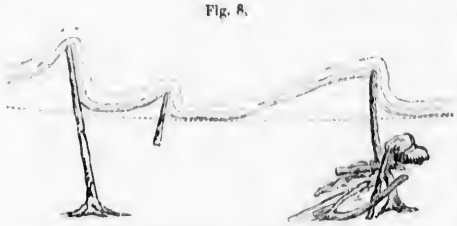


Fig. 8.



Sketches of natural Groynes.

was supposed to be the original water-mark. In all cases, the water was from one to two feet deep on the westerly side of the logs, and in several instances the sand was five or six inches above their upper surface on the easterly side. These groynes, formed by accident, show very clearly the results of the westward motion of the beach, and, although simple in the extreme, are natural models from which may be designed other contrivances for the retention of the moving sand, and will be referred to hereafter in treating of the preservation of the Harbour.

In addition to these indications of the westward motion of the beach, it may be observed that, on an examination of the mouth of several small streams discharging into the lake east of Ashbridge's Bay, it is found that, whatever be their general direction inland, so soon as they intersect the sand beach, their course is westward. In most cases they run parallel to the shore, separated from it by a small ridge of sand, and ultimately discharge into the Lake some distance west from the point where they leave the woods.

We have also palpable and positive proof of the westward motion of the beach in the extension of the Peninsula itself in that direction. Joseph Bouchette, late Surveyor-General of the Province, made a survey of Toronto Harbour in 1796, a reduced plan of which was published in 1815 along with his work on Canada. At the date of the survey, that part of the Peninsula on which the Lighthouse is erected was then the margin of the lake. Since that time, one sand ridge after another has been washed up, until now, after a lapse of only fifty-four years, a tract measuring upwards of thirty acres has been added, and the Lake is now distant from the Lighthouse about eighteen chains.

The general appearance of this recent addition to the Peninsula resembles so closely other older portions, and its geological character is so clearly identical not only with the adjacent parts, but also with the whole formation, that we may very properly infer they are each and all produced by the same causes. Admitting, then—and it is indisputable—that this enlargement of the Lighthouse point is due to the progressive motion of the beach sand through the mechanical agency of the waves from the eastward, we come to the conclusion that the whole Peninsula is the result of the same action, continued through past ages, and traceable to the same eastward source.

Arrived at this conclusion, we are now naturally led to enquire whence has the abundant supply of material for so extensive a deposit been obtained. About five miles east of Toronto, a high bluff, known as the Scarboro' Heights, stretches along the shore for several miles. The bluff is about three hundred feet high, and is chiefly composed of sand, with at intervals a stratum of clay. It is known by the farmers residing in the neighbourhood to recede ten or twelve feet annually at the present day. Farther eastward, the coast has a low aspect, and is of a soil capable of providing but little of the substances of which sand and gravel beaches are composed. Moreover, by contouring the country bordering on this high cliff, it is found that the lines betoken a former great projection lakeward, of which Fig. 9 (see plates) is an ideal outline, and Fig. 10 a sectional sketch on the line K L, at right angles to the shore. For these reasons, then, we are induced to fix upon this point as the locality from whence has been drifted the materials forming the deposit in question.

Founded on demonstrative and probable evidence, here in part set forth, I will now venture to lay before you what I believe to be a correct theory of the gradual formation of that singular deposit which has provided for Toronto so good a harbour.

On the subsidence of Lake Ontario from a high to its present level, the land fell in easy slopes to the water's edge, and the gradual, descending surface lines were continued outward under water; the abrupt terminations of the land along the boundary of the lake having been formed by its encroachments through a long course of ages, the promontories which formerly projected have been rounded off by the destructive influence of the elements. The sand clay of which they consisted, and which lay between the ancient and present margins of the water, having been removed to other parts, the clay carried out and stratified at the bottom of the lake, and the sand formed into new deposits, kindred to the one under discussion.

Referring to Fig. 10, we have an illustration of this as applied to the Scarboro' Heights. K represents the present position of the cliff, and L the supposed former shore of the lake, the point of land extending from K to L, Fig. 9, having been removed by the waves.

Figs. 9, 10, 11, 12, and 13 are sketches of the deposit at several periods prior to and during its formation. The first shows the supposed original outline of the lake immediately after its subsidence, prior to any encroachments or changes of the shore line; the second, a small spit running westerly from the Scarboro' promontory; the third and fourth, farther extensions of this spit, and wearing away of the promontory. At this period (Fig. 12) the River Don has brought down a large quantity of drift fro n its valley, as explained in the first part of this paper, and the lake deposit is now going on over the shoal water. Only a small portion of the spit thrown up at this period now exists, the remainder having been encroached on and moved westerly as the heights at Scarboro' receded. The portion referred to is a narrow ridge running landward to the west of the Don. It may now be seen stretching from near the wind-mill outward, and separating the marsh from the Harbour.

Fig. 13 shows still further encroachments on the land at Scarboro' the almost entire removal of the spit shown by Fig. 12, and the advancement of the Peninsula westward.

Fig. 14 represents the present state of the deposit. The dotted lines are contours, (explained on the plate,) showing the rapid progress of the shoal landward at the western boundary of the Harbour. Its edge between the point of the Peninsula above water, and the mainland, at the Queen's Wharf, may be taken at the ten feet water-line, within which it immediately rises, and gives a depth of about four feet only along the eastern side, and from six to thirty inches along its western boundary.

Figs. 17, 18, 19, and 20 are sections across the Harbour and Peninsula, on the lines G H, E F, C D, and A B, drawn on Fig. 14. These show clearly, without unnecessary explanation, the nature and limits of the deposit. Fig. 20 runs from the foot of George Street southerly, through that point of the narrows proposed for the eastern entrance to the Harbour, hereafter mentioned; Fig. 19 on a line parallel to the first, from the Parliament Buildings southerly; Fig. 18 from near the Queen's Wharf directly across the shoal at the entrance: this, as well as the last, cuts several of the many ridges of sand, with long narrow

ponds between, by which the upper surface of the formation is characterised. Fig. 17 runs from the old French fort parallel to the other sections, intercepting no portion of the deposit, but passing very close to its western limit at the Lighthouse point, in sixty feet water. The depth of water increasing as the deposit was extended westerly, accounts very satisfactorily for its spreading so much towards the north. Although an equal amount of sand may annually have been brought forward, yet, as the deposit was forced out into increasing depths of water, this rate of extension westerly would in proportion be diminished, thus allowing the southerly waves more and more time to act in moving the deposit towards the north.

In the manner above explained, it is argued that the Peninsula has been formed, is still undergoing great changes, and is even now receiving large annual additions from the same source. It seems, too, from what will shortly be laid before you, that the same natural agents which have raised up a breakwater, and formed one of the most capacious harbours on the Lake, are as actively engaged in its destruction, by fencing in, as it were, the whole smooth water basin they have made, and justify the inference that, if left entirely to themselves, will at some future period unite the Peninsula to the mainland west of the Queen's Wharf, in the same manner as it was originally connected by the ridge from near Privat's to the Windmill. This stage of the deposit is illustrated by Fig. 15, at which period the surplus water of the Don would in all probability find egress over the bar by a shallow channel, fluctuating in position as well as depth during every southerly gale, or by such gaps as are occasionally opened in the narrow belt of sand separating Ashbridge's Bay from the main Lake.

The progressive motion of the beach, observable only on close examination, and apparently of little moment, is when continued during incalculable periods of time, thus proved to be productive of very extraordinary results. Nor is it confined to this neighbourhood, for we discover unmistakeable indications of its operations along the shores of all the great inland lakes.

Round Lake Ontario its effects can be traced at Burlington Beach, the mouth of the Niagara River, Presque Isle, Cobourg, Port Hope, Windsor Bay, and at innumerable points along the east and south boundaries of the Lake.

Round Lake Erie we see its results at Sandusky Bay, Point aux Pins, Long Point, Port Colborne, Buffalo, and at Erie.

At Saganaw Bay, Thunder Bay, Riviers aux Sable, north and south, at Nottawasaga, and the Christian Islands, on Lake Huron.

Round Lake Superior we also have many examples of a like kind; at Fond du Lac, a gravel beach resembling in a marked degree, both in appearance and position, the Burlington beach, near Hamilton. At the mouth of the Bad River, and at Point Iroquois, also, are found beach formations.

Many of these closely resemble in outline the Peninsula at Toronto. Some of them are kindred to the hypothetical stage denoted by Fig. 15; all of them are identical in geological character, and exemplify the working of one of Nature's ever active agencies, co-existent and co-extensive with the lakes themselves. One fact which very strongly confirms the theory of the formation of the Peninsula here propounded, is worthy of notice: all the examples above mentioned invariably conform with the rule laid down—the trend of the deposits bearing in a direction opposite to the longest fetch of the waves, or the largest area of open water traversed. The entire absence of boulders is also very remarkable, and whenever gravel forms part of the drift, the largest size is generally found nearest its source, the finest kinds being at the greatest distances. This circumstance is explained by Fig. 2, and the accompanying remarks, which show that small bodies are moved onwards with the greatest facility. Large boulders, in consequence of being unable to resist the mechanical force of the waves, remain at rest, and therefore can form no part of beach formations.

To arrive at a knowledge of those changes more particularly referred to, which have taken place on the shoal at the mouth of the Harbour, I have with permission carefully examined the old maps and charts in the Surveyor-General and Ordnance Departments; many of them are wanting in detail, and in this respect of little service to the inquiry; others are of considerable value, the most reliable of which appear to be the charts of Bouchette, Bayfield, and Bonnycastle, dated respectively, 1796, 1828, and 1835; for although they do not profess to much nicety of detail, yet emanating from these sources we have no reason to doubt their general accuracy. Fig. 2 shows the position of the shoal at the several dates of these charts, and as it now exists; the soundings have reference to its present state. I have much to regret being as yet unsuccessful in procuring a copy of one very old chart, the possession of which would be invaluable, seeing that it is without doubt the earliest record of Toronto Harbour in existence. This chart is said to have been made by a corps of engineers who accompanied the first pioneers from France, nearly 200 years ago. A copy, perhaps the only one on the Continent, was unfortunately destroyed with the Parliament Buildings in Montreal, in 1849; the original is supposed to be deposited in a Jesuit College in Paris.

On comparing the charts of Bouchette, Bayfield, and Bonnycastle, with my own from a recent survey, showing the state of the Peninsula at the present time, we obtain results as follows:—

First, that the channel between ten feet water lines was,

In 1796 about	.....	480 yards wide.
" 1828 "	.....	340 "
" 1835 "	.....	260 "
" 1850 "	.....	120 "

Second, that the quantity of sand deposited at the south side of the entrance by an approximate estimate is as follows:—

From 1796 to 1849-50 nearly 660,000 cubic yards, being in 53 years about 12,400 yards per annum.

From 1828 to 1849 nearly 235,000 cubic yards, being in 21 years about 11,200 yards per annum.

From 1835 to 1849 nearly 155,000 cubic yards, being in 14 years about 11,000 yards per annum.

The alarming progress of the shoal landward is from these figures very apparent. Fifty-three years ago the entrance is shown to have been four times its present width, and fourteen years ago more than double, thus decreasing at the rate of from seven to ten yards annually, by the deposit of about 11,000 cubic yards.

If such be the case, and it is founded on the most authentic information relative to the past condition of the Harbour as yet in our possession, we have substantial reasons for believing that if left unheeded it will in ten or twelve years be innecessible except to the smallest craft.

The extension of the shoal may be attributed to the same causes which are proved to have formed the whole Peninsula. The beach sand having reached the Lighthouse point cannot by reason of the great depth of water, as shown by the contour lines, Fig. 14, make much progress in extending the Peninsula from thence westerly; there is therefore nothing or at least not much to prevent the southerly waves from acting in full play, they having a fetch of forty miles in opposition to the northerly immediately off the land, and washing along the bar (scarcely under water) towards the north "dump," as it were periodically, large quantities of sand into the channel.

Certain outward and inward currents occasionally exist at the entrance, caused probably by gales slightly varying the level of portions of the lake, or, as it is also supposed, by local variations of the atmospheric pressure on its surface; these may assist to a limited extent in prolonging the existence of the channel, but from all the observations I have as yet been able to make, they appear to be surface currents only, having little or no appreciable effect five or six feet under water: even this supposition therefore is very problematical.

ITS PRESERVATION.

Having by sufficient evidence set forth the probability if not the certainty of an early destruction of the Harbour by the damming up of its entrance, we may now proceed to the practical, and so far as the commercial interests of Toronto are concerned, the vitally important part of the inquiry, and endeavour to obtain a satisfactory answer to the query—How can such a catastrophe be obviated or indefinitely postponed? A problem which becomes of comparative easy solution when the immediate cause of the evil is set beyond a doubt, and the nature of its operations clearly ascertained.

