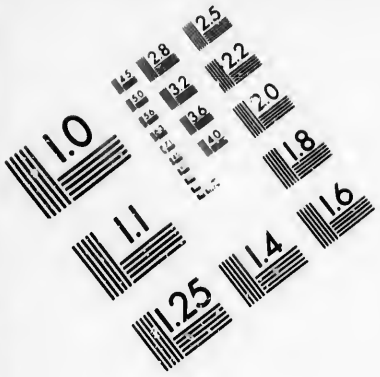

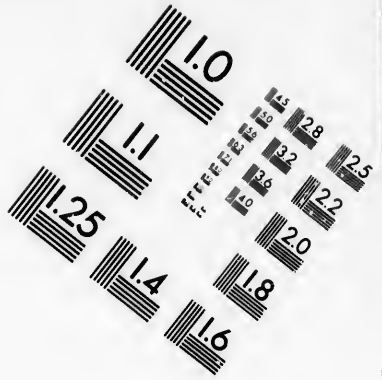

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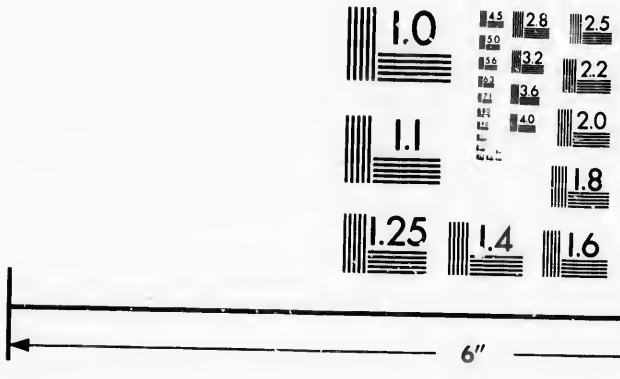

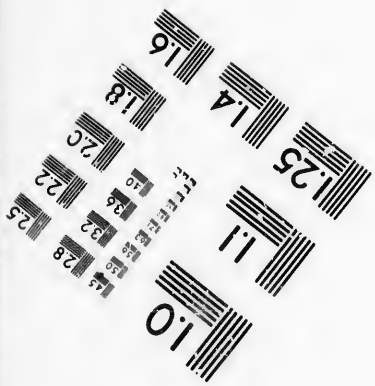

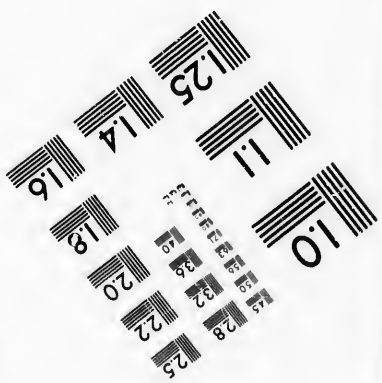

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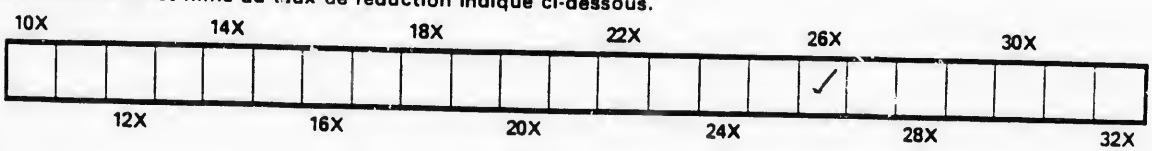

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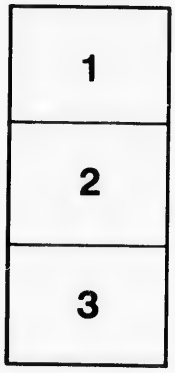

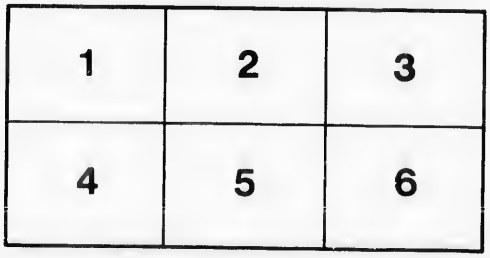

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EFFECTS OF ENGINEERING WORKS ON WATER CURRENTS.

By Cyrus Carroll, C.E., M.Can.Soc.C.E.

To be read Thursday, 12th March, 1896.

