

attain an honourable position; whilst there, they were eminently useful, and it is to be hoped, that before long, other active and useful members of the profession will assume places in that House.

Of the urbanity and impartiality with which Mr. Locke acquitted himself of the duties of President, it is unnecessary to say a word; all that he said and did is so recent, and has been so universally approved. The Members of Council, and those who enjoyed his friendship, will long lament the loss of a genial companion, and the Institution a valuable and influential Member.

The discussion upon the Paper, No. 1,028, "On Breakwaters," by Mr. M. Scott, which was commenced at the last Meeting of Session 1859-60,¹ was resumed, and occupied the entire evening, to the exclusion of any other subject. The whole of the discussion is printed consecutively, in the Minutes of Proceedings for 1859-60.

November 20, 1860.

GEORGE PARKER BIDDER, President,
in the Chair.

No. 1,026.—"On the River Orwell and the Port of Ipswich."
By GEORGE HURWOOD, M. Inst. C.E.

THE Author has been induced to prepare this Paper, from the remark made by the President,² during the discussion of the Paper, "On Arterial Drainage and Outfalls," by Mr. Grantham, (M. Inst. C.E.,) that it would be rendering valuable service, if faithful records of the treatment of rivers, with the results, were submitted to the Institution.

Ipswich is the chief town of the County of Suffolk. The population in 1851, at the time of the last census, was 31,215, but it has been increasing for many years past, and it may now be taken at several thousands above that number.

The River Orwell constitutes, more properly, an arm of the sea, inasmuch as the inland navigable River Gipping, of which it was formerly a continuation, now terminates with a lock, within the limits of the borough of Ipswich. The Orwell extends from this lock, and a small side creek a few hundred yards above, which is covered with water at high tides, to the fine and capacious harbour of Harwich, twelve miles distant from Ipswich. The jurisdiction of the Ipswich Dock Commissioners extends to Downham Reach, and they have, hitherto, exercised control over the whole river.

¹ *Vide* Minutes of Proceedings Inst. C.E., vol. xix., p. 651 *et seq.*

² *Ibid.*, p. 105.

The following observations refer to the state of the river and port, about the beginning of the present century. That period is selected, because from that time, there exist good data for tracing the leading points of management and treatment to the present day. Prior to the passing of an Act of Parliament, in the year 1805, for the improvement of the river, the Corporation of the town had the sole management and control of the port and river; and so seriously had the latter been encroached upon and neglected, and the funds arising therefrom, been misappropriated, that great injury was inflicted upon its trade and commerce. The leading merchants, shipowners, and inhabitants, had, for many years previously, felt the grievance, and they combined for the purpose of taking active measures to correct the abuses. A Committee was appointed to undertake the management, and after due deliberation, it was determined, that an Engineer should be employed to survey the river, and prepare plans for its improvement. The services of Mr. William Chapman, of Newcastle-upon-Tyne, were engaged for that purpose. In May, 1797, he submitted a Report, with two plans, and estimates of the cost of carrying the proposed schemes into effect. Early in the year 1803, the Committee called a public meeting of the inhabitants to consider the subject, when it was almost unanimously determined to apply to Parliament for powers to improve the river, as suggested by Mr. Chapman in his plan No. 2; or at least, so much of it as the state of their finances would permit. This resulted, after considerable opposition from the Corporation, in obtaining the Act of Geo. III., cap. 101, in 1805, by which the managing power was virtually taken out of the hands of the Corporation, and was placed in those of the principal merchants, shipowners, and inhabitants of the town.

The condition of the river and port, at this time, is given in the following extracts from the Report of the Committee:—

“The channel, for about two miles from the quays, but more particularly so for the first mile, is materially reduced in width and depth, and the navigation thereof becomes intricate and difficult. The force of the tides flowing and ebbing, being thus impeded, the soil deposits more rapidly than formerly, and lessens the supply and depth of water, which, usually, at neaps, is only about 5 feet, and at spring tides, 8 feet at the quays, whereby much inconvenience and expense are caused to the trade of the port, from the detention of shipping, which frequently has to wait ten days for a tide, in getting to, or from the wharfs; and it sometimes occurs, that there is not a tide during springs sufficient to remove the shipping, without the expense of lighterage and portorage, during which, the goods are exposed to suffer much speculation and waste, and if of a perishable nature, to injury also. * * * It is true they, [the Corporation,] are the supposed conservators of the soil of the

river, and it is admitted, that they have faithfully preserved it from injury, by not suffering it to be removed for the accommodation of the trade and shipping; for want of which, the evils now complained of have principally arisen. * * * It is very usual for vessels to deliver and take in their cargoes, about three miles below the wharfs at Downham Reach, into small craft, at an additional expense beyond what would be incurred, if ships came up to the wharfs; for coals, of not less than 1*s.* 6*d.* per chaldron, on corn nearly 1*d.* per quarter, and on other goods, * * without calculating the loss for waste and speculation, which, indeed, is difficult to estimate, from the impracticability of ever seeing the transactions carried on so far from the wharfs; all which falls upon the merchant and consumer. * * * These combinations of circumstances have, at different times for the last eight, or ten years, engaged the attention of some of the principal merchants and inhabitants of the town and port of Ipswich. * * * It is the opinion of an able Engineer, that nothing short of the proposed improvements will be effectual in rendering the needful accommodation, or will put the river in such a state as the present trade of the port requires.