To keep those Harbour channels subject to obstruction from moving sand-bars in a navigable condition, three expedients are generally resorted to: First, continuous or periodical dredging; second, the application of a scour to remove the bar as it is formed; third, the construction of such works as are calculated to prevent the deposition of the sand in the channels, by retaining it at a distance, when its source is known, or by diverting it to those points where depth of water is not essentially necessary.

The first is often applied as a temporary remedy, and as such may at times be viewed as a fit expedient, but to employ it as the lasting counteracter of a constantly increasing evil, is to adopt an indubitable source of unceasing attention and endless outlay; it should accordingly be dreaded as a permanent restorative, and employed only by compulsion from unusual difficulty in the application of other measures that are generally less costly and always more satisfactory.

The second is obtained at *marine* ports by taking advantage of the tidal fluctuations, and is generally produced twice each day by using the currents of rivers at low tide, or by holding up the sea water in large artificial basins at flood, then concentrating and guiding it to the bar at ebb. The impracticability of procuring a scour on Lake Ontario from tidal fluctuations must be admitted, since practically there are none; true it is we have a gradual rise and fall of about two feet annually, and at times successive oscillations in level to the extent of several inches, much resembling small tidal waves; but the latter although they give to the surface water at the entrance of the Harbour a perceptible current, are too rare and too feeble to be of any real value. Nor have we at Toronto a river sufficient for the service; for the Don has hitherto failed to keep open its own channel to a greater depth than two or three feet. Indeed I feel quite convinced that all attempts on these inland waters to keep permanently open those harbour channels much exposed to beach drifts by other than the largest class of rivers must sooner or later prove ineffectual. The currents of the Nottawasaga, of the Sable, and of the Saugeen, are unable to keep open to a sufficient depth or width the mouths of those rivers, and yet they are in volume from ten to twenty times greater than the Don.

The third remedy can always be advantageously employed in cases when the obstructions are the natural results of moving beaches, and when the works are located and executed with proper care they usually answer a good purpose; the second is often after great outlay under favourable circumstances of doubtful efficacy. In the case of Toronto, even if we had at command a current capable of removing the sand on its arrival at the point of the shoal, I question very much if it should be considered as more than an auxiliary, since it would of necessity tend to spread the deposit, and thus, although injuring the channel in a less degree, would impair the Harbour generally by lessening in depth the approach to it. Without doubt the steps likely to confer the greatest security, and hence the most advisable to be taken, are those which are calculated to keep the drift at a distance from that point where it is not wanted.

I therefore beg leave to submit for your consideration the following preventive and remedial measures:—

1st. That a Groyne should be constructed at the Lighthouse point from the shore outward to 8 or 9 feet water for the retention of the moving sand, on the principle of those very simple natural ones shown by Figs. 6, 7, and 8.

2nd. That an auxiliary Groyne be run westerly across the outer edge of the shallows, a little to the south of Gibralter point.

3rd. That a Pier or breakwater be built along the south side of the channel as shown on Fig. 21, increasing the navigable water to six hundred feet, by cutting off the point of the shoal north of the proposed line of pier.

The third alone would probably suffice for many years to keep the channel perfectly free from deposit; but the sand, if not retained at the Lighthouse point, would as at present be moved northward by the southerly waves, and would gradually accumulate to such an extent as to fill up the whole space along the south side of the pier until ultimately rounding its extremities. To effectually prevent this the first and second should also be constructed, the first would divert the drift westerly into deep water, where the navigation could never practically be obstructed; and the second groyne placed about midway between the first and third would have the effect of counteracting all progressive action along the west end of the Peninsula.

If the destruction of the Harbour entrance, and the formation of the Peninsula generally, be satisfactorily determined, I think it is equally conclusive that these works, or works of the same character, would, if established in due time, be exercised to a very beneficial result—the preservation of the Harbour for an indefinitely long period.

There are other evils, which, if they affect the salubrity of the city more immediately than they prove detrimental to the Harbour, are not on that account of the less consequence. The Don annually transports even at this day considerable quantities of silt from the interior of the country to the Marsh, and, during freshets, a portion escapes from thence into the Harbour through the openings in the beach between the Wind-mill and Privat's, tending of course, where deposited in the basin, to lessen its depth. All the drains and sewers empty into the bay, making it, in truth, the grand cess-pool for a population of probably 30,000 inhabitants, with their horses and cattle. The sewers of necessity bring down no inconsiderable portion of solid matter, impairing greatly the purity of the water in the Harbour, as well as gradually lessening its depth. This evil, increasing in a proportionate ratio to the growth of the city, might be greatly ameliorated, if not almost totally removed, by the construction of a main sewer along the whole city front eastward to the Marsh. Into this sewer all the lateral ones from the north, and the drainage of gas, chemical and other such like works should be made to discharge. The feculent mixtures produced would thus be collected and conveyed to a distant point, where, by similar operations to those now ripening in Britain, which will strip them not only of their noxious, but even of their offensive characters, might be profitably converted into a marketable commodity of the highest value to the farmer.

The prejudicial effect of the Don on the depth of the Harbour may also be destroyed by closing its present outlet, and forming an opening of sufficient capacity in the beach separating the main Lake from Ashbridge's Bay.

All proposed works relative to the improvement of the Harbour should be carefully considered before any be proceeded with, lest some of them may interfere with preservative measures, or the general improvement of the whole. It may not be out of place, therefore, to consider briefly another proposition, which, for many years past, has engaged public attention perhaps more than any other in connexion with the Harbour, viz., the forming of an eastern entrance.

Judging from the following paragraph extracted from the *Courier* newspaper, dated 5th March 1835, the project was seriously talked of fifteen years ago:

"CUT ACROSS THE PENINSULA.—A respectable meeting of the friends to this measure was held on Thursday evening at the Commercial Hotel, when a Select Committee was appointed to request the Governor to name an Engineer, and also to request the Mayor and Corporation to name another, to meet him for the purpose of reporting on the probable result of the cut. The Committee waited on his Excellency this morning, who very readily named Captain Bonnycastle, at the same time expressing a hope that a measure so adapted to promote the health of the city would be carried into effect. His Excellency also promised to do all in his power to put the entire Marsh at the disposal of a company, with a view to its being reclaimed as far as it is possible to do so. There is every reason to expect that the Corporation will take the same view of the case; and if the report of the Engineers shall be favourable, a number of wealthy merchants and others in the city have expressed their intention to take up a sufficient quantity of stock to complete the undertaking."

A few months thereafter the following was gazetted amongst the Notices of Public Improvement:—

"TAKE NOTICE.—The Inhabitants of the City of Toronto will make application to the next session of the Provincial Parliament to incorporate them into a company for the purpose of opening a Ship Navigation through the neck of the Peninsula between the Lake and the Bay of Toronto.

"Toronto, August 1st, 1835."

It is unnecessary to say that the contemplated improvement has not been carried out. The spirits of the projectors were probably dampened, and their stock-book laid aside, after the opinions of the engineers appointed to examine were made public. I have only been able to obtain the perusal of one of these documents, but am informed that the report of the gentleman appointed by the Corporation was even less favourable.

Captain Bonnycastle says, relative to cutting a navigable canal through the Peninsula:—

"If this should be done without due consideration, the barrier which nature has interposed for the preservation of a Harbour formed probably by the cutting action of the Don when it was a larger river, which it only requires to look at its banks to convince one's self that it anciently was, will be thrown down, and the Harbour entirely destroyed.

"The reasons to be assigned for this opinion are as follows:—

"The southern face the of Peninsula, a low ridge of sand, is bordered to some distance out, excepting near the Narrows, by large and fluctuating shoals, well known to the fishermen, who have so recently established a profitable trade on them.

"The force of the easterly and westerly gales on these shoals and the bounding shore is tremendous, as every person in Toronto has frequent opportunities of hearing, even at the great distance which the city is from them.

"Should a navigable canal, without due restrictions, be cut through the slender belt which divides the waters of the Lake from the basin, all the millions of tons of large shingle, small rounded and angular fragments of granite and other hard rocks which line the beach will be put in motion!—will break down by their erosive power any barrier opposed to them!—will carry before them the whole extent of the Narrows, and perhaps penetrate through the ponds, fill the basin, and convert it into a fresh sand bank." This he goes on to show might be produced by a current through the canal, and further states, "It might in fact tear away all the strip of beach along the western or bay shore of the great Marsh, and let the whole of that body of the mud of ages into the basin.

"It is argued that all this may be avoided by running out extensive piers into the Lake, and forming a strong embankment along the Ontario face of the Narrows. These, if placed in such situations as to break off the strength of the easterly or westerly swells, will do much towards it, but it will be also necessary to make the canal of stone, to puddle its sides to a considerable thickness or extent, to make it narrow, and to place gates both at its entrance and exit.

"With these precautions there can be no harm in trying the experiment."

Although entirely concurring with Captain Bonnycastle in the expediency of closing up the present outlets of the Don, and of conveying the whole sewage of the city to the Marsh; yet having already, with all due respect, expressed my reasons for differing from the view he takes of the formation of the Harbour, and since conclusions on this point affect directly and very materially the consideration of all works of improvement immediately connected with the Peninsula, I may also be permitted to entertain opinions not altogether coinciding with his as to the probable effects of the proposed south-eastern entrance, and its mode of construction.

Knowing the nature of the action of the beach at the proposed site of the canal, and I think it is established beyond a doubt, there can be no possible danger of any part of the Peninsula being torn away, or the basin within being filled up with sand, if proper steps be taken to counteract such action. This action is chiefly the progressive motion of the beach, which would effectually be suspended for many years by the piers of the canal themselves, constructed with crib work in the ordinary manner. The canal need neither be narrow, as suggested, nor provided with gates, since the former would increase the danger in entering, while the latter would add to the cost and inconvenience, and no benefit could result from either.

Fig. 22 shows the proposed position of the canal. Its extreme length from 13 feet water in the Bay to 17 feet in the Lake, is 1600 feet, with a width of 300 feet. The eastern pier presenting an obstruction to the motion of the beach westward, would, acting as a groyne, retain it permanently at its eastern side; the western pier, on the other hand, would be exercised to a similar result in suspending the retrograde motion. The sand gradually accumulating in the space north of the lines A B and D C would thus strengthen the Peninsula at its weakest point, and remove any danger which may be feared from the destruction of the narrow separating ridge between the Lake and the Harbour. The entire destruction of the Isthmus, although hypothetical, is nevertheless a contingency advisable to guard against. Openings have repeatedly been forced through the ridge bounding Ashbridge's Bay by gales' point blank on the beach: these, having a destructive action only, might produce a similar result here. If at the same period the base of the Scarboro' Heights became partially protected from the fury of the waves by the lodgment of an unusual number of trees, or the falling of boulders from the cliffs above, the supply of sand from the east would for a time be diminished, the gap would remain open, and liable to be widened by every southerly wind. The Peninsula would thus be converted into an island, resembling its kindred formation "Long Point" on Lake Erie.

Through course of time (roughly estimated at about 20 years) the sand accumulating east of the canal would reach the line A B and ultimately round the piers. Then it would be necessary to make another provision for its retention. A groyne on the line G F would effect this object, and retain the sand for another period, until it reached as far as the line E F. The canal might thus be kept open by repeating the construction of groynes like E F and H K, *ad infinitum*, from time to time as necessity required; or the same purpose may be affected by simply extending the eastern pier as the sand accumulated outward along its eastern side.

The canal, having thus the effect of widening the Isthmus and removing all probability of its destruction, would, besides being a great accommodation to sailing craft in adverse winds, and to *steam vessels at all times*, likely enough prove of service in another respect. The purity of the water in the Bay is ever liable to be impaired by the vessels in dock, and its close proximity to the city. The canal would provide an additional opening for the ingress and egress of the slight tidal wave formerly referred to, doubtless presenting greater facilities for the renewal of the water in the harbour on its occasional fluctuations in level.

From certain simple and well-established premises it has been my purpose to draw reasonable conclusions, which in recapitulation may briefly be stated as follows:—

First, That the foundation of the Peninsula enclosing the harbour may be attributed in its early stages to the debris of the country traversed by the Don, in conjunction with a drift from an ancient promontory at Scarboro'.

Second, That the drift from Scarboro' has supplied and gradually deposited the main part if not the whole of the materials composing the more recent portions of the formation.

Third, That the drift is in consequence of the singular progressive action given to sand and gravel beaches under certain circumstances by the waves.

Fourth, That the harbour is daily being impaired by its chief agent of formation, and that its only entrance is threatened with early destruction by the same cause.

Fifth, That its preservation may be permanently effected by the construction of groynes at well selected points.

Sixth, That the dangers to be feared from the silt of the Don and sewage of the city although remote, would, taken in conjunction with the increasing deleterious effects of the latter on the water of the harbour warrant their total exclusion.

Seventh, That the construction of a south-eastern entrance would be a great accommodation to the shipping, may improve the purity of the Bay water, and, if properly executed, have no effect in lessening its depth; but would only assist in the preservation of the harbour so far as its piers, acting as groynes might retard the sand, widen the narrows, and thus strengthen the weak point of the Peninsula.