It is believed that in designing piers, abutments, breakwaters, wharves, and the like, too little attention is generally given to the effects such works are likely to produce by reason of their inducing currents or interfering with those already existing. We see fairly navigable rivers ruined for purposes of navigation by currents interfered with by costly works that have not fully answered the purpose intended. These failures very frequently result from ignoring certain fundamental laws that should guide us into working in harmony with the natural tendency of the elements we have to deal with. If at present a beach is forming, let us, if possible, in using it so manage as not to prevent it from continuing its formation. If a river enters a lake in a peculiar manner, beware of diverting it—rather assist it in keeping its normal course. In whatever way the bar across its mouth has been made, heightened and strengthened in one part so as to form a basin at the mouth of the river, by penning back its waters by the dam so made,—and in another part washed away to form a deeper channel for the river, the natural tendency of *the elements* is to continue such action and formation.

Does a current follow along the lake shore or meet a river-current in any prevailing manner: do not obstruct it very much if you would avoid shoaling water. Do not divert it without weighing well the effect such diversion may have on works already constructed or hereafter to be made in such locality.

In the case of rivers having one constant direction of current, resulting from gravity, it has been found that the planting of abutments on either side, and piers in the stream will cause a washing away of the banks above such works—that is to say, on the up stream side. This is especially true of rivers of 50 to 100 yards in width, and having a rapid current. Such effects will be minimized by planting the abutments well back into the banks, and making piers as narrow as possible. Where timber is easily got, the writer has found it most economical to drive a single line of piles for each pier for common road bridges, then to frame a heavy cap on top, making it a bent in fact. The sides are planked up to above high water line, not only to keep out floating timber, but to serve as diagonal bracing as well.

Where banks begin to wash away, it has been found that fine brush is generally the best and cheapest remedy. It should be secured by stakes or stone, or both, as the case may warrant.

In Lakes Huron and Erie the shore currents point down the lakes, in the direction of the natural flow of the water. This, it is thought, is a mere coincidence, as there is not enough of flow of water to make any appreciable current. The prevailing winds are no doubt the cause of the more constant currents along the shores.

In Fig. 1, (Plate H), we have a very fair illustration of the mouths of the Rivers Saugeen, North Sables, Penetangore, Pine River, Maitland,

Bayfield, South Sables and other rivers. By turning the same diagram as indicated by the dotted north point, it fairly represents Kettle Creek, Big Otter Creek, Little Otter Creek, Catfish Creek, and other rivers and streams flowing into Lake Erie. Long Point too bears down the lake.

It will be noticed that sand bars are formed across the ends of the river valleys, as the results of the opposing currents of rivers and lakes meeting, sometimes fairly and squarely, but generally at an angle, when they coalesce and form one current, the direction of which is determined by their relative forces after the manner of the polygon of forces.

These sand bars begin at the windward side of the valley, and extend quite across, being crowded out into the lake water at the end, by the river current prevailing over the lake current at that point. The river too is crowded against its leeward bank, which is often very steep from being washed away at the base. As a result of such crowding of bar and river, the channel is often narrow and deep where it passes the bar. The bar or bank on the windward side is strengthened and re-enforced by the wash of lake silt up against it. On the river side of the basin the bar is strengthened by the silt of the river constantly being deposited. The river bank, or rather the lake bank, on the leeward side is generally washed away. This is particularly noticeable at Port Burwell and Port Stanley, where large areas of high table land have been washed away within the last 50 years.

In Fig. 2 (Plate II) we see how some of these basins have been made to answer as harbours, after a fashion, as they could not always be entered during storms, though, as a general rule, any vessel making the lee side of the longer pier could in the stiller water move along into the harbour, or tie up to the pier. In case of very rough weather on Lakes Huron and Erie, vessels make for the large rivers at either end of such lakes, or seek the shelter of an island if near to one. Failing these, they anchor and endeavour to ride out the gale.