“The town of Ipswich consists of about 13,000 persons, exclusive of military, * * and about 6,500 to 7,000 tons of shipping belong to the port.”

As before stated, Mr. Chapman, in 1797, submitted two plans, Nos. 1 and 2, with a Report of considerable length, from which the following extracts are taken:—

“Previously to the discussion of the two different schemes which I have to offer for the improvement of the navigation to the town of Ipswich, I will make some observations on the causes of the present bad state of the river above Downham Reach, which was formerly, and even in the memory of man, much better than at present. * * The obvious cause of the channel to Ipswich being so bad, is the reduction of the tide water which, in the progress of nature, will always be growing less from the deposit of silt, but in this instance, occasioned, principally, by the inclosure of lands from the river. A part of Ipswich has, no doubt, been acquired from the ooze, but what has more particularly affected the river, has been the inclosure of, as far as I can judge from the plans, about 120 acres above Stoke Bridge, except such part as is now used for the tide mill, which so far produces a greater effect than formerly, as it is let off after the river has subsided, into a narrow channel; and also of about 60 acres between Stoke Bridge and Nova Scotia, which system still continues to exist, as still more recently, about 6, or 7 acres have been taken in, between the cliff brewhouse and the rope yards. These causes have nearly destroyed the port of Ipswich, and a remedy becomes absolutely necessary.

“You called upon me to give an opinion upon the straightening

and embanking the course of the river downwards, which might have been done with some improvement of the navigation, and great advantage as to the value of the land acquired; but the certain result of this would be, that a nearly equal extent of the river below Downham Reach, would become unnavigable as the present river down to Downham Reach, and if the same system were pursued, it would finally destroy the harbour of Harwich.

“The two schemes, or modes that occur to me, are the making of a sea lock at the head of Downham Reach, for vessels of 15, or 16 feet water to enter at all tides, and proceed by a canal to the common quay; or otherwise, the improvement of the navigation itself.

“The former is what I shall first explain. * * The advantage of this plan is, that vessels of sufficient magnitude may, at all times, go from and to the common quays at Ipswich, to Downham Reach, without regard to tides, or winds; as they may be tracked by horses all the way, and there will be no want of depth of water, although some untoward circumstances prevent its being so perfect and easy of execution, as it otherwise would have been. What I allude to, is the impracticability of obtaining land water to supply the channel, on such elevation as would be most easy of execution, without purchasing the tide mills and the next mill above them; and the impracticability, even then, of making a watercourse to the town, without an expense beyond the effect to be acquired; and also the incapability of extending the canal navigation, effectually, to the warehouses and quays, on account of the tide mill and marshes above Stoke Bridge, which could not obtain a drainage, or the mill water a passage, without a long tunnel of vast expense. These evils are, however, in a great degree obviated, by making the channel, the major part of the way, with one bank only, and consequently, flooding a considerable quantity of ooze on the inside, which, in the period intervening between the height of spring tides, would not sensibly be lowered by the consumption of the lock, in passing all the vessels that might come; and also by making a lesser lock suited to vessels under 25 feet beam, by Stoke Bridge. The expense of this plan would, according to the estimates, amount to about £27,000. * *

“Another cause, besides that I have mentioned, of the badness of the navigation, is the great crookedness of the river, which, exclusively of giving the water a less fall in a given space, checks the effect of its velocity and renders the navigation extremely difficult even for small craft. * * In laying out the new course, I have availed myself of the present channel of the river, as much as might be consistent with regular curvature, of course, and have also avoided going into the higher part of the ooze. A small curvature consistent with the width of the river is no detriment. * * *