Although the preventive and remedial measures are founded on what I believe to be correct deductions, yet, seeing that they differ materially from those advanced by others who have considered the subject, they are presented on that account with some degree of timidity. I purpose, however, with the view of either confirming or modifying the conclusions arrived at, to continue a series of observations, carefully noting the various changes going on: and will if deemed worthy, take much pleasure in laying the results of such observations before the Institute at a future time.

By the perusal of that paper, it will be found to be chiefly founded on a very laborious and expensive survey made between August, 1849, and the spring of 1850. Without such a survey, I am inclined to think any opinions on the subject would be too speculative to be of much practical value, and I may therefore claim that in this competition due consideration be given to my previous labors, of which this Report may be considered as the result.

All the leading characteristics of the peninsula were laid down by careful triangulations—the shoals lakeward by soundings and angular intersections, and the nature of the bed of the basin ascertained by boring and soundings through the ice, and chaining on its surface; these soundings amount to between two and three thousand, and are reduced to an approximate mean level of Lake Ontario, ascertained in conjunction with Captain Lefroy, from a series of lake levels taken by his directions during several years. The chart made from this survey is a necessary accompaniment of this Report, and I shall be happy to submit it any time for your inspection; but since I have yet hopes of refunding myself (by its publication) for the cost of its production, you will be pleased for the present, therefore, to consider the copyright secured to me.

The results deduced from the evidence set forth in the paper referred to were so startling, that on the occasion when I had the honor of laying it before the Institute, I determined to lose no opportunities of verifying or contradicting them. The promise then made I have not failed to make good, having from time to time instrumentally observed the various natural changes in progress: and since those observations were made with the greatest care, and appear to be of considerable value, I am gratified by the opportunity now afforded me of laying them before you. Being led to believe that my views on this subject are at variance with the acknowledged opinions of parties officially connected with the harbour, I have been especially careful to review the grounds of my decisions, and have discovered no reason for departing from the opinions originally expressed by me in the paper referred to, but on the contrary have been strengthened in them by subsequent and very recent investigations. I therefore frankly submit to you my convictions, taking leave to remark, that they are based on well ascertained facts, capable of positive proof, and not at all on any of the many prevailing rumors and baseless suppositions which are current amongst us in relation to this harbor formation and its present state.

It may be laid down as an axiom that a right understanding of the causes of the formation of the Harbour and of the continual changes it is undergoing, is essential to the consideration of any preservative measures. The document attached enters so fully into this part of the question that it appears to me unnecessary to enlarge thereon, more especially since four years additional observation very materially strengthen and go far to confirm the opinions therein promulgated. I will first, then, explain the nature and results of the instrumental observations recently made.

My attention has lately been more particularly bestowed on the subaqueous operations at the Entrance, not that they are here most active, but because they are least conspicuous and most to be dreaded. To ensure accuracy the following steps were taken:

The approximate mean level was referred to a permanent stone benchmark, the stone step of one of the cellar doors of the Custom House, under which it was found to be six feet and one inch. The mean being only approximate and subject to after corrections, six feet under this benchmark was assumed as a good datum, and to which all soundings were reduced. Scales were established at various points with zeros corresponding in level.

A floating chain 462 feet in length, made of long wooden rods linked together with iron rings, was constructed for measuring with the greatest possible accuracy horizontal distances on the surface of the water.

An iron triped was erected on the shoal as a fixed point from whence to stretch the chain and measure distances.

A graduated standard sounding pole was used for measuring depths.

A self acting tide guage was constructed for the purpose of giving a continuous register of every fluctuation in level, and affording a means of arriving at the extent, nature, and precise number of fluctuations, of which so little is known, and on which phenomena so much value is placed by many as being the cause of currents in your Harbour. I regret to state, however, that I have as yet been unable to apply this instrument to its purpose, for being unrecognized and unassisted in this service, I could find no position in which to establish it, nor have my means justified me in incurring the necessary attendances for observation during my own absence from the city.

Thus provided (omitting the last mentioned instrument) I commenced my second survey on the 27th November, 1850, and was to a certain extent very successful, but during the night some evil-disposed person unknown, removed the iron tripod stationed on the shoal leaving, to my regret, the survey only partially finished, and thus vexatiously disheartened I had on after occasions to adopt other, though perhaps not much less accurate measures.

Two theodolites were placed at stations as far apart as possible on the Queen's Wharf, their distance being carefully measured, and the points where soundings were made ascertained by a proper code of signals and angular intersections. The soundings were in three cases likewise made by the standard rod, and all were carefully reduced to the same datum, the assumed approximate mean level.

In this manner surveys were again made on the 27th November, 1851, the 12th December, 1853, and the 25th April, 1854, each of which are delineated on the accompanying diagram. The soundings and contour lines of each survey are shown respectively in different columns as follows:—

The survey of the 27th November, 1850, in *Red*.
" 27th " 1851, " *Blue*.
" 12th December, 1853, " *Black*.
" 20th April, 1854. " *Yellow*.

An examination thereof will show very clearly the progressive advancement of the shoal northward, attributable to the same causes and formed in the same manner as already explained in the paper referred to. The diagram shows the minimum width of the channel between ten feet water lines to be as follows at the several dates:—

1st October, 1849,	108 yards.
27th November, 1850,	100 "
27th November, 1851,	90 "
12th December, 1853,	77 "
20th April, 1854,	73 "

As the north ten feet water line of the channel is 13 yards south of the Queen's Wharf, in taking the width of the entrance from the edge of the Wharf 13 yards must be added to each of the distances. Although these figures are not a fair criterion to judge of the rate of advancement of the shoal, seeing that the precise position of the annual deposit is not always in the line of the minimum width of channel; yet these and the diagram prove very positively the progressive encroachment, and show an average narrowing of the channel of about eight yards annually, thus establishing the truth of the deductions based upon my previous survey as stated in the accompanying paper and illustrated by a model of the entrance deposited in the museum of the Canadian Institute.

With these measurements taken with the utmost care, and with others similarly taken at the Isthmus, we are now in a position to answer in very positive terms those questions most particularly referred to in the notice you have issued.

These propositions are as follows: "The effects which have been produced, or are likely to be produced by the present breach at the eastern extremity of the Bay of Toronto, particularly with reference to the bar at the entrance to the Bay. If prejudicial to the Harbour, suggest the best means of closing it, and of strengthening that part of the Peninsula against further encroachments by the waters of the Lake."

First, that the breach has had no appreciable effect on the bar, for during the period when it was open, the bar has been enlarged in precisely the same manner, through the same causes, and at a similar rate to that in which its formation proceeded when no breach existed.

Second. Reasoning by analogy from the above, the breach (if again opened) will not likely produce any appreciable effect, beneficial or otherwise on the bar.

Third. The effects produced on the harbor generally by the breach amount only to an unimportant change in the contour lines under 15 feet water in its immediate vicinity, and there only; which change, when viewed in relation to the harbor as a whole, cannot be considered of any moment whatever. Whilst however it has hitherto been prejudicial to an almost inappreciable extent, and although now completely closed by the westward progressive motion of the beach, it is undoubtedly subject to be opened again by the same causes which formerly produced it, viz.: the destructive action of storms point blank on the shore, and may, by a continuance thereof be dangerously enlarged. It is therefore desirable that a recurrence of this breach should be guarded against, and I proceed to submit how in my opinion this may be effected.

To strengthen this part of the Peninsula two methods present themselves: 1st. The construction of groynes. 2d. The construction of a canal or eastern entrance. Two properly constructed groynes, established on the lines marked in red on Plan No. 2, would effectually and permanently strengthen and protect this part of the peninsula by retarding the progressive motion of the beach, and thus arresting the moving sand and gravel, an accumulation would gradually be formed on the outer shore calculated to prevent further encroachments of the lake.

The construction of a Canal at the Isthmus is a proposition on which, along with the beach, there has been great diversity of opinion, as will be seen from the following extracts from reports on the subject recently published.

Mr. Shanley says, 28th January, 1853:—"The very great advantage to be derived from having an eastern entrance to the lake will probably keep this subject so constantly before the public, that the experiment will ere long be tried, more especially as the breach which has lately occurred would seem to have taken the initiative in the matter and 'pointed out the way.'

"The making of such a channel will be a simple matter of *cost*, and, once made, a short time will serve to show whether the advantages accruing from it will be sufficient to counterbalance the expense of maintaining it. I have termed it an experiment, and

such I believe it to be in the widest acceptation of the term—being doubtful that the problem of what its effects upon the harbor will be can be satisfactorily solved beforehand. It may prove immensely detrimental to the bay in drifting in vast quantities of silt and shingle; or it may simply fail to accomplish the end intended by working out its own destruction by silting up more rapidly than the dredge could free it. None I think will deny that one or other of these results is amongst the possible contingencies waiting on the experiment in question; and though I have not given the matter the attention necessary to enable me to pronounce confidently on the above points, I must record my opinion that the new channel would not be a self-sustaining one, and that its effect upon the present entrance would be the reverse of beneficial."

Mr. Kivas Tully says, 10th February, 1853:—"I would now direct attention to the eastern entrance, which has been lately formed, and which I venture to predict will not be closed again." And, further, he says: "The breach which has been made lately at that portion of the peninsula called the Narrows, about half a mile east of Privat's tavern, shews the practicability of constructing an eastern entrance, and it is not likely that this new channel will ever be filled up from natural causes. I examined this channel on the 8th inst. It is about fifty yards wide and three feet in depth, with a current of about two miles an hour running through it in a south-easterly direction. The wind blowing strong at the time from the S.S.W., the current was quite sufficient to keep the channel clear of the sand which was washing into the entrance with the return of the waves, which were pretty high at the time. At all times there will be a current through this channel either into or out of the harbor. During the prevalence of an easterly gale the current will be inwards at the eastern and outwards at the western entrance; and during a westerly gale this action will be reversed, and the velocity of these currents will be sufficient to keep both entrances open."

Captain Richardson says, January, 1854:—"The boundaries of the harbor being of sand, unless known physical laws be suspended for the benefit of Toronto harbor, *a current through it will accelerate its ruin*." "I will here simply state my opinion on the effect that a canal 200 feet wide and twelve feet deep at the Narrows would have upon the harbor: During a strong S. W. wind it would cause such a current over the bar and along the south side of it (judging from the effects as now seen at the breach) as not only to deluge the harbor with sand, but in a short time to sweep away block-house point and all the inequalities of the north side of the peninsula, and convert the harbor into a wide-mouthed bay, at the expense of the east end of it first. With the peninsula intact all gales are favorable to the channel and maintainance of the bar. During a breach in the peninsula all high winds are more or less destructive to the harbor." "The present breach by the lake at the Narrows is similar to the warning shock of an earthquake before volcanic eruption—it forbodes coming events—and an irruption of sand into the harbor, during some extraordinary gale, may be found as destructive to it as an irruption of lava to vineyards and villages."

I am inclined to agree with Mr. Stanley, in considering the effects of an eastern entrance somewhat problematical, whilst I am induced to believe that both the opinions above quoted are based on very insufficient grounds, as on the one hand the breach has been already closed without artificial aid, and on the other its effects have not fulfilled the predictions. As a proof also that by far too much stress has been placed on the effects of lake currents, the breach is now filled to such an extent with sand, that without a previous knowledge of its position one could hardly tell where it had existed.

That currents exist at the present entrance there is no doubt, and whether attributable to the wind or other natural causes, these currents are doubtless due to occasional differences of level between the waters in the bay and the open lake. If a particular wind exerts a force sufficient to elevate the lake in the vicinity of Toronto a certain number of inches, that rise must of necessity be communicated to the bay through the entrance, and hence a current of a certain velocity; and this operation would be reversed on the falling of the water in the lake by a change or fall of the wind. If, therefore, the harbor be provided with two entrances, and if we assume, for the sake of argument, that the sectional area of the second entrance be equal to the first, the current in this case will be equally divided, and its effects, whatever they may be, diminished one-half, and so in proportion to the relative sectional area of the entrances. Thus, then, the effects of currents at the western will be diminished in proportion to the width and depth of the proposed canal at the Isthmus.