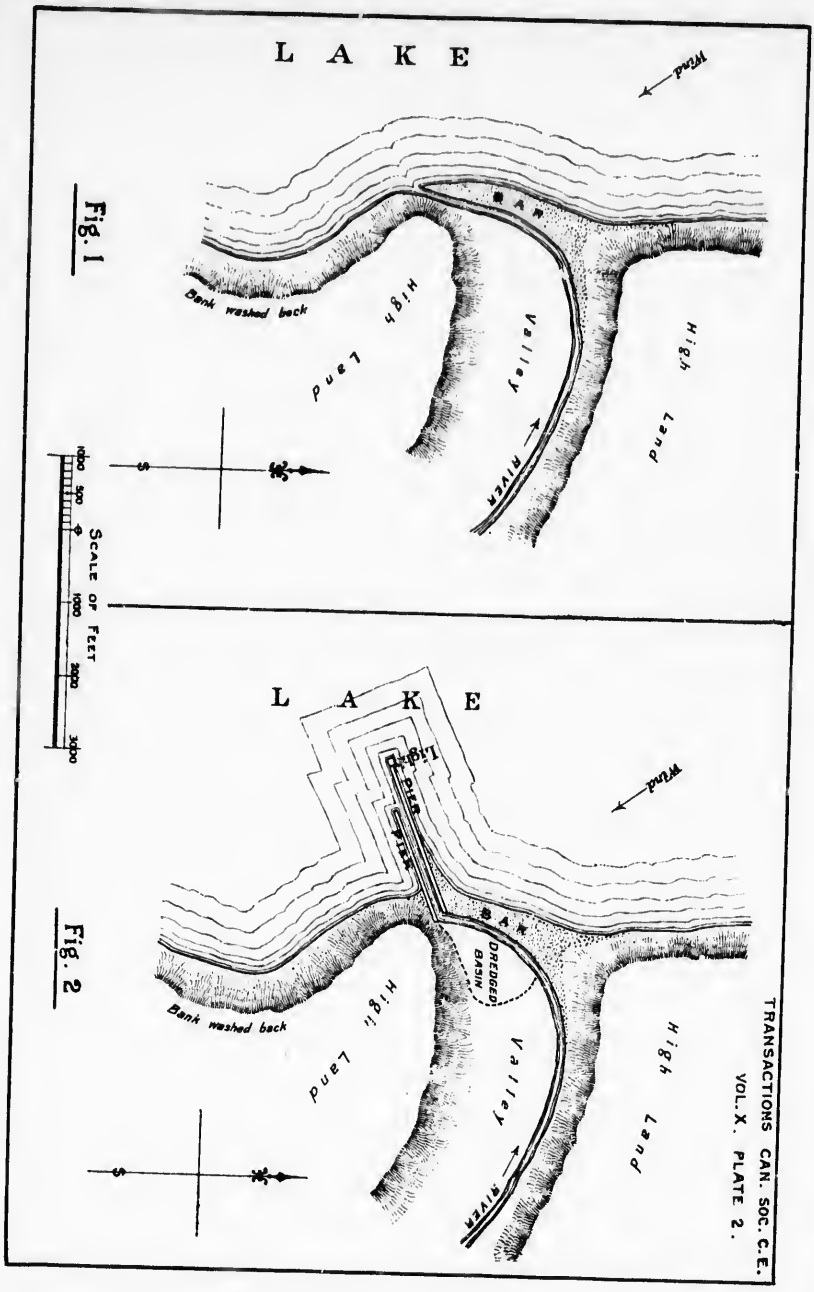
It is here submitted that the plan, Fig. 2 (Plate II), is the best that can be adopted in utilizing at a moderate cost the mouths of rivers entering lakes. Where such works have not proved sufficient, it would be much the best and cheapest way to continue such works out into deeper water.

In no case is it advisable to close up the old channel and form a new one by cutting through the bar or beach. In Fig. 3 (Plate III) we have an illustration of the effects of changing the channel of a river.

Lake Burwell, with its neighbour, Lake Smith, formerly portions of Lake Huron, but in comparatively recent times cut off from that body of water but not yet filled up by sand dunes, have for their outlet the South Sables river. The sand dunes extend from the old shore of Lake Huron to its present shore, the distance between such old and new shores being at Port Franks about 4 miles. The river reached the lake by a very circuitous route. Lakes Burwell and Smith being first cut off by the dunes, the river flowed out northerly, the dunes about said lakes becoming higher and extending northerly by the action of Lake Huron, crowded the river up against the edge of the higher land. Thus was the line of the dunes extended northerly—and with it, the channel of the river, till the nature of the shore at the Great Bend turned the river nearly due west. There the current of the lake opposed it from the north west, and then a bar or beach began to form between the river and lake, crowding the river close up to and along the base of the dunes already formed. The beach extended several miles, as shown in the sketch. Had the river not been interfered with, the beach would in time doubtless have reached Kettle Point, where, from the nature of the bottom, the formation of the beach and of the dunes must have ceased.

In the sketch Fig. 3 (Plate III) it will be noticed there are a few sections of old channel not yet filled up. The river must have been obstructed here at different times from natural causes—new mouths made and old ones closed.