“ I will now proceed to make some observations on the present state of the river, from Freston Reach to Ipswich. At the head of Freston Reach, there are 10 feet at low water; and spring tides rise there nearly 12 feet, when they rise only 8 feet at Ipswich Quay upon a low-water channel of little more than a foot deep; consequently, there is a fall of nearly 4 feet in the surface of the river, and 13 feet in the bed of it; there is also more than a proportionate width of channel. The distance between these two points is, by the present crooked course of the river, $3\frac{1}{4}$ miles, and by a right line, barely 2 miles. The greatest curvature takes place immediately above Freston Reach, from the head of which it strikes off nearly at right angles, and after a circuit of half a mile, arrives at the north end of the channel that dries before three-quarters ebb, called Round Ooze Lake, which is little more than 200 yards long. From thence, tracing the river upwards to Fenn Bight, the distance is half a mile, and the course of the Black Ooze Lake is but 500 yards. These two lakes form a high-water channel in a right line from Fenn Bight to the head of Freston Reach, and would, undoubtedly, have become the regular channel of the river, if it were not, that they are protected from deepening, being covered by the long fibrous grass, common to the rest of the ooze, below neap-tide high-water. On the covering of the ooze, which takes place at half-flood, and previously to its covering, the tide sets with considerable velocity through those channels, which are only from 6 to 18 inches lower than the adjoining part of the ooze. * * The main channel, notwithstanding the crookedness of the course, still continues of several feet depth at low water, near Upper Hearth Point, decreasing, however, considerably in width; from thence upwards, the bed of the river rises, and is not navigable for boats at low water.

“ The plan No. 2 shows the present channel of the river, as laid down by Mr. Bransby's survey, and the proposed altered course, which shortens the distance from Stoke Bridge to Freston Reach, full one mile, * * and at the same time, it avoids, as much as may be, the high part of the ooze, and coincides with the bed of the river, in several parts. The width of the new course of the river, as I have laid it down, is nearly what I suppose it may naturally assume, if the full extent of the proposed plan be carried into effect. * * I, however, by no means recommend the formation of so wide a channel throughout, as I have drawn it, but only to excavate between the red lines, and to defend the concave shore, by groins and jetties, and to leave the river to do the rest. Straightening alone, without producing an additional current of water, would not be productive of sufficient effect, but if an equivalent can be obtained to the quantity of water that flowed over the land that has been embanked from the river, this, in aid of the greater

straightness of course, must produce the effect desired. By running a bank in front of the quay from the head of the proposed cut * * to below Lower Hearth Point, and closing it to the east shore, [with flood-tide entrance gates,] a reservoir of 80 acres of 5 feet average depth at spring tides, would be found, and all the water to fill and empty it would pass up and down the channel which, to the lower extent of that reservoir, would produce a similar effect, or nearly similar to what an equal quantity of water, overflowing the marshes above Stoke Bridge, did formerly. * * In the making of the two channels, (that for the combined waters, * * and that in front of the quay from the reservoir,) the earth, or silt raised, will form a valuable island on which I have sketched outlines of quays, &c. * * * From these causes it is clear, that unless attended with great expense, it will be advisable to carry this plan into effect * * the sum I have estimated the works to cost is £17,000. * * In process of time, but at some distant period, the proposed reservoir will silt up so far as to fail of its full effect, and * * the ooze bordering the channel of the lower part of the river, will likewise rise; but the remedy will not be difficult, and should you apply to Parliament for the improvement and conservation of the Orwell, it may be prudent to provide for it, by obtaining the dominion as conservators of the river, from shore to shore."

In March, 1803, Mr. Chapman addressed to the Committee another Report of considerable length, in which he states:—

"In my Report of May, 1797, I had the honour of laying before you two plans; the first of them was to rise by a tide lock near Downham Reach, and to communicate from thence by a canal to a basin before the town. But as this, at that time, did not appear to me capable of including the warehouses, west of the common quay, without an expense more than adequate to the end, I was inclined to prefer the second plan, which by the measures pointed out, [viz., cutting off the abrupt turns, and improving and deepening the bed of the channel,] would have given deep water and equal accommodation to all the warehouses in the town, which bordered on the river. The latter plan was only applicable to the use of such vessels as will bear the ground; therefore, as on further inquiry, I find it highly probable, that the future commerce of Ipswich may require copper-bottomed vessels, I recommend, that if any considerable expense be incurred, it should be in the execution of such a work, as will give this rising town the means of carrying its trade to the extent it is capable of, or otherwise, that you content yourselves with obtaining a few feet more water up to the quay."

In the concluding part of this Report, Mr. Chapman endeavours

forcibly to show the advantages that would result, by carrying into effect plan No. 1, which he strongly recommends.

In November of the same year, a further Report was made by Mr. Chapman, in which he again enters fully into the advantages, both financially and otherwise, which would follow the execution of plan No. 1, but instead of proposing a navigable depth of 16 feet, as recommended in his first Report, he reduces the depth to 13 feet, which, he states, he was induced to do from having had the soil tested by borings which, in some places, were not so favourable for his project, as he had, at first, conceived. No doubt, the