We now arrive at the question: *What are those effects?* The undoubted tendency of currents in a channel such as the entrance to Toronto Harbour, is to increase its width and depth: it does not follow that currents in this case have no such tendency, because neither width nor depth have been increased, since they may have been exerted in counteracting other causes as powerful as themselves; but I think it will clearly follow that the currents have no effect, or at least no effect of real or practical value, if it can be shown that the channel has been narrowed in width nearly at an equal rate during equal or proportionate times; for it must be observed that the currents would necessarily increase in velocity, and hence in their scouring effects, the more the opening through which they passed was contracted. Since the end of last century up to 1849, the average rate of the encroachment of the shoal is shewn to have been from 7 to 10 yards per annum; since then, during 4½ years, it has advanced 35 yards, giving an average rate per annum of 8 yards; and during the last four months, it has advanced at the rate of nearly 12 yards per annum. Thus, then, while the width of the entrance has been diminished, the annual rate of the encroachment of the shoal has actually increased, and the deposit moreover has generally occurred at that point where the current (if it had any effect) would have been the most active. Hence no other conclusion can be come to, than, that there are *no undercurrents* in the channel, or if there are, they have proved to be of no practical value. The fear, therefore, of destroying or diminishing the effects of currents at the western entrance by the construction of a Canal at the isthmus may be entirely laid aside, seeing that there are none.

We have now to consider whether or not the proposed canal would be self-sustaining; and, in this respect, I am still of opinion that it would not. To place its outer entrance beyond the influence of the beach action, it would be requisite to extend the piers into deep water, as shewn on the plan; through course of time, the progressive action being totally arrested, an accumulation would gradually form, more especially on the eastern side of the canal until reaching the extremity of the piers, ultimately rounding

them to the detriment of the artificial channel; to prevent which contingency the formation of additional groynes from time to time would be necessary: the construction of which although not involving much outlay would always be chargeable to the revenue of the canal.

I accordingly conclude that in relation to the present Harbour entrance the construction of the canal would be neither beneficial nor detrimental, and that if the preservation of the Bay be alone desired that object can more cheaply and quite as effectually be attained by the much more economical expedient of the Groynes on the Lake beach. These Groynes would probably cost £750 or £1000, whilst the canal could not be constructed for less than £45,000, and inasmuch as the latter may not be considered an engineering necessity, it may be simply viewed in its commercial aspects. Whether the convenience be desirable for the eastern trade of the Port, and if desirable but not being actually necessary, whether the work would be remmnerative. Upon this latter point I entertain strong doubts, yet it is sufficient for me in the performance of my present duty to express my opinions only on the engineering question, leaving the better qualified body whom I am addressing to determine that of the commercial convenience. There exists no engineering necessity for the canal and its construction would result in no advantage beyond that due to increased facility of communication between this Port and the eastern portions of Lake Ontario.

I now proceed to reply to the next question submitted, viz.: "The advisability, or otherwise of enlarging the opening between the Harbour and Ashbridge's Bay, or of making a permanent opening into the Lake from Ashbridge's Bay." In doing so I shall consider it first in regard to engineering, and secondly in reference to commercial purposes.

Ashbridge's Bay as commonly known comprises an area of about 800 acres, triangular in form with the apex eastw rd, half of which area may with sufficient accuracy for our present intention be taken as marsh land, the other moiety water of very various depths. It is divided from the Bay of Toronto by a narrow belting of sand and gravel beach, through which two channels have been formed by the waters of the Don delivered into the main bay. Lakeward it is protected and separated from the main Lake by a long narrow sand beach precisely similar in formation to the neck of the Peninsula, and through which the Lake storms make repeated breaches. To construct proper works of protection to a beach so exposed and so treacherous, and to excavate so large an area of marsh would be a work of such immense cost, as not to be justified except by the most stringent and positive necessity, and under the warranty of certain and indisputable advantages.

It has been argued that by increasing the body of water within the Bay of Toronto, *thus extended*, a strengthened scour at the entrances would result sufficient to ensure their maintenance through all time. I have already I trust satisfactorily proved that no scour results from the present currents which indeed are entirely superficial, and I think it is undeniable that those currents are mainly created by fluctuations in the Lake levels, traceable to variations in the wind and possibly to some more remote and unappreciable agencies. Now the maximum variation in the Bay water levels hitherto observed, even on extraordinary occasions during any 24 hours (and it is clear that to extend the time would be to diminish the effect) may be taken at five inches, and would give 800,000 cubic yards of water in the whole Bay due to the rise and effective for scour, but the discharge of this quantity as has been shewn has never retarded the formation of the bar. Excavate Ashbridge's Bay, combine it with the present Harbour, and we should obtain at times of similar variations of level 530,000 cubic yards of water additional, or an increase of 66 per cent. on the quantity of water now occasionally flowing through the channel. And this addition can only effect the duration of the current, not its velocity, since the vertical column of water is not increased thereby, and hence also the velocity is not. Moreover, I am inclined to think we have taken much too favorable a view of the question, in assuming a rise of five inches, I have done so in the absence of more correct knowledge regarding phenomena of which so little, indeed I may say nothing authentic of value is known (for this purpose the self-acting tide gauge referred to was intended). Although in possession of daily and occasionally more frequent observations reduced to a common datum, the information conveyed thereby is quite insufficient on which to venture an assertion, yet from the evidence before me I doubt much if the daily fluctuations exceed one-fourth the amount above stated throughout the year. It is not reasonable in view of the utter insufficiency of the present currents to anticipate that this addition in duration only would yield an effective scour, and accordingly I conclude, that with such an object the combination of Ashbridge's with the Toronto Bay would be valueless.

Again, it has been suggested that by such a combination, together with an opening or canal to the extreme eastward, a constant current would be insured through the entire Bay, and thus the channel kept open by efficient scour. Such an opinion would seem to be based on erroneous observation. The currents still always due and identical with the variations of Lake levels, would still be superficial, and so long as those variations continue to be (and they always will be) unimportant in amount and gradual both in regard to volume and time—so long I believe will all efforts fail to secure an efficient scour.

I do not, therefore, think it necessary or expedient in an engineering view to effect this combination, or to unite these Bays even by the enlargement of the present channel. If the present breach of the Toronto Bay be such as to require protective works, how much more would they be necessary where the existing beach of Ashbridge's Bay is weak and treacherous, and extended in a tenfold degree. And, moreover, if a channel only were constructed imminent danger would result from the contact of so large an area of swamped land, unless the channel were in fact constructed throughout the length of the marsh as a canal. It might be expedient to direct the water of the Don permanently into Ashbridge's Bay, not indeed that the deposit from that river is so extensive as to be much feared, for the chart shows that the deposition is of slow growth and far less than is popularly imagined, but that as those waters are of no value to the main harbour and might be made an effective conduit for the sewage of the City, the diversion would with such an object be conducive to the health of the City whilst not in a degree detrimental to its harbour.

If then I am correct in asserting that no advantage would result in engineering point of view by the opening of Ashbridge's Bay, it only remains to be considered whether when regarded commercially it is a desirable work, and I confess that when contemplating the extent of the present Harbour, and the construction of the

Esplanade by which shipping accommodation may so largely be extended, I can discover no necessity by which to justify so costly and I fear so doubtful if not dangerous an experiment.

Having thus expressed my opinion on all the points submitted in your advertisement, I shall now take leave to direct your attention to another, and in my opinion, the most important of all the questions relating to the efficient preservation of this Harbour. Until a comparatively recent period the formation to which this Bay is due was entirely consistent with the most admirable provisions of Harbour capacity, shelter, anchorage, and the conveniences of navigation. Up to such a period (and it is demonstrated by the charts) Nature was engaged in work eminently useful, and in a manner most fortunate and unimpeachable: nor did our predecessors fail to discover how excellent a haven had been formed, as to its inducements may be traced the selection of the site for the city, just as surely as to its influence may be attributed the rapid growth and great prosperity of this metropolis. At that time, and it may be taken as A.D. 1800, Nature began to destroy that which she had herself so well completed, and recently by such palpable encroachments on the Entrance to the Bay as naturally to induce alarm lest its commercial value might be endangered.

I have already shewn how regularly and constantly this encroachment has been proceeding, how year after year the channel has been decreasing in width and the shoal extending, and I have endeavoured to trace the source and causes to which these dangerous accumulations are to be attributed, showing, I trust satisfactorily that the same agencies are engaged to this day in the same work of injury.

And yet it is strange that with the exception of the construction of the Queen's Wharf in 1835, and its extension in 1853, works in my opinion entirely inconsistent with, and as the event has proved entirely inadequate to the object sought, no effort has been directed to the preservation of the present Harbour channel, but public attention has been attracted by speculative and ambitious attempts to alter where alteration is unnecessary and dangerous, and to improve that which Nature has left perfect to our hands; neglecting meanwhile the one and only point in which her operations may be regretted and where interference is justified by danger. It is to this point that I shall now address myself, convinced that if this be neglected works at no other place can compensate for the omission or preserve the Harbour in an efficient state.

In the Harbour Master's Report of January last, he says, "Upon the faith of the current (to which in a preceeding paragraph he declares that the Harbour owes its navigation) the extension of the Queen's Wharf was advised, and although it is as yet only constructed half its length, a widening in the channel has already taken place." I have already proved (by demonstration of actual measurement) that the currents here are too feeble to be of any service in retarding or removing the deposit, and the declaration of the Harbour Master appears to be inconsistent with the facts. This is scarcely extraordinary, for unless the measurements be made with the greatest delicacy and reduced to a well-established datum, it is difficult, nay impossible, (owing to the frequent variations in level), to arrive at accuracy.

From recent measurements made by me in continuance of the whole system of survey upon which the charts have been laid down, it appears indisputable that since the extension of the Queen's Wharf was brought to its present state, and in the space of 128 days the ten feet water line of the shoal has been projected fifteen feet, the eight feet line twelve feet, and the six feet line twenty-five feet into the channel northerly, thus diminishing its widths by those amounts. It is accordingly apparent that the Queen's Wharf works, recent as well as remote, although fortuitously now of eminent advantage in a commercial point of view, have failed in the engineering service for which they were advised; and they have failed because they have *not* resulted in strengthening the current and creating a scour as was anticipated, because in truth the current which has ever been inoperative in checking the shoal formation is so still, being now as always superficial.

In the paper to which I have so frequently referred I have demonstrated the manner in which this encroachment is proceeding, and it is sufficient here to repeat that it is brought from the southward, and that every effort to check it by the current has been ineffectual. We may, therefore, reasonably abandon such an expedient, which, however excellent and efficient it may be found in tidal waters, should not, therefore, induce us to rely upon its adequacy when attempted under such totally different circumstances.

To preserve the Entrance from further encroachments of the shoal and to arrest the beach drift at a convenient and safe distance therefrom I would recommend the early construction of the following works:—

1st. A groyne at the Lighthouse Point to retard the sand now moving northerly, and divert it into deep water westerly.

2nd. An auxilliary groyne opposite Gibraltar Point, to arrest and counteract all progressive action along the west side of the shoal, thus enabling all drift to accumulate south of the clear water opening of the Bay and preserving the present extended passages to facilitate the early removal of ice in spring.

3rd. A Pier along the south edge of the channel as shewn on the plan of a total length of 290 yards, cutting off about 350 feet from the point of the shoal to a depth of twelve or fourteen feet by dredging, thus enlarging and permanently deepening the navigable entrance from 240 as now to 600 feet as proposed. With such work properly constructed, I am confident in the opinion that the difficulties hitherto connected with the western channel would be removed, and that the Entrance to the Bay would be permanently preserved in an efficient condition. The Harbour would then be such as for extent and convenience, would I believe be altogether sufficient and satisfactory. And I take leave very respectfully to repeat my conviction that it is more consistent with prudence to content ourselves by checking an ascertained evil, by simple, palpable, and safe expedients, than to rush wildly into costly experiments having no actual bearing on, and at a distance from, the only evil by which we are embarrassed in the frail hope of begetting an advantage of uncertain value.

The following is an approximate estimate of the several works proposed:—

1st. A groyne at Lighthouse Point, 450 feet in length	£900	0	0
2nd. A groyne near Gibraltar Point, 800 feet in length	600	0	0
3rd. A Pier at the entrance, estimated 14 feet under water, and 55,000 cubic yards dredging	10,200	0	0
4th. Two groynes at the Isthmus	850	0	0
	£12,550	0	0

It will be observed that a large item in the above estimate is involved by the proposed enlargement of the present entrance to a full width of 600 feet of deep water; that although 400 feet might suffice and reduce the first cost about three thousand pounds, yet the increased and permanent advantages resulting from the enlarged entrance, would I am inclined to think warrant the additional expenditure. Since you do not at present require detailed plans and estimates of the proposed works, I have deemed it unnecessary to prepare them. I may, however, again refer to the fact that I have in my possession charts and other documents bearing upon the question before you, and although they are the bases upon which the opinions now submitted have been formed, as they have been prepared at great labour and expense, and are of some value to me, I have refrained from attaching them to this Report.

If, however, you should desire to examine them, I shall be most happy to attend at any appointed time, and submit them to your inspection.

I have the honour to be, Sir,
Your obedient servant,
SANDFORD FLEMING.

Toronto, May 4, 1854.

REPORT

ON THE MEANS TO BE ADOPTED

FOR THE

PRESERVATION AND IMPROVEMENT

OF THE

HARBOUR OF TORONTO,

BY KIVAS TULLY, ESQUIRE, PROVINCIAL SURVEYOR.