From Grand Bend to Port Franks the course of the river shows that



has now made a channel out to the lake 100 to 200 yards in width. As might have been expected, a beach or bar at once began to form across the mouth of the canal from its north side. This is rapidly extending southerly, and carrying the channel along the base of the old dunes, on the line that was the margin of Lake Huron previous to the building of this canal, with the beach between the channel and the lake almost parallel to the old channel of the river.

* The term "regimen" has for several years been used by the U. S. A. Engineers to express the natural and equable condition of a river such as it has acquired from natural causes and in a long period of time.

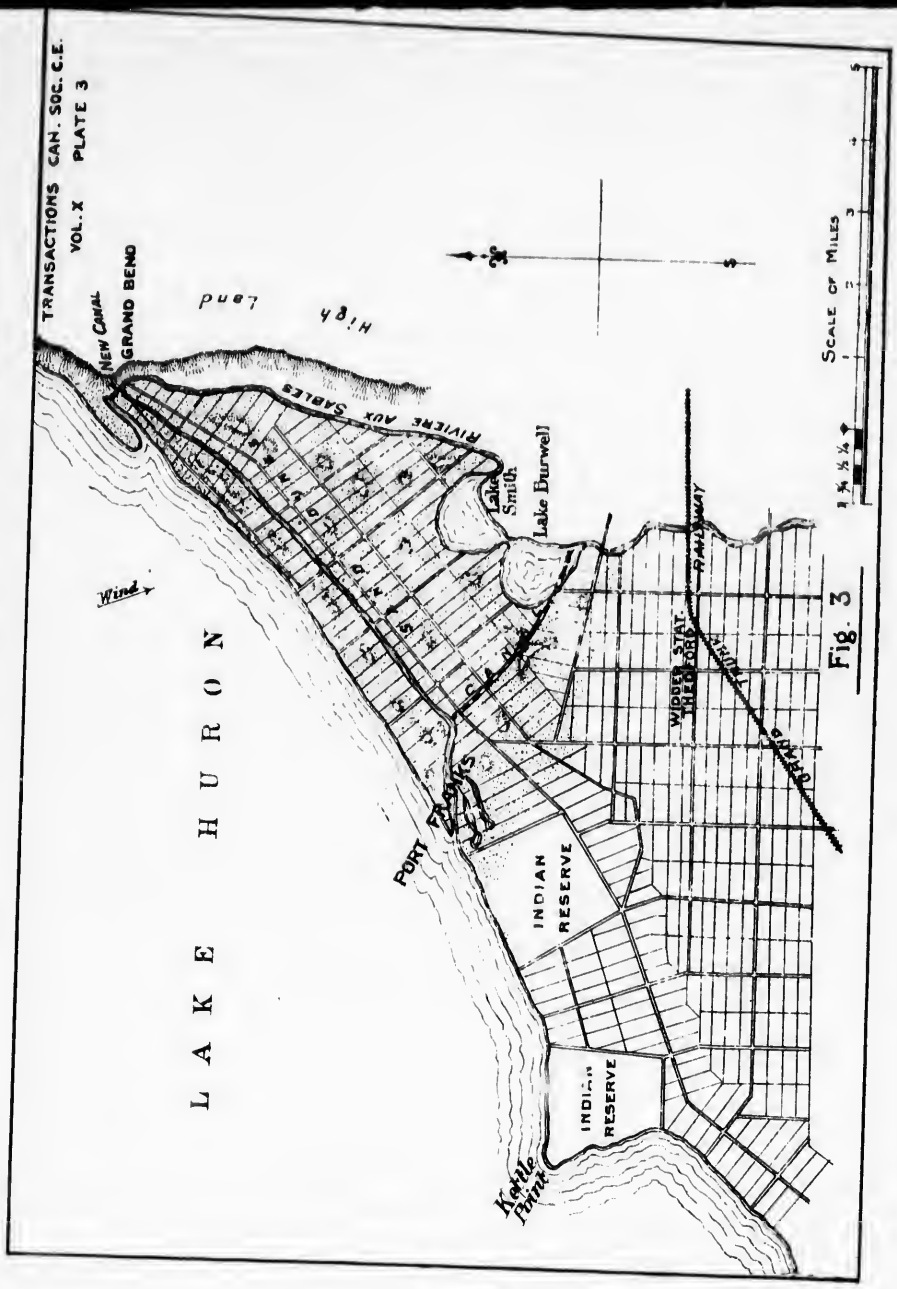


Fig. 3

channel of the river, in which it was at least once disabled by coming in contact with timber buried in the mud and sand. The flow of water has now made a channel out to the lake 100 to 200 yards in width. As might have been expected, a beach or bar at once began to form across the mouth of the canal from its north side. This is rapidly extending southerly, and carrying the channel along the base of the old dunes, on the line that was the margin of Lake Huron previous to the building of this canal, with the beach between the channel and the lake almost parallel to the old channel of the river.

