

## APPENDIX.

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[A.]

[See page 24 of this report *ante*.]

### REPORT OF THE ENGINEER ON OSTERVILLE AND COTUIT HARBORS.

BOSTON, NOV. 13, 1897.

*Board of Harbor and Land Commissioners.*

GENTLEMEN:—In accordance with your instructions, I have made an examination and survey of Osterville and Cotuit harbors and the strip of land lying between Osterville Bay and Vineyard Sound, between Wianno Beach and the mouth of Sepuit River, and have obtained such information as I could in relation to the construction of a channel between the South Bay, so called, and the Sound.

Chapter 483 of the Acts of 1897, which authorizes this investigation, is based on the petition of Nathan E. West and others to the Legislature, and the object is to open a passageway for small yachts and other boats from the South Bay into the Sound, in order to avoid the long and difficult trip from the North Bay through the Narrows and Cotuit Bay into the Sound, making a saving of two to three miles on a trip.

The Cotuit and Osterville harbors consist of a series of basins located between the villages of Cotuit and Osterville on the south shore of the town of Barnstable, opening into the Sound by what is known as Cotuit entrance. This entrance lies between Codman's Point, which projects easterly from Cotuit highland, and the westerly end of a ridge or sand beach known as Dead Neck Beach, which extends westerly from the main land at Osterville. Between these two points lies Sampson's or Daniels' Island, which divides the entrance into two channels, known as the Main Channel and the Old or Eastern Channel. After passing Sampson's Island the Main Channel divides into two others, known as the Middle Channel and the Western or Rushy Marsh Channel. Between these lies a small patch of marsh surrounded by a large shoal, and known as Gull Island. Inside of this entrance the first bay is called Cotuit Bay, with an area of about 295 acres, forming the

harbor of Cotuit. Lying north-easterly of this is the North Bay, with an area of about 326 acres, the easterly end of which forms the western harbor of the village of Osterville. This is connected with Cotuit Bay by the Narrows, so called, having an area of about 127 acres. Lying south of North Bay and east of Cotuit Bay is the South Bay, with an area of about 334 acres, which it is proposed to make into a new harbor for the village of Osterville by means of a cut through the narrow beach which separates it from the Sound. This South Bay is connected with the North Bay by a short channel, and with Cotuit Bay by the Sepuit River, which has an area of about 44 acres, with a general width of about 300 feet, and separated from the Sound by the narrow sand ridge called Dead Neck Beach. Lying north of and connected with the North Bay is another small bay, known as Prince's Cove or Mill River, which has an area of about 60 acres.

The general depth of water which can be utilized for sailing through these various bays and their connection is from 4 to 6 feet at low water, though at places in the Cotuit and North bays there is a much greater depth. The upper part of Sepuit River and the southerly portion of the South Bay are quite shoal, and at present are not navigable, even for light draft boats, except at or near high water.

In 1876 a petition for authority to construct a similar cut through the beach "between the necks" was made to the Legislature by Orville D. Lovell and 113 others, in which they state that it would greatly advance their business and convenience, and that this strip of beach was gradually washing away, and would within a few years leave such a passage by the natural action of the waves.

Thomas Chatfield and 43 others, largely residents of the village of Cotuit, presented a petition remonstrating against the petition of Mr. Lovell, stating that in their opinion the cutting of such a channel would prove an injury to the harbor of Cotuit; that it would lessen the current on the ebb tide, by which the Cotuit channel was kept open over the bar; and that it would make an island of Dead Neck, so called, and destroy the means of getting teams onto Grand Island, so called, which had lately been purchased by New York parties, who intended to erect buildings for summer residences there. The petition also stated that between twenty-five and thirty vessels winter at Cotuit annually, and required all the water then on the bar at average tides to pass in and out.

These petitions were referred to the committee on harbors, and the petitioners, on the recommendation of that committee, were given leave to withdraw.