[*The Third Premium of Fifty Pounds was awarded to the author of this Report.*]

The opinions of the several professional and scientific persons who have previously written on this subject, are so widely different, that, to discuss each separately, would far exceed the limits of a report of this description, and which, for all practical purposes, cannot be considered necessary. The present intention, therefore, is to condense the subject as much as possible, consistent with a due explanation of the means to be recommended, founded on the most reliable data.

It is proposed to divide the report into two heads, one on the Preservation, the other on the Improvement of the Harbour; the expense necessary for preserving the Harbour, as it will be shown, being far less than that which may be required for its improvement.

Previous to entering on the discussion of the subject, it is necessary to remark, that the construction and extension of the Queen's Wharf was the most advisable course that could be followed heretofore, both for the preservation as well as the improvement of the Harbour, and must be a source of much satisfaction to those who recommended its construction originally, and were afterwards instrumental in carrying the project out—to think that, up to the present time, there has been no useless expenditure, a result that cannot always be avoided even by the most experienced persons.

1st. The preservation of the Harbour.

In order to form a correct opinion, it is necessary to inquire into the causes of the original formation and increase of the Peninsula, forming its southern boundary.

Sir Richard Bonnycastle, in his report in 1834, in reference to this subject, states—

"The Peninsula, opposite the southern face of the city of Toronto, appears to me *a much more ancient formation than is generally imagined*; it is composed of sand in various states of cohesion, the surface being usually disintegrated, and increasing only in firmness and tenacity as it increases in depth. It is probably one of the many ridges of the bottom of the vast Lake, which existed before the present Ontario and Erie were formed out of its drainage, nor has the shape of the Peninsula materially altered for a vast length of time.

"The French entered the basin, and fancied it a river, when they first explored the country under the guidance of Hennipen, and the oldest surveys show little or no difference in its outline.

"It is not necessary, however, with the object at present in view, to enter into a geological description, to prove that the Peninsula was made during the sedimentary deposition of the tertiary periods; but it is useful to that purpose to ascertain that it is not comparatively new, or in the constant habit of receiving great accessories to its bulk and extension."

These opinions, written twenty years ago, besides being corroborated by later authorities, have been proved to be correct by recent examination.

A superior set of boring irons were constructed for the purpose of ascertaining the substratum of the Peninsula, and in order to set the question for ever at rest.

The first and second trials were made at Gibraltar Point, and the same result was obtained in both instances, namely, sand and gravel in alternate layers, three feet in depth from the surface of the water, and finding, after considerable labour, with four persons working the boring irons, that no greater depth than three feet could be obtained, a specimen of the substratum was procured with the shell augur, and found to be blue clay, or hard pan, as it is more commonly called.

The resistance of the sand and gravel on the third trial, at the Narrows, east of Privat's tavern, was found to be so great, after boring about two feet, that a lighter boring iron was procured, with

one end hollowed out to receive the substratum, and after several trials between Gibraltar Point and the Narrows, along the centre of the Peninsula, the same result was obtained. Specimens of the clay and a memorandum of their respective positions and depths are herewith submitted for inspection. The hollow in the iron being of small capacity, a small portion of the clay could only be procured, and even this is mixed with the fine sand which lies on the surface of the clay.

There is, however, sufficient evidence of clay in the several specimens to prove the assertion, that the base of the Peninsula is coeval with that of the mainland, and not a deposit caused by the action of the waters of Lake Ontario.

It is intended to pursue the investigation still further, and, in all probability, the same result will be found on boring east of the Narrows, towards the heights of Scarboro', and also on the neck of land that separates the Harbour from Ashbridge's Bay.

Whether a portion of the sand and gravel resting on the substratum of the Peninsula was an original formation or not, it would be difficult to ascertain; but the most likely conclusion would be, that it has been deposited on the ridge forming the base of the Peninsula since the period when the water which covered the greater portion of the North American continent subsided to its present level.

The sources from which this deposit is and has been supplied, is explained in a letter of mine, dated February 10th, 1853, as follows:—"The continued accumulation of deposit on the Peninsula, are the washing away of the shores of the Lake to the east and west of Toronto. During an easterly gale, which generally lasts three days, the 'debris' from the Scarboro' heights is washed along the shore of the Peninsula to the lee of the Lighthouse Point, and during westerly gales, which generally succeed easterly ones, the 'debris' from the shores west of Toronto, as far as the point of the Humber Bay, is washed along the shore towards the Peninsula, and meeting the current of the Don at the western entrance, is deposited on the Bar."

A comparison between the deposit on the Peninsula and the formation of the Scarboro' heights will prove, that not one-twentieth part of the "debris" finds its way to the Peninsula.

The formation of the Scarboro' heights being principally argillaceous, and the deposit on the Peninsula being granitic detritus, the argillaceous portion of the debris being the lightest is carried to a much greater distance, and sometimes three or four miles out into the Lake by the underton, where it is deposited when the causes that originally removed it cease.

Pursuing this question still further, it will be found on examination that a considerable portion of the "debris" travels eastward as well as westward, the prevailing winds being westerly, though the easterly winds are the most violent. The effect produced by the prevailing westerly winds in Lake Erie is evidenced by the more extended deposit forming Long Point, and also the Harbour of Erie.

The above remarks, though more diffase than may be considered requisite, are introduced to prove that the whole of the "debris" from the Scarboro' heights is not deposited on the Peninsula, and the same may be said of the deposits from the river Don.

That the construction of the Queen's Wharf has had the effect of changing the line of deposit on the Bar, cannot be for one moment doubted.

By referring to the map published by Mr. Bouchette in 1815, it will be observed that the point of the bar was more easterly than it is at the present time, and to the increased back current out of the Harbour, caused by the contraction of the channel, may principally be attributed this result.

Assuming the above remarks to be admitted facts, as such, they cannot be controverted by mere conjectures—some of which are calculated to remind a person of the reply of a celebrated member of the British Parliament to the speech of a consequential representative from one of the inland counties, who felt flattered at being noticed by him—"There is a great deal in the hon. member's speech that is new and true, but, unfortunately, what is true is not new, and what is new is not true;" and with these remarks he went on with the subject under debate.

Whatever may have been the result of the action of the current of the river Don on the formation of the Peninsula, it has not much influence at the present time—the current being very trifling at ordinary times.

During floods, the injury to the Harbour by the deposits of alluvial matter suspended in its waters are very considerable, though, fortunately, the direction of the flood, when the Don overflows its banks, is into Ashbridge's Bay, where the greatest amount of deposit is made. A large portion, however, reaches the Harbour, and the lighter particles are even carried out some miles into the Lake before they are deposited. During the prevalence of a flood in the Niagara river, about five years ago, caused by continued wet weather, when the ice was breaking up in Lake Erie, the water at the mouth of the river for five miles, at least from the shore, and an equal distance on either side, was quite discoloured, and the neutral line between the Lake and the river waters was quite distinct.

If the foregoing remarks are correct, and there can be no reason to doubt them, it must be admitted that the injury to the Harbour, in consequence of this deposit, is greater than the benefit to be derived from its current. As one of the precautions necessary for the preservation of the Harbour, it is advisable to alter the direction of the current into Ashbridge's Bay, and allow it to find a passage into the Lake through the eastern entrance in Ashbridge's Bay, and if at any future period a canal should be made, connecting Ashbridge's Bay and the Harbour, the entrance into the Harbour should be protected by gates, so as to prevent the current from the east bringing with it the mud that has been deposited in the marsh for ages past, the mud in Ashbridge's Bay being at least twenty feet higher than the bottom of the Harbour.

Fortunately, the present connection between the Bay and the Harbour is very slight, and, according to the annexed estimate, a comparatively small amount would be necessary to close up the mouths of the Don, and alter the direction of the current into Ashbridge's Bay.

The deposits from the sewers of the city in the Harbour, is much more considerable than would at first be supposed; from experience in the construction of wharves, piling, &c., it has been found that, from Yonge Street on the west to the Don on the east, the average depth of deposit from the sewers alone is not less than two feet, taking the distance to be 5000 feet, with an average breadth of at least 300 feet we have a quantity equal to about 100,000 cubic yards, a very serious amount, considering that it only extends over a period of say twenty years; the annual deposit will

of course increase in proportion to the population, so that at the end of twenty years more, taking the population at that time to be 100,000, the increase of deposit may be fairly calculated to be at least 700,000 cubic yards in addition.

In Sir R. Bonnycastle's Report, this subject is also briefly alluded to, as follows, and the injury to the Harbour anticipated: "I also beg to remark that in making the sewers for this City, it would be very advisable to construct one main sewer through the whole length down to the Marsh, instead of lateral ones into the Bay."

The difficulty of constructing a main sewer in an easterly direction is insurmountable, in consequence of the want of a sufficient fall, a sewer constructed as above described being almost on a level, would be always subject to be choked up with the deposits from the lateral drains, and from this inevitable result would be destroyed in a few years.

In a letter of mine addressed to the City Council in 1853 it is recommended "that a covered channel should be constructed in the centre and beneath the intended Esplanade, from the River Don to Queen's Wharf.

The drains of the City to be extended to this channel, and a portion of the current of River Don to be turned into it by damming the present channel and allowing the surplus water to flow into the Marsh as at present over a waste weir one foot in height above the present level of the water." This would be self-acting, and would carry off the unhealthy deposits which are now being made in the Harbour, as evidenced by the rank vegetable growth in the stagnant water about the wharves.

As the final disposition of this matter rests with the City Council it may be considered sufficient for the present purpose to state, that for the preservation of the Harbour the sewers should not be permitted any longer to empty their filth into it, which if otherwise provided for, instead of being an injury to the Harbour and a cause of unhealthiness to the citizens, would eventually be a source of profit.

For the preservation of the Harbour the next question that suggests itself is the strengthening, or the opening, of that portion of the Peninsula termed the Narrows; when the question of the improvement of the Harbour is taken up, it will be sufficient then to show the advantage to be derived from the construction of an eastern entrance, or the contrary; but as far as regards the preservation of the Harbour is concerned there can be no doubt that the strengthening and not the opening of this portion of the Bay is the safest and the most advisable plan.

Considerable damage has already been done by allowing the breach at the Narrows to remain open so long as it had been, as some thousands of cubic yards of sand have been washed into the Harbour during the high water and the action of easterly gales.

Very little damage can be done to the Harbour at present at this point, as the prevalence of westerly gales in the autumn of last year, and the formidable barrier of ice that protected it during the winter, collected a considerable deposit on the Lake side, and since that time, the water having fallen about 15 inches, has increased the width of this portion of the Peninsula considerably, but from its position being a curve from the regular line of the beach, it will always be subject to damage during high water, as the whole force of the waves produced by an easterly storm breaks on it and carries the lighter particles of sand into the Harbour.

To strengthen it and encourage the accumulation of sand at this point two rows of piles, 20 feet apart, and five feet above the surface should be driven on the inner or Harbour side from the Marsh to Privat's Tavern, the piles to be lined with plank on the inside, and the space filled up with the deposit from the Marsh, which is convenient, the base of a substantial bank will thus be formed, which can still further be strengthened by planting, &c.; the action of both wind and water on the sand will be to form a slope on the Lake side, which will most effectually secure this portion of the Peninsula from further encroachment. The cost of the above is also stated in the annexed estimate.

The construction and extension of the Queen's Wharf having determined the result at the western entrance as before stated. The old adage of "let well enough alone" may be safely applied in this instance.

If 100 feet is dredged from the point of the bar, so as to widen the channel to 400 feet, to enable sailing vessels to beat into the Harbour during easterly winds, as they were in the habit of doing until the present, and the wharf extended westerly in a line with the point of the bar, which work is now under contract, and will be completed this year; the bar cannot possibly close up the channel as the current into and out of the Harbour will always be sufficient to keep the channel clear; the opinion which was expressed in my letter of 1853, experience has proved to be correct, as the extension of the Queen's Wharf 200 feet since that time has produced the very result which was then anticipated.

It is there stated "as to the extension of the Queen's Wharf westward it cannot effect the channel, provided the deposit on the bar is removed as recommended, it would not increase the deposit, it would merely alter its form, which would then assume a westerly direction."

In order to understand the subject thoroughly it will be necessary to investigate the effects of the current into and out of the Harbour during the prevalence of easterly as well as westerly gales. As to the fluctuations of the water on the Lake during calm weather they are so irregular in their action that the result is inappreciable though certainly beneficial.

During a westerly gale the water rising suddenly in the Lake by the action of the wind the surface level will of course be maintained, and the water will flow into the Harbour. The effect of the force of the wind on the surface level of the water, causing it to rise at the opposite point from which the wind may be blowing at the time was ascertained by Smeaton to be eight inches in one mile, the wind blowing a strong gale, or at the rate of 40 miles per hour at the time. The experiment having been made on the water in a narrow canal, is hardly any criterion of the effects that a gale of wind of the same velocity might have on so large an expanse of water as Lake Ontario; but still it will afford some data to be coabled to judge of its effects by comparison.