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it followed along the base of the dunes that had been previously formed. In 1882 a contract was let for the excavation of the Lake Burwell canal. The canal was intended to act as a drain, to reclaim 16,000 acres of land, which at $5 per acre would amount to $80,000.

The cost of the canal was about $80,000, but the result was very disappointing. Land was benefited to some extent, but not reclaimed. Only 1000 acres of the benefited lands have been sold. The canal began at 1½ miles east of Lake Burwell, bottom width 30 feet, side slopes 1½ to 1, average depth about 6 feet in clay and vegetable matter. About one mile of the canal through Lake Burwell in water and soft mud. Then west of Lake Burwell, through two ridges of 65 and 75 feet elevation, and generally about 30 feet of elevation for the distance of 1½ miles to the Sables River, where the canal ended. The author has been unable to learn how the excavation was done, but thinks it was probably by tram-cars and dredge. Lake Burwell was about 4 feet above Lake Huron. As soon as a trench was made, the water rushed out with such force as in a short time to excavate a channel an eighth of a mile wide. The immense amount of sand carried out into the river stopped up the mouth, and a new mouth was formed farther to the north. Mouths were successively formed and closed in a retrograde manner,—that is to say, each new one to the north of that which had preceded it. The river channel from the canal forwards was continually choking, shifting and shoaling. A tug at the end of the canal could only get out to Lake Huron and back again by going backwards, so that the screw would scoop out the sand so as to leave a channel for it to float in.

There was a considerable amount of lumber produced at Port Franks; also salt,—there being large salt works there. Since the canal was dug, the river is so spoiled for navigation that these products are teamed 4 miles over the soft dunes to the Grand Trunk Railway.

The *regimen** of the river has been completely destroyed. No works of a permanent nature can be made at the lake shore or along the river. The damage resulting is not easy to compute in dollars and cents. Every year, and up to the present time, every freshet brings down a lot of sand for the river to work through and out of as it may. The narrowest part of the canal is 60 feet, its widest ¼ of a mile, and this through and amongst the highest of the dunes. Lake Burwell is nearly dry every summer. Lake Smith covers two-thirds of its former area.

From the Grand Bend, the old channel, deprived of its current and of carrying the water out of Lakes Burwell and Smith, filled up for a very considerable part of the distance between Grand Bend and Port Franks—on this portion so filled, the sands are heaped up so that no trace of the former channel is visible. The lands near Grand Bend became worse flooded with water than before.

In 1892 a new canal was cut through the beach at Grand Bend, at a cost of $21,500. It was to have a bottom width of 30 feet, slopes 1½ to 1. The general depth of the beach was 30 feet; length of canal ¼ of a mile. It was excavated as follows: top part by scrapers; then by spade, tram car, etc., till a small stream trickled through the trench. This soon washed out a channel nearly as required. The work was completed by a dredge worked in from Lake Huron through the beach, and thence where required, for several miles up the old channel of the river, in which it was at least once disabled by coming in contact with timber buried in the mud and sand. The flow of water has now made a channel out to the lake 100 to 200 yards in width. As might have been expected, a beach or bar at once began to form across the mouth of the canal from its north side. This is rapidly extending southerly, and carrying the channel along the base of the old dunes, on the line that was the margin of Lake Huron previous to the building of this canal, with the beach between the channel and the lake almost parallel to the old channel of the river.

* The term "regimen" has for several years been used by the U. S. A. Engineers to express the natural and equable condition of a river such as it has acquired from natural causes and in a long period of time.

The lake bottom at Grand Bend being harder than it is farther south, the dunes were less there than they were farther to the south, —where the soft nature of the lake bottom favoured their formation. Hence the waters penned back flowed out at Grand Bend, and scoured out a channel from that point to Lake Smith, through the soft material along that part of the river. But at Grand Bend a hard bank of clay with boulders was encountered, which turned the stream west or south of west. Here the beach began to form which crowded the old river up against the base of the dunes,—and extended itself, carrying the river with it to and below Port Franks.

One of our learned Chief Justices has remarked, that the man who diverted a large river assumed an immense amount of responsibility. As the writer in 1885 stood on the bank of the canal 100 feet above the water, with the washed-out channel $\frac{1}{8}$ of a mile wide in front of him, he thought he could appreciate the force of the Judge's remark.