While the petitions were being considered, the Harbor Commissioners, at the request of the committee on harbors, directed their engineers, Prof. Henry Mitchell and D. Koppmann, to make a general examination of the locality and to report thereon. In their report they state that the storm seas are washing away the headlands along the coast in this vicinity and strewing the sands into and across little fiords, which are characteristic features in the physical geography of this part of the country. Their visit to the locality in March, 1876, was shortly after a violent equinoctial gale. They found that the bluff about  $1\frac{1}{4}$  miles eastward of the site of the proposed cut, according to the statements of the occupant of the house at this point, had fallen back about 7 feet during that gale, the bluff at this point being about 18 feet above sea level. At the time of their visit little or no trace of this material could be distinguished on the beach. From the same parties it was learned that the material was swept to the westward as it fell. The storm began from the north-east, but veered to the south-west before it reached its greatest fury. All along the bluff, toward the site of the proposed cut, they found freshly fallen trees lying on the face of the bluff, and from the appearance of these trees and of others still standing, they judged that the bluff had fallen back at least 6 feet in the recent storm. Not only did they notice none of the material on the beach, but the parties living there stated that the width and elevation of the beach had not been noticeably changed. On the beach where the proposed cut was to be made they could discover no marked effects of the storm, with the exception of traces of trifling runs of water over it; and they state that "this isthmus, as well as we could observe, is a dry bar created by the sea, and probably falling back on the bay as the uplands on either side crumble away." They found that the bluffs to the westward of the proposed cut showed traces of great slides during the recent gale, but these slides generally did not extend to the crest of the bluff. They go on to state that "Dead Neck is slowly advancing to the south-westward, probably with material supplied by the wear of the bluffs, upon which we have commented, the point having gained 12 acres within the memory of one of the two owners, and 20, as estimated by the other. . . . The west shore of Cotuit entrance is mostly upland, presenting here and there bluffs facing the sea. The recent storm has torn the lower bluff of Cotuit Highlands (which is about 25 feet high), precipitating several living trees of considerable size. Stumps of trees are also seen beyond the bluff, betraying the effects of the storms of past years. The islands, also, of Cotuit entrance are being washed away, although the marshes, of which they are in part composed, resist obstinately

the action of the sea." In regard to the Cotuit entrances, they state: "Leaving Cotuit port, the channel is divided into two waterways by Sampson's and Russia Marsh islands; and these two divisions, although they again approach each other slightly, cross the bar separately. They no sooner escape from the confinement of the inlet than they begin to shoal up, from 10 or 12 feet in the Narrows, to 3 or 4 feet before you get 500 feet beyond them."

No surveys were made at this time, the only observations being those which could be taken during a short visit to and inquiries made at the locality, together with such information as could be obtained from the printed coast survey charts.

The information which I have sought to obtain through my surveys and investigations was to determine to what extent the volume and velocity of the tidal flow through the Cotuit entrances would be affected, providing such a cut should be made through the beach from the South Bay, as would create a navigable channel for boats drawing in the neighborhood of three or four feet.

I first obtained from the U. S. Coast Survey Office at Washington copies of all their surveys of this locality up to the present time. They sent me three plans of soundings, one made in 1854, one in 1855 and 1856, and one in 1888, the survey of 1888 being the only one in which the soundings were taken in the bays, but even at this time none were taken in the South Bay. They also sent copies of the plans of their surveys of the topography, one made in 1846, and the other in 1890. This last survey I have used as the basis for the plan which I have made.

In starting the work, I first established tide gauges, one near the entrance of Cotuit Harbor on the wharf of Mr. Morse, just south of Cotuit Highlands; another on the wharf of Mr. Scoville, about a mile east of the proposed cut; and a third at the bridge between the village of Osterville and Grand Island. Four subsidiary gauges were established, one at each end of the Narrows between the North Bay and Cotuit Bay; one at the head of Eel River, near the proposed cut; and the fourth at the south-westerly corner of the South Bay, near the head of Sepuit River. Soundings were taken all over the South Bay, Eel River, Sepuit River, the Narrows, and from Cotuit Bay out through the entrances and to a line beyond the bar. Observations were made of high and low water for more than a month at each of the three main gauges, and simultaneous readings were taken at all of the gauges on two different occasions for a full tide.