The great damage caused occasionally at the Harbour of Buffalo, and other ports on Lake Erie, by the sudden rise of water, caused by severe westerly gales in that comparatively shallow Lake, is also a further proof of the force that is produced by the action of the wind on a large surface of water, the actual effect can only be ascertained by continued observation. The records kept during the last few years by the Harbour Master prove the sudden rise of the water from the effect of an easterly as well as a westerly gale to be from four to six inches, and even more.

The above remarks refer to the first effect; for the flow of water into the Bay through the western entrance the reaction has also to be considered, and according to the laws of motion, which are applicable to fluids as well as solids, the action and reaction are equal; the action is constant in its effects when the water in the Harbour is raised to the same levels as the water in the Lake a reaction takes place and two currents are established one into and the other out of the Harbour; and these currents are much increased by the surf on the bar, which acting as a sunken breakwater, the surface water is forced into the Harbour by its momentum and returns by the deep channel near the wharf. To the effect of this current may be attributed the steep edge on the inside of the bar, and it has also been found efficacious in scouring the channel.

The effect produced by an easterly gale is the same, with the exception that as the waves do not break with such great violence on the bar, the additional effect from this cause is lost.

The difference of level caused by an easterly gale is greater than that produced by a westerly one, as it acts on a larger surface of water.

As an easterly gale increases the deposit on the bar on the Lake side more than a westerly one, it is evident that a westerly gale is more beneficial in its effects on the maintenance of the channel.

From the above remarks the conclusion may fairly be drawn that a channel which has been maintained by natural causes for years past may be injured by an interference with those causes which the construction of a pier on the point of the bar parallel to the Queen's Wharf would most decidedly produce.

The recapitulation of the several recommendations for the preservation of the Harbour will therefore be as follows:—

1st. The closing of the Don, and diverting the current into Ashbridge's Bay.

2nd. The sewage of the City to be prevented from being emptied into the Harbour.

3rd. The strengthening of the Narrows of the Peninsula.

4th. The continued extension of the Queen's Wharf, so as to be always on a line with the point of the bar.

That the Harbour can be preserved for ages by the course above recommended I have not the least doubt, and should such a contingency ever arise as the removal of the deposit on the base of the Peninsula by any future action of the waters of the Lake, which is extremely doubtful, the recent examinations by boring prove that the substratum is sufficient to bear a stone facing on the Lake side, similar to the one constructed in front of the New Garrison, which has stood the test of six years' experience without any injurious effect, and to resist the action of the waters of the Lake for an indefinite period, so that as far as the decay of the Peninsula is concerned it is altogether mythical, and reduces the question to one of expense.

THE IMPROVEMENT OF THE HARBOUR.

With respect to the improvement of the Harbour it is intended to treat this question altogether as a separate matter.

The only alterations from the preceding remarks on the Preservation of the Harbour would be instead of strengthening the Peninsula at the Narrows the opening is recommended.

The disposition of the River Don, the sewage of the City, and the maintenance of the western channel would remain the same; the question, therefore, to be considered will be, the practicability of constructing an eastern entrance, its maintenance, and the effect produced on the western entrance in consequence of its construction.

The engineering difficulties to be encountered in the construction of an eastern entrance will be considerable and attended with much greater expense than at first would be imagined.

The base of the Peninsula having been ascertained to be of blue clay or hard pan, as it is commonly called, and being five feet from the present surface of the water at this point, the difficulties are rather increased than diminished, though the work when completed would be more substantial than if it was altogether sand.

The only way in which the blue clay or hard pan can be excavated to a depth, so as to afford 12 feet at low water, would be by the construction of coffer dams instead of dredging, which could be resorted to if sand and gravel alone had to be excavated.

The foundation of the piers would, however, be more secure and less liable to injury from the effects of the heavy sea that will have to be encountered than if sand and gravel formed the foundation.

Accompanying this Report is a map copied from one in the possession of the City Council which explains the position and capacity of the proposed eastern entrance.

In order to prevent the "debris" from the Scarborough Heights from being conveyed into the Harbour by the current which will be caused by an easterly gale, it would be necessary to run the piers into 20 feet of water at least, or to the line where the waves break, which indicates the state of the under current; to carry this out successfully will require the piers on either side to average 3000 feet each; the eastern pier to project 500 feet farther than the other, so as to afford sufficient shelter to vessels during moderate gales in running into the Harbour.

For reasons that will hereafter be evident it would not be advisable to make the entrance wider than 200 feet.

The piers would require at least to be 40 feet wide, and loaded with stone in the same manner as the extension now in course of construction at the Queen's Wharf.

By constructing the piers as proposed it is considered they will be sufficiently strong to resist the effect of the most severe easterly storms, and the piers being run out into 20 feet of water, beyond the extent of the under current, no substance further than the lighter particles of argillaceous matter, which are held in suspension by the agitated water, can enter the Harbour; and in case of a current being established through the Harbour, which would occur in an easterly storm, this suspended matter would not be deposited in the Harbour, but would be carried with the current through the western channel into the Lake again, and *vice versa* in case of westerly gales, in fact it would not be more injurious than at the present time.

If this is correct the maintenance of the eastern channel cannot be questioned, the effect that would be produced on the western channel requires more serious consideration from the fact, that the back current at the western channel would be lessened in the exact proportion as the current through the eastern, and this remark applies whether an easterly or westerly gale prevails.

The data to decide the questions are as follows:—

The sectional area of the western channel, including the water on the bar, is in superficial feet 21,350

The sectional area of the eastern channel, 207 feet wide by 12 feet in depth, would be..... 2,400

Still leaving a surplus in favour of the western channel of..... 18,950

By reducing these amounts to the lowest fraction, the proportion of the sectional area of the eastern channels to that of the western, would be, as nearly as possible, one-ninth.

From the above calculations, it may be inferred that, during an easterly or westerly gale, there would still be a current flowing out of the Harbour at the western channel. In an easterly gale, there would be a current from the east to west through the eastern entrance, and *vice versa*, in either case the current into, or out of, the Harbour, through the western channel, would be diminished one-ninth, and the consequent scouring effect on the western channel would be lost in this proportion. Whether this would have the effect of destroying the balance which has been maintained for so long a period, is a matter of opinion.

Supposing that the point of the bar advanced eight feet per year across the channel, which, however, it does not, the encroachment would be nine feet instead of eight feet. When the present contract for the extension of the Wharf westward 400 feet is completed, I am of opinion that the back current will be sufficient to scour the increased channel 400 feet wide, even in the event of an eastern entrance being constructed.

The current through the western channel, caused by the displacement of the water by steamers passing at full speed, is very considerable for the time it lasts, and has a good scouring effect, tending to prevent the encroachment of the Bar on the channel. If an eastern entrance is constructed, a portion of this effect will, of course, be lost, the proportion in this instance it would be difficult to ascertain. I do not, however, think that the loss would be so great in any case, as to endanger the filling up of the western entrance.

With regard to the arrest of the deposit on the bar, by the construction of piers or groins along the shores of the Peninsula, it can only be considered as temporary; and to be effectual, would have to be renewed and kept in repair year by year, an expense which will be found as much, if not greater than using the dredge.

In Sir Charles Lyell's Principles of Geology, page 318, speaking of the encroachments on the south coast of England, it is stated—

"It appears, from the observations of Mr. Palmer and others, that if a pier or groin be erected anywhere on our southern or south-eastern coast, to stop the progress of the beach, a heap of shingles soon collects on the western side of such artificial barriers. The pebbles continue to accumulate till they rise as high as the pier or groin, *after which they pour over in great numbers during heavy gales.*"

According to the old saying, "prevention is better than cure," if the true remedy requires to be pointed out; and admitting that the continued deposit on the Peninsula is caused by the "debris" from the Scarboro' heights, expend the money that would be wasted in the construction of piers or groins, in the protection of the base of the Scarboro' heights, and the object is attained; but the wisdom of this course is to be doubted; the deposit from this source is not so great as is imagined, and it must be borne in mind, that a considerable portion of the deposit on the Peninsula is removed by the under-current not to be replaced, except by this very supply from the Scarboro' heights, which is considered so great a nuisance—taking all matters into consideration, this supply, on the contrary, will, on reflection, be considered advantageous in preserving the Peninsula, and consequently preserving the Harbour. As to "making a permanent opening into the Lake from Ashbridge's Bay," it is a question that can be well postponed, as the present opening is quite sufficient for the requirements of that portion of the Harbour; and in all future speculations on the subject, it would be advisable to view it as likely to form a separate Harbour altogether from the present one; as such, with an entrance into Toronto Harbour duly protected with gates, to keep the mud which has collected there for ages from destroying Toronto Harbour, an excellent Harbour may be constructed by running out piers into deep water, as recommended for the eastern entrance of Toronto Harbour; the cost of such work is stated in the general estimate; though the expense is not advisable, as all available funds will be found little enough for preserving and maintaining a Harbour, which, up to the present time, stands unrivalled on the great Lakes of this Continent.

KIVAS TULLY,
Civil Engineer.

Toronto, May 3d, 1854.

ESTIMATES.

For the Preservation of the Harbour.

1st.	Closing the River Don, and diverting the current into Ashbridge's Bay	£7,500	0	0
2d.	The strengthening of the Narrows of the Peninsula.....	2,500	0	0
		£10,000	0	0

For the Improvement of the Harbour.

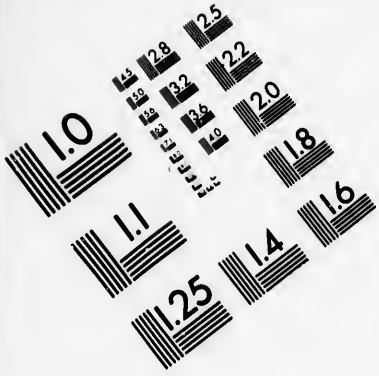
1st.	Closing the River Don.....	£7,500	0	0
2d.	Constructing the eastern entrance 200 feet wide and 12 feet in depth, piers 40 feet wide, running into 20 feet of water.....	60,000	0	0
		£67,500	0	0

Improving Ashbridge's Bay.

1st.	Constructing channel in eastern end of Ashbridge's Bay, with piers, &c.....	£50,000	0	0
2d.	Constructing canal, with gates, &c., 60 feet wide, 10 feet of water, where shown on the Map.....	10,000	0	0
		£60,000	0	0

KIVAS TULLY,
Civil Engineer.

Toronto, May 3d, 1854.



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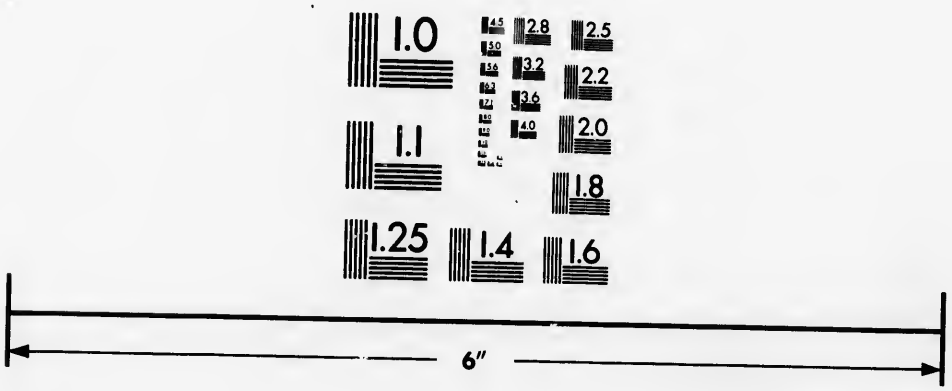

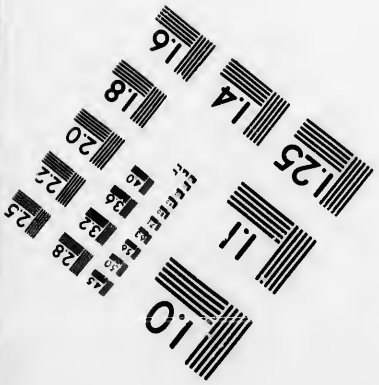

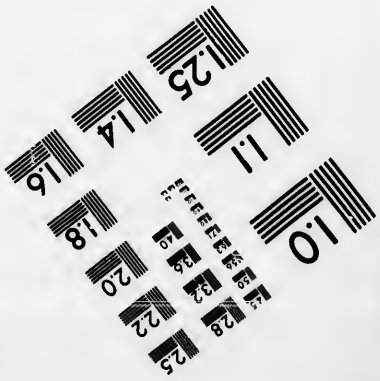

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REPORT

ON THE PRESERVATION AND IMPROVEMENT OF

TORONTO HARBOUR,

BY HUGH RICHARDSON, ESQUIRE, HARBOUR MASTER, TORONTO.

[*A Supplementary Premium of Seventy-Five Pounds was awarded to the author of this Report.—See Extract from the Minutes of the Harbour Commissioners on page 38.*]

To the Commissioners of Toronto Harbour:—

Gentlemen,—Not with any pretention to engineering, not with the presumption of competing with scientific men, in plans, and estimates of plans, for the improvement of the Harbour: but, if I have understood the advertisement right, it admits the opinions of observers and of practical men, as well nautical as scientific, to compete in a sort of essay on the subjects embraced therein, which may lead to some beneficial decision, or induce more scientific aid.

If projects are in agitation, which, if carried into effect, I think would be destructive to the Harbour, nautically of little value, and commercially onerous, I, as a nautical man, a practical man, and an attentive observer of the Harbour of long standing, am entitled to intrude an opinion, and compete in the race of competitors, the labours of whom tend to the public benefit.

In my Report to the Commissioners of Toronto Harbour last year, I stated as my opinion that the breach then open was injurious to the Harbour, and urged the necessity of closing it, and so simple and trifling was the injury then, that the beach that was made on the 13th and 14th January last, closed by the operation of Nature on the 17th February following, and had the Harbour belonged to myself (with the opinion I held of its injurious tendency), I should then have raised the beach with the material around me to a height above the reach of the wave. If the aspect of the breach now is in any way formidable, the delay in closing it must be attributed to the public divided opinion, as to its beneficial or prejudicial effect upon the Harbour. But the mass of material that has been removed from the beach, essentially altering its feature, and the drift that has been brought into the Harbour, to say nothing of the undetermined effect it has had upon the Bar must convince the most sceptical of its injurious effect; and an examination of the shallow shelving coast is sufficient to preclude the idea of a natural channel ever forming there, if such an idea was ever entertained.

Further neglect may bring this Harbour into the perilous and costly condition of Erie Harbour at this time, to which it has a close resemblance, where, from having allowed it to become a presqu'isle by a breach at the West, it is continually inundated with sand, and threatened with destruction.

The means of closing the breach when no more formidable than when I observed it last fall appear to me very simple. It can hardly have escaped the notice of the observer that whenever the height of the Peninsula was above the reach of the wave, the wave was rolled back from whence it came harmless to the beach; and that it was only where the wave surmounted the apex of it that it became injurious in its descent on the opposite side.

To repair the breach in its then form with a current through it, it required first to stop the current, which might be done with as many rough plank of 2 inches, made into cases 6 feet long by 2 feet 6 inches × 2 feet 6 inches, filled with the material of the beach, as would stretch across the narrow neck of the breach in double row, ten or twelve feet apart, and filled in between, this would effectually stop the current, (the narrow part being only sixty feet wide and far removed from the bent of the wave), the current once stopped the process of raising the beach is the mere affair of carts and wheelbarrows, with labour and a plentiful supply of the material of the Peninsula. The object of these cassons being only to stop the current, which done all would be buried up. With moderate winds at S.W. and N.E., the lip of the wave would repair the beach in a fair line to a certain height almost as soon as the most active labour would raise the other part to the required height. More scientific and a more expensive process might be adopted, but none more efficient.

On examining the beach I observed the wave had never reached a height above five feet, where that height was twenty feet from the line of calm water, and treating the Lake for all immediate practical purpose as at a constant level, I had only to consider the casuality of an easterly storm; then looking round me for even the lowest part of the Peninsula that withstood that storm, I placed in imagination in the interval of the storm a section of it in the breach, and I felt myself secure, convinced that nothing could be so effectual in repairing the breach as the material of which it was composed.

The Lake was, when I observed it last fall for the purpose of estimating the height of beach required to resist the sudden encroachment of the Lake, two feet lower than the highest level, and two feet higher than the lowest; I therefore concluded that a beach six or seven feet above the highest water at 20 feet from the line of calm water, and a hundred feet wide in all, would be amply sufficient to secure the Harbour against further inroad from the Lake. I do not think that for many years the beach in that part has been five feet high. Be it remarked that the water being shoal without, the wave in any storm is greatly reduced in height and force in passing over the shoal water before it reaches the beach.

If cribs are made use of to stop the breach, the retrocession of the Peninsula (as I shall show) will in the course of time lay them bare, and even if they extended all the way to the head of Ashbridge's Bay, yet in time the whole line would be taken in reverse. Keeping the beach at all times and in all parts above the reach of the solid water of the wave, the retrocession will proceed safely, uniformly, and almost imperceptibly, but proceed it will, as it has done, and still does; breaches accelerate this, as witness the present effect, and examine the marks all the way from the fishing houses below the cross beach to some hundred yards West of Privat's Hotel.

But until the important question of a canal at the East end of the Bay is settled, I fear even the preservation of the Harbour will be a secondary consideration, I shall therefore publicly treat this question fully in all its bearings upon public interests, that is physically, nautically, and commercially.

Physically.—The superstructure of the Peninsula, the southern boundary of the Port is composed of drift—that is, clean washed sand and stones; the base of it I believe of all the material of the cliffs of Scarboro', the substratum most probably of indurated clay. The bar or western boundary of sand and clay.

I shall not enter upon the theory of its original formation, it is sufficient for my present purpose to assume what a quarter of a century's observation bears me out in, that all the drift comes from the East, mainly the debris from the high lands of Scarboro', that the Peninsula is the crest of a large shoal, that its maintenance above water is essential to the preservation of Toronto Harbour.

This drift is always more or less in motion by the lateral actions of the waves of the N.E. and S.W. winds.

Whilst the N.E. wind supplies the Peninsula with drift, it also by the violent action of its stormy wave erodes the beach and carries the produce gradually West. The S.W. wind more constant, but its waves less violent, brings back by a more gradual process much of this drift and mainly repairs the damage done by the former wind. But for this counteraction the Peninsula would erode and be extended more rapidly West. Were the tides always one way erosion would be constant on one side of an island, and accumulation on the other.

At right angles to this moving beach it is proposed to project out into deep water some eighteen hundred feet or more piers for the purpose of a navigable canal, intercepting the motion of drift both from the East and from the West.

The effect of these piers would be to cut off the supply of drift from the N.E., and bring it down from the S.W., filling in the angles until it ultimately made a passage round them. But so extended would these be, and so considerable the body of water to be filled in, that bays would form both East and West, giving greater force to the wave to act upon any attenuated part of the Peninsula; and it is more than probable that a very serious breach would be made in it East of the piers. The West end of the Peninsula no longer supplied would assume another shape, bearing down from West to East, and wasting away at the West.

This is the effect to be expected, presuming the piers built upon a sandy foundation and broadside on to the N.E. sea, which is heavier here than at any other part of the Lake, withstood its repeated concussions. It is common to allude to the piers of the Burlington Canal, to support an argument in favor of the facility of erecting piers for the Canal in question. The piers of the Burlington Canal are placed in the strongest possible position for piers to be, that is end on, to the only sea that can affect them. Whereas those of Toronto would be placed in the weakest possible way to resist the sea, that is, broadside on, and would require to be doubly massive, compared with those of the former, to stand at all.

The interior effect of a Canal, two hundred feet wide and twelve feet deep, would be to create such a current through the Harbour, with a strong south-west wind from west to east, as to bring down the sands of the Bar into it, sweep those of the north margin of the Peninsula down upon the Canal and the east end of the Bay, whilst the evil consequences of some extraordinary gale could not be calculated. I think I have seen such a hurricane upon the Lake from south-west, as might render both channels unnavigable for a time.

The action of the current last season, the breach open about one hundred feet wide and two-and-a-half feet deep during a south-west gale, illustrated, upon a small scale, what would be the effect of a large opening and deep water, and amply confirms the opinions that I publicly expressed twenty years ago, when the subject of a Canal was then in agitation, that it would create such a current through the Harbour, whose bar and boundaries were composed of sand, as to prejudice the existing channel.

Nautically.—The Canal, if constructed, would be useless to sailing vessels in calms. With the wind off the land, it would be useless for entrance, but useful for exit to all vessels bound down the Lake. With the wind at S.W., and not stormy, it would be valuable again for exit, but for entrance from the east every nautical man would prefer making a stretch out into the open Lake, weathering the light at one long board, and rounding into the Harbour with a fair wind, to hauling through the Canal, coming in dead upon a lee shore, and having to beat up the Bay in short tacks. With the wind at south, it could only be used for entrance with the wind at north-east, and moderate, it would be useful to all vessels from the east, but useless to them for exit.

For steamers, to all bound inwards from the east, or outwards to the east, it would be useful in moderate weather. In high winds, either north-east or south-west, it could not be used.

Commercially.—There have entered the Port of Toronto last year, by the Harbour-Master's books, during the whole season for navigation, 2433 vessels of all sizes and classes, which include the daily steamers, and 1012 visits of wood and stone boats. Add to these 100 vessels in transit or weather-bound, not reported, say 2533 in all. Double these, upon the presumption that every vessel that comes into port goes out again, and say that 5066 vessels, in all, pass the entrances of the Harbour during the year. Now, taking every advantage of numbers, admit that one-half of the whole pass by Canal, or 2533 craft of every description. What toll would you put upon these vessels or cargoes to make the Canal *self-paying*, where the interest alone of the expenditure, at the lowest calculation, must be betwixt £3000 and £4000?

But take a view of it approximating to its true light, and say there are two entrances to the Port—the one tolled, and the other free. The tolled Canal would about share the fate of a turnpiked road, where there are two roads to the same place—the one a little round-about but free, the other taxed—the greater part of the traffic would go out of the way to avoid toll.

It is looking upon it in the most favourable light, to say that one half of all the vessels entering or going out of Port *could*, if they *would*, take the Canal. Deducting the Niagara, the Hamilton, the Port Dalhousie vessels, and nearly all the wood and stone boats, the casualties of wind and weather upon all vessels, and not one-fourth of the whole for entrance or exit, if both channels were free alike, *could* take the Canal.

Then there remains the only possible way of compensating for the large outlay of constructing and maintaining this Canal and another channel, that is, to make them both free alike, and resorting to compulsory Harbour dues upon all vessels or cargoes coming in or going out of Port.

What must be the amount of Harbour dues collected to pay interest on the capital invested in this Canal, reduce the principal; and maintain two channels to the Harbour instead of one?

Will it not be a great commercial disadvantage to a town like Toronto, surrounded by small Harbours, connected by railroad, and in close proximity to the rival Port of Hamilton, and hitherto enjoying light Harbour dues, and just relieved of all export dues, to be saddled with enormous charges, and those to sustain two bad channels instead of one good one?

What would the citizens of Hamilton give to exchange their costly Canal for the almost free Port of Toronto? With them it is Canal *or no Port*.

It may justly be asked, whence comes the desire to risk the stability of a good natural Harbour, by making another costly channel, which, at the best, can only benefit a partial navigation?

To the east end of the Town it can bring but evil, if it injure the west of the Harbour.

Is the entrance to the west of any benefit to the west end of the Town?

Are not almost all the commercial wharves east of Yonge Street? And is not Yonge Street the pivot around which all commerce centres?

Will any merchant ask, or care whether his goods come in at the east or at the west end of the Harbour, provided the Harbour charges be light? Will he consent to pay enormous Harbour dues merely for the accommodation of a partial navigation? In no other light can *commerce* look upon this project of a Canal. Lastly, as Provincial property, can there be a reasonable hope that any Legislature or Government will assent to the making of a second opening into one of the finest Harbours in the Province, at an acknowledged risk and heavy cost, unless an urgent necessity can be shown for such risk and such cost?

Until this vexed question is set at rest, the citizens of Toronto generally will not turn their attention with due anxiety to the preservation of the valuable Harbour they have the happiness to enjoy.

I have endeavoured to show, in the light I see it myself, that, physically, a Canal to the east would be destructive to the Port; that its nautical advantages are largely delusive; that it would act prejudicially on the commerce of the Town; and, lastly, that the assent of Government to such a project is all but hopeless. I will now turn my attention to a subject more worthy of the care and economy of a great commercial town like Toronto—the improvement of the Harbour, active steps of preservation of the main features of it, as traced out by the hand of nature, repairing that which is decaying, and improving without dangerous innovation such parts as are susceptible of improvement, is the only safe course that the guardian power of the Port can pursue. Like the human system, in all ordinary derangement, ordinary care may suffice, but where the danger is imminent, we call in the most skilful aid; so would I, in the important case of the derangement of any vital feature in the Harbour, consult the most eminent engineers, nay, a board of engineers, for no expense should be spared to secure the stability of a Port, upon which the value of so much property depends.

I, in the matter of the improvement of the Harbour, only give opinions founded upon long observations, and which observations may be useful to engineers; for it is only by observations on the present operations of nature, that we infer of the past, or anticipate for the future; therefore, in furtherance of my opinions and observations, although I did not mean to touch upon the theory of the formation of the Peninsula, yet as the means for its preservation call for some opinion of its origin to account for its present appearance, its constant state of transition however gradual, and to adopt measures to retard its decay, I here submit them.