A system of triangulation was extended from two stations of the coast survey over the area under examination. Based on this

the shore line of Mill River, Eel River and a portion of the North and South Bay near the Grand Island bridge, and of the South Bay near the head of Sepuit River, was surveyed and mapped to supplement the copies of the coast survey maps, which we obtained from Washington. The velocity of the flood and ebb currents was measured at three stations,—one in the Sound about 1,000 feet south from the shore of Dead Neck; one in the old outlet of Cotuit harbor, between the point of Dead Neck Beach and Sampson's Island; and the other in the present outlet, between Sampson's Island and Codman's Point. From the results of these surveys and observations we find that the mean range of the tide in the Sound at this locality is nearly three feet; the area of the various bays, mean range of the tide and tidal volume of each are given in the following table:—

	Area. Square Feet.	Mean Range of Tide. Feet.	Mean Tidal Volume. Cubic Feet.
Cotuit Bay, . . . . .	12,832,500	2.85	36,572,625
The Narrows, . . . . .	5,525,000	2.7	14,917,500
North Bay, . . . . .	14,225,000	2.6	36,985,000
Mill River, . . . . .	2,581,500	2.0	5,163,000
South Bay, . . . . .	14,570,000	2.14	31,179,800
Sepuit River, . . . . .	1,937,500	2.7	5,231,250

The depth of water at the present time over the bar at Cotuit entrance is about  $3\frac{1}{2}$  feet at mean low water, which is substantially the depth testified to at the hearings at Osterville and Cotuit.

An examination of the cross-sections of the beach on either side of Dead Neck shows that from the crest of the ridge down to nearly 3 feet below mean low water the slope of the outside beach is quite regular and rapid, averaging about 15 to 1. Below this the bottom is very flat, the depths of 3 feet below mean low water being found from 200 to 300 feet beyond the high-water mark; 4 feet, from 600 to 800 feet; and 5 feet, from 800 to 1,000 feet beyond the same mark, the water deepening most rapidly opposite the head of Sepuit River.

The bottom of the Sound just outside of the bluff of Dead Neck, and opposite Sampson's and Gull islands, is covered with boulders generally 6 inches to a foot or more in diameter, indicat-

ing that these areas were originally portions of the upland which have been washed away. There appears to be no eel grass growing in these localities, but the bottom is very flat, with the boulders lying practically on the surface.

I have examined the shore of the Sound from the East Bay at Osterville to Popponessett entrance, a distance of about 5 miles. All the bluffs along this distance show the effects of having caved down and been washed away by the sea, and, wherever they are unprotected by artificial structures, are still being worn away. The protected portions extend about 1,500 feet north-east and about 3,000 feet south-west from the wharf near the Cotocheset House, and for a distance of about 2,000 feet in front of the premises of Mr. Morse and others at Cotuit.

The method which has been adopted for protecting the bluffs in this vicinity consists of building a wooden bulkhead at the foot of the bank at about extreme high-water mark, consisting of heavy stakes driven by hammers, with 2-inch plank spiked on the inner faces of the stakes. Extending from these and at right angles thereto are similar bulkheads or jetties which extend down to or below low-water mark, and from 20 to 50 feet apart. The top edges of the plank are left about a foot above the surface of the beach. These jetties tend to break up the waves striking on the beach and prevent them from undermining the bulkhead and from drifting the material along the shore. The tendency of the sand and shingle to drift along the shore is shown wherever these jetties are placed, by the sand being piled up on the side of the jetties from which the sand is coming and being cut away from the opposite side. The bulkhead along the high-water line intercepts the material which has caved down from the bank by the action of the frost and surface water, and prevents it being carried out into the sea, where it would be drifted along the beach. This construction is comparatively light and is often injured by the heavy seas and requires constant repairs, but has proved quite effective in stopping the wear of the bluffs. The bluffs of Dead Neck are still unprotected. Portions of the westerly end of Dead Neck Beach and the easterly ends of Popponessett and East Bay beaches are growing. The accumulations of sand collected by the protective works which have been built show that the sand has apparently been drifting along the shore from west to east, while the growth of the Popponessett and East Bay beaches is an additional indication that the drift of the sand is in the same direction. The growth of the westerly end of Dead Neck Beach would seem to indicate that at some point between Dead Neck bluff and the Cotocheset House the drift of the sand changes, and along Dead Neck Beach and bluffs

the material travels from east to west. In studying the question of the wear of the shore, I have compared the topographical sheets of the coast survey, made in 1846 and 1890. This comparison shows that between the break which was made in the Popponessett Beach about 1886 or 1887, and the present entrance to the East Bay (a distance of about 5 miles) the bluffs and beaches have worn away in some places and advanced in others, so that the areas within the high-water lines of 1890 show a loss of 110 acres and an increase of 58 acres in these forty-four years. The increase is principally at the ends of Popponessett, Dead Neck and East Bay beaches, while the decrease is mainly along the high upland bluffs of glacial drift and at the two islands in the Cotuit entrance. Portions of the Popponessett and East Bay beaches have been driven in toward the main land without material change in their size, while other portions of Popponessett Beach and a portion of the Dead Neck Beach have been materially reduced in width. One of the islands in the Cotuit entrance has been practically all washed away. The whole of the sand ridge which formed the main portion of it has been washed away to below the level of low water, leaving only a small circular area of marsh, about 30 or 40 feet in diameter, whose surface is a little above the level of low water.

As before stated, no soundings were taken by the coast survey previous to 1888 within the Cotuit entrance and bays, and the 1888 surveys were too general to be of much value in comparing with our more detailed survey.

I learned from some of the boatmen and others that within their remembrance there was an area of deep water lying between the end of Popponessett Beach and Gull Island, where vessels could lie at anchor afloat at all stages of the tide. They stated that this had so filled up that it would be dangerous for a vessel to anchor there now. By comparing the survey which I made in July, 1893, in connection with the investigation to locate the boundary line between Mashpee and Barnstable through Popponessett Bay, with our recent surveys, I find that since 1893 the westerly point of the Gull Island shoal has grown out into the Rushy Marsh channel, reducing its width and depth; also that the channel from Popponessett Bay has been forced farther to the north-east, and is now partially within what was in 1893 the channel from Cotuit Bay; also that a shoal has grown out from the main land opposite the north-westerly point of the Gull Island shoal, so that the Rushy Marsh channel is now only 60 to 70 feet wide for a distance of about 300 feet at this place. The sand along the shore between Popponessett Beach and Codman's or Bluff Point appears to be drifting from the

south-west to the north-east, as testified to by Mr. Morse at the hearing at Cotuit, and as shown by the piling up of the sand against the jetties which have been built in front of his premises, and along the shore south-westerly from him. As this sand reaches the end of Codman's or Bluff Point, the ebb current evidently takes a portion of it and pushes it back toward the sea, making the hook-shaped shoal extending from Codman's Point southerly and south-westerly, substantially parallel with the north-westerly side of Sampson's or Daniels' Island, the main entrance to the harbor lying between the island and this shoal. The balance of the material has probably been carried along by the flood tide and spread over the outer or southerly portion of the Cotuit Bay, but I have not been able to find any direct evidence of this. The material from the southerly end of Sampson's Island appears to have been driven round to the north-westerly point of the island, and mainly deposited there in a long shoal which extends westerly and south-westerly therefrom. These two shoals appear to be ridges built out into a deep depression which formerly existed between the main land and Daniels' and Gull islands, and apparently are tending to gradually fill it up, leaving only a small channel through it for the passage of tide water in and out of Cotuit Bay.

The investigations which I have made tend to show that Daniels' Island and Gull Island are the remains of two points of a large island of glacial drift, which covered the territory lying south-east of the existing islands, the basin lying between it and the main land being of considerable depth, and similar to the present Cotuit Bay. By the wearing away of the island, material has been supplied for building the shoals in the vicinity; and now the main land, having lost the protection from the wind and waves which was afforded by the island, is wearing away, the point south-west of Mr. Morse's estate having lost over 8 acres since 1846; and the material so furnished, together with material from the remains of the island, is gradually filling up the basin, and it seems to me that it is only a question of a very few years before the Rushy Marsh channel will be closed at the narrow gut between the north-westerly point of Gull Island shoal and the main land, and the only available entrance to Cotuit will be through what is now known as the Middle channel between Gull Island and Daniels' Island.

In the petition of Orville D. Lovell and others to the Legislature in 1876 for authority to excavate a channel from Eel River into the Sound, they stated that the beach at this point was washing gradually away and would within a few years leave such a passage

by the natural action of the waves. In commenting on this, the engineers of the Board in 1876 state that "this isthmus, as well as we could observe, is a dry bar created by the sea and probably falling back on the bay as the uplands on either side crumble away." By a comparison of the coast survey plans of 1846 and 1890, I find that the inner edge of the ridge or sand bar on both sides of Dead Neck has not moved appreciably, while the high-water line on the outer side has worn away very much, a comparison of the plans showing a loss of about 50 to 60 feet in width opposite Eel River and about 40 feet on the west of Dead Neck. From this evidence it would seem that there is some ground to expect that a cut would be made here at some time by the operations of nature; but at the rate the beach has worn away in the last forty-four years, it will take considerable time yet to accomplish it, and even if such a break should occur, it might close again in the same manner as the break through Popponeset Beach closed within a few years after it occurred, unless some means were taken to protect and maintain it by building jetties or similar structures.

In studying the question of a new entrance for Osterville harbor through the beach into the South Bay, which will not injure the harbor of Cotuit, the following conditions are to be satisfied. The amount of tidal volume passing in and out of the new entrance shall not reduce the volume now passing in and out of Cotuit entrance, and the cut shall be of sufficient size to enable yachts and boats to pass in and out readily. From the results of our tidal observations, we find that the rise and fall of the tide in the South and North bays is not as great as in the Cotuit Bay. If an entrance can be made of such a size as to allow an amount of tide water to enter and leave the South Bay through it, which, together with the tide water which now enters and leaves it through the Cotuit Bay, will give as great a range of tide there as now occurs in the Cotuit Bay, the Cotuit entrance would still have its full volume of tidal flow, the new entrance taking only the volume given by the increased tidal capacity caused by the direct connection with the Sound. After making many inquiries and calculations, I have finally fixed on a channel with a maximum width of 175 feet and a depth of 3 feet at mean low water, with jetties at its mouth extending to a depth of 4 feet at mean low water in the Sound; the width of 175 feet to extend through the beach from low water on the outside to the edge of marsh on the inside. This part should be protected by timber bulkheads. The jetties on the outside to gradually diverge from the low-water line, so as to be 200 feet apart at their outer ends. The channel in the bay to be excavated 225 feet wide on the bottom, and to extend from the edge of the

marsh at the end of the cut through the beach about 2,000 feet into the bay, in a north-easterly direction, to where there is at present a depth of 3 feet at mean low water. This channel, with tidal velocities on an average tide equal to those which were measured in the main channel of the Cotuit entrance, would allow 13,000,000 cubic feet to pass through it on an average tide. The increase in the tidal volume, which can be obtained by giving freer access between the South Bay and the Sound, is 10,300,000 cubic feet for the South Bay and 1,500,000 cubic feet for the North Bay. The changes in the other bays will probably be too small to seriously affect the result, the tendency being to increase the tidal volume in each case. If such a cut is made and the sides thoroughly protected, I think that the effect on the entrance at Cotuit will be so immaterial as not to influence navigation, though, at the same time, I wish to call attention to the statement which I have previously made, that the Cotuit entrance is liable in a very short time to have its available navigable depth materially reduced from existing causes.

In considering the best location for the proposed cut, two places have suggested themselves: One through the beach at the head of Eel River, "Between the Necks" so called, which is the place described in the petition to the Legislature, and the other through the beach on the westerly side of Dead Neck near the head of Sepuit River. As before stated, the beach at each place slopes down rapidly nearly to the level of 3 feet below low water. Beyond this slope the increase in depth is a little more rapid at the west side of Dead Neck than at the Eel River location. The amount of excavation required through the beach and to the 3-foot curve on the outside beach is about the same in either case. The total excavation required is 18,000 cubic yards greater on the west side of Dead Neck than on the Eel River side. On the west side the bay is open and the wind has a free sweep across it, especially from the southwest, which is the prevailing summer wind. The Eel River is very narrow, there being a distance of only 200 to 300 feet between the trees lining the banks on either side; these trees intercept the wind to such an extent that sail-boats would have to be rowed or poled through it most of the time, even in windy weather, while on the west side of Dead Neck, the wind being comparatively unobstructed, they could sail in and out freely. The amount of jetty work would not be materially different in either location, — probably a little less on the west side. Taking everything into consideration, it seems to me that the best location for the cut is a section of the beach owned by the proprietors of Grand Island, and situated just west of Dead Neck. If this location is

adopted, it will also do away with any question of damages to be claimed by the owner of Dead Neck on account of cutting off his access to the same from the main land.

The methods to be adopted in excavating the proposed channel and in providing for its maintenance require much study and consideration. Any simple excavation through the beach, with the expectation that the tidal current will scour out a navigable channel, will probably result in failure, as the material drifting along the shore and scoured out by the current would undoubtedly form bars around the mouth, which would render it useless for purposes of navigation, even if it did not completely close it. Owing to the small rise and fall of the tide, the volume of water which will pass in and out of such an entrance will be comparatively small; and in a channel of sufficient size for the purposes of navigation, the velocity of the currents must necessarily be small, so that we cannot rely on the currents—whose maximum velocity would probably never exceed 3 feet per second and whose average maximum velocity will probably be less than 2 feet per second—to do much more than maintain a channel which has been artificially excavated. In order to direct this current so that it shall disperse material which may be drifted across the channel along the shore and also as far as possible to intercept such material and prevent its entering the channel, it will be necessary to build jetties extending for a considerable distance out into the Sound on each side of the channel; these should extend out to where the depth of water is such that the bottom is not materially disturbed by the waves; in this case I think that it would be sufficient to extend the jetties about 500 feet from high-water mark to where the depth is not less than 4 feet at mean low water. These should be built of stone, to be permanent; but, from the success which has been had with timber jetties along the coast to the eastward of this locality, and as the best dimensions for the proposed channel may be shown by experience to be somewhat different from those first adopted, I recommend that the jetties here should be built at first of piles and timber, with the expectation that when they are weakened or destroyed by the action of decay and the worms they can be replaced by stone, and the permanent work can probably be done more cheaply than at the present time, as the vessels bringing the stone will at that time have the advantage of the deep water of the new channel and the protection afforded by the timber jetties. A timber jetty will probably last at least four or five years, which will doubtless be long enough to determine whether the new entrance is of sufficient value to warrant the additional expenditure for a more permanent construction.

I have made the following estimates of the cost of construction of such a channel, with the necessary timber jetties to protect the sides of the cut through the beach and to protect the entrance from the drift of sand along the beach.

*Estimate for Channel 175 Feet Wide.*

550 oak piles, 12 to 20 feet long, in place, . . . . .	\$2,240 00
67 M spruce timber, at \$18, . . . . .	1,206 00
6,000 pounds bolts and nails, at 3 cents, . . . . .	180 00
Labor, . . . . .	1,500 00
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	\$5,126 00
Plus 10 per cent., . . . . .	513 00
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	\$5,639 00
Excavation: —	
50,000 cubic yards, at 30 cents, . . . . .	\$15,000 00
Plus 10 per cent., . . . . .	1,500 00
	<hr/>
	16,500 00
	<hr/>
	\$22,139 00

The depth of this channel was fixed by the depth of water required for boats used in this locality, and the width is the maximum width to which a channel of this depth could be excavated without liability to injure the Cotuit entrance. If a channel of less width was excavated, the volume of water which could pass in and out with each tide would be less, and no disturbance to the currents in Cotuit harbor would result therefrom. The boats which are used in this locality are small, and, in order to reduce the expense of the work, I would suggest that the width of the channel to be constructed should be fixed at 100 feet, which would enable the boats to pass in and out freely, except when the wind is dead ahead.

In accordance with this recommendation, I have made the following estimate for a channel 100 feet wide, the other conditions being the same as those in the first estimate: —

*Estimate for Channel 100 Feet Wide.*

550 oak piles, 12 to 20 feet long in place, . . . . .	\$2,240 00
67 M spruce timber, at \$18, . . . . .	1,206 00
6,000 pounds bolts and nails, at 3 cents, . . . . .	180 00
Labor, . . . . .	1,500 00
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	\$5,126 00
Plus 10 per cent., . . . . .	513 00
Excavation: —	
25,000 cubic yards, at 30 cents, . . . . .	\$7,500 00
Plus 10 per cent., . . . . .	750 00
	<hr/>
	8,250 00
	<hr/>
	\$13,889 00

The following are the statistics of the work done in making the surveys :—

Triangulation stations occupied, . . . .	23
Triangulation stations determined, . . . .	29
Shore lines surveyed (miles), . . . .	8
Lines of soundings run (miles), . . . .	83
Number of soundings taken, . . . .	11,339
Lines of levels run (miles), . . . .	13
Tide gauges established, . . . .	7
Full tides observed, . . . .	11
High and low waters observed, . . . .	430
Current stations occupied, . . . .	3
Current observations made, . . . .	542

The results have been plotted on a series of plans, on a scale of  $\frac{1}{5000}$ . In addition, a plan of the South Bay has been plotted on a scale of  $\frac{1}{2000}$ , for the purpose of studying the best location for the proposed cut. A number of other diagrams of tidal and current observations have also been made.

Respectfully submitted,

FRANK W. HODGDON,  
*Engineer.*