The Peninsula is still fed by drift and detritus from the east, and still grows from the root whence it sprung, the point where the land falls away at the head of Ashbridge's Bay, striking out in a fair field of growth into deep water, the present formation, the result of ages of destruction of the highlands of Scarborough, even from the undefined time where the Lake changed its level from a higher to a lower, of which the whole boundaries of it bear incontestible evidence.

The action of the north-east storm has had the same effect upon the *then* advanced promontory of Scarborough, as the north-east storm has upon it at the present day. Acres and acres have been removed from the flats below Scarborough Heights within my recollection.

The result of ages of this work of destruction has been the formation of the present peninsula and shoal, the latter of which is upwards of a mile in width and six miles in length, the crest of it being the present Peninsula. If my theory be correct, the superstructure will be the gravel and stone of Scarborough flats, underneath of necessity *clay*, and below that most probably indurated clay. The crest has started in continuation of the land, with its broadest part above water, where now it is narrowest, for as the Peninsula extended west, and the Promontory of Scarborough receded from erosion, so did the neck of the Peninsula at the east, as it could not stand out prominent from the protecting land. Hence the more rapid retrocession of the Peninsula east, and the tendency to a Presqu-isle formation.

The proof of this retrocession of the Peninsula or crest of the shoal, is traced in the flat shelving shore, leaving little water as the crest recedes from the south, and meeting comparative deep water to the north, the Peninsula not being acted upon by the sea on that side. The modern marks of retrocession, within my own observation during the last twenty-five years, are the long line of aged trees undermined and thrown down by the sea all the way from the head of Ashbridge's Bay to Privat's Hotel.

On examining the beach on the inside at the head of Ashbridge's Bay, although the Lake has frequently make breaches there, and swept over the whole part, from where the trees cease east; increasing the beach inside, as it was swept the outside; yet there is no such thing as that which we s e breach in Toronto Bay; that is, two long piers of sand inwards, showing the range of current in; in Ashbridge's Bay there is no ready vent in an opposite direction for the bodies of water thrown in by the sea, consequently it returns in under-current again through the beach; hence no leading marks of a current, but augmentation of the beach within.

In Toronto Bay, the wide mouth of it affords rapid exit for the water as fast as thrown in, and hence the long banks of sand above water as leaders, and the mass ejected at their head into deep water.

It is easy to account for the spreading of the Peninsula tree-like to the west. The material being finer as removed from the source of supply, spreads over the lake, as seen by the turbid waters in all easterly gales; these gales are invariably met by a counter gale from the south-west, driving back the charged water upon the west end of the Peninsula and the mouth of the Bay, the reaction of the water from the Bay causes the deposit which forms the bar at the entrance. It is useless to speak of the phenomena of ridges caused by the action of the waves.

The Bar is now marked out by beacons nearly three quarters of a mile wide in the centre from the west beacon, east, and carries from three to six feet of water on the top, in ridges varying from three to six feet; over the whole top of this the sea ranges and it is encroaching upon the deep water of the Bay, for the sand shoots down from ten feet, where a buoy is laid on the slope, to fifteen and sixteen feet water almost immediately. No greater proof need be of the encroachments of the sand, and the resistance it meets by currents. This resistance has been reduced the last summer, and will be removed by every neglected breach, *and would be permanently so, to the ruin of the Harbour by a canal.*

The retrocession of the Peninsula is so gradual and uniform, that with due care no apprehension for the Harbour need be felt for a long series of years, unless neglect allow casual breaches to exist, which any extraordinary storm may occasion; then the evil is apparent, as witness the effect of the present breach into the Bay, a more rapid erosion and retrocession takes place.

The preservation of the Peninsula, it seems, rests with the city authorities; then the city authorities hold the responsibility and control the safety of the Harbour. With my opinions I should as soon think of leaving my fences down and my corn-fields open to the depredations of cattle, as expose this Bay for one season to the consequences of the inroads of the Lake.

The repairing of the Peninsula, maintaining it to a certain height and width, the soiling, planting and seeding it, to secure the surface against the action of the high south wind, will be improvements compared with the state of neglect to which it has been consigned since the hour that Toronto became a town. The thick growth of timber that the Lake spared has been plundered off it, and so little has the Peninsula itself been appreciated in its true light, that for the last few years it has rather been dealt with as an island of Guano, than as a barrier upon which the safety of the Port depended.

I was once of opinion that the bar should be raised above water by dyking, and the channel contracted from the Peninsula, but with the experience of Erie Harbour before me, where they have closed the entrance to a narrow channel by piers, it is more clearly demonstrated to me that the large body of water driven over the bar by the S.W. wind is more valuable in its reaction or undercurrent in resisting the encroachment of the bar upon the Harbour and coursing round through the channel, than if the same body of water were shut out and the maintenance of the current at the channel left to the mere varying levels betwixt the waters of the Bay and those of the Lake, and the small contributions from the Don. But be it understood that it is of *necessity* that there be no breach or outlet of water to leeward.

As to the shutting out the Don from the Bay of Toronto, that can no longer be thought of, as it would largely effect private interests, therefore it must be treated as an adjunct and made valuable to the Harbour. Not only should the entrance to it be cleaned out, but the whole of the bed of rushes entirely removed from the head of the Bay, and the water be allowed to flow freely in and out of the Don, the wave to beat upon the shore, and in a short time a clean beach would form all round the head of the Bay, leaving only the mouths of the Don to be bridged over.

The Bay is sufficiently large and contains surface enough to contribute to a great reaction during the prevailing S.W. winds in favor of the channel. It is ascertained that the water according to the wind fluctuates from one to four inches during 24 hours, by correct index in the centre of the Harbour, and that the Harbour contains a surface of nearly six square miles, that one inch rise or fall of water causes 144 cubic inches for every foot of surface to flow in or out of the Bay: that four inches rise or fall will cause one cubic foot, or one cubic yard in every three of surface to flow by the outlet of the Bay, in other words one-third of this surface water in cubic yards to flow by the mouth of the Bay, principally by the channel; but if the wind be strong S.W. a more rapid circulation is kept up by the water being blown over the bar, and dammed back from returning that way by the wind and broken water on it, it forces a passage by the channel.

If this body of water be allowed to traverse to leeward through a channel of 200 feet wide and 12 feet deep, which it certainly would; with such a sluice open, what is to retain the bar composed of moveable sand in its position, if, instead of backwater, there is a current over it, and through the Harbour from west to east?

It would certainly be an advantage to the Harbour if the system of considering it an arm of the Lake were extended to the head of Ashbridge's Bay, by making a wide opening of 700 or 800 feet past the mouths of the Don, through the cross beach, the rushes dredged away, and the winds and the waves allowed to play freely over the surface; this large circulation would benefit the Harbour and conduce to the health of the town, and the money that would be, unprofitably to commerce and injuriously to the Harbour, wasted upon an experiment, might have been applied with a better chance of profit. The whole of Ashbridge's Bay might, in the course of time, be converted into clear water and profitable land.

It is certain that the Marsh is both too valuable and too mischievous to be left much longer in the state it is in contiguity to a large populous and wealthy town like Toronto.

In looking to the channel I see no inconvenience likely to attend it, but through neglect of the means of preservation such as the dictates of science may point out.

The North point of the Bar progresses West at the rate of 19 or 20 feet annually. It has taken 22 years to advance about 400 feet, say it will take 50 years to progress Westerly 1000 feet, no further than Mr. Shanley has laid out in extent from the Queen's Wharf West, in his Report for an entrance to the town for the Toronto and Guelph Rail Road. We will presume as a matter of course also that the Harbour pier is carried West parallel with the advance of the point of the shoal 1000 feet in 50 years.

The buoys and beacons with flags on them show the shape and advance of the Bar, and it may be observed how it knuckles out abreast of the old head of the wharf, showing its effect on the shoal, the channel being 150 feet wider there than at the point West of it.

The channel has never yet been cleaned out since Toronto was a harbour. I think it ought to be, and if it was dredged to a depth of 14 feet in its best water when the Lake was at the lowest, that it would require no more looking to for at least ten years, probably twenty, as the longer the head of the pier, the more concentrated the action of the flux and reflux.

I cannot close this essay without claiming for myself larger and closer observations, and more devotion of time to the interests of the Harbour than has fallen to the share of many individuals for the last twenty-five years, and I trust my age, my experience, and

my long observations warrant me in making an urgent appeal to all the inhabitants of Toronto to appreciate the great value of their Harbour *as it is*. To oppose the stubborn bulwarks of common sense to delusive and costly projects of innovation which oppose the *operations of nature*.

There are but two natural Harbours on the North shore of Lake Ontario. These are Toronto and Kingston, Hamilton is only a port by means of its costly canal. Cobourg is entirely an artificial one, and one of continuous cost; Port Hope does and will owe all its haven properties to art and cost. Port Dalhousie on the other side has claims to that designation at great cost as the terminus of the Welland canal.

But Toronto, the very best Harbour on Lake Ontario, comprising an all but land locked basin, with a superficies of water of nearly six square miles in extent, possessing what no other port possesses, besides its safe basin within, *an excellent roadstead without*, a channel of easy and safe access, and moderate harbour dues: yet with all these advantages there is a suicidal call for speculative and dangerous innovation. It will be instructive to hear arguments in favour of this canal as beneficial to the Harbour in a *physical* and *commercial sense*, I speak not of the practicability of construction, for the science of engineering is equal to any task; but the advertisement that calls forth this essay is an invitation to constructing engineers to meet if possible the expressed and known wishes of a large portion of the inhabitants of this town, and the temptations to the undertaking of a work of such importance are very great. But the advertisement also calls for and challenges other opinions.

I, as an official of the Port, as an advocate for the safety and preservation of the Harbour, with a feeling of great interest for its commerce, with a knowledge that the value of ALL property in the town is based upon the stability of the Harbour as IT IS, oppose my opinion, grounded upon my long observations and much reflection, against those who advocate what in my opinion is a dangerous and speculative experiment.

It cannot be denied but that the Harbour good as it is, and may be for years and years to come is one of gradual transition and decay. To preserve it, to improve it, to protract its decay, call in aid if needful the most eminent science, but touch not with a rash and speculative hand its *vital part*.

As a last appeal, and probably the last I shall ever make, I cannot impress too strongly upon those who hold property in the town to guard against all attempts at making a *second opening* into the Harbour. The integrity of the Peninsula is essential to its safety, upon it depends the stability of the Bar, and the flux and reflux to which the channel is due. *As long as the Harbour is as safe and as commodious for all the purposes of navigation and commerce as it now is to adopt the common sense and homely adage of "letting well alone."*

When this paper was written so far the breach at the narrows was open. It is now closed up, this is as it should be, and it behoves the guardian authorities now to raise the beach to a standard height above the reach of the wave sufficient to guard against future evil.

I have no interests to serve but those I ought to serve, the safety of the Harbour, and the interests of navigation and commerce. Now, that the Peninsula is intact from end to end, keep it so. If any engineer can be found to assert that a body of water can come in at one end of the Harbour, and go out at the other without current, or that a current can pass over sand without affecting it, it will be an anomaly worthy of explanation. For certain purposes it is convenient to treat the present channel, much as the Czar of Russia treats the Turkish Empire, that it is *sick* and *ought* to *die* for the benefit of others. But I here assert, and I am willing to subject that assertion to the test of the most experienced engineer or to be examined upon it by a board of engineers, that *as long as the Peninsula is maintained intact, and as long as there is surface water in the Bay that the last drain of it will pass by the channel.* Neglect in extending the pier coequal with the march of the shoal may allow the water to flow over less navigable bottom, but as long as this is attended to, and the pier carried West, so will the channel be good, even unto the Humber Bay, which will not be for some generations yet to come. As long as the same phenomena of winds and currents exist as now, the guardian powers of the Harbour must be guided by *their past* and *present effects* to calculate on the means of its *future preservation*.

I have the honor to be,

Gentlemen,

Your most obedient servant,

HUGH RICHARDSON.

Toronto, 1854.

EXTRACT FROM THE MINUTES OF THE HARBOUR COMMISSIONERS.

Moved by MR. THOMPSON, seconded by MR. HARRIS,—

That, inasmuch as it is a matter of doubt whether the Harbour Master, being officially connected with this Board can, with propriety, be allowed to compete for the premiums to be awarded for the three best reports on the Harbour, the Commissioners are of opinion, that Captain Richardson's Report should not be considered as in competition with the other Reports that have been sent in.

The Commissioners, however, are decidedly of opinion, that had no such objections existed, Captain Richardson's Report would have been entitled to stand as second. The Board therefore decide that the sum of £75 should be awarded to Captain Richardson from the funds of the Harbour Commissioners, as an acknowledgement of the very great merit and the amount of information contained in his Report.—*Carried.*

(Signed), J. G. CHEWETT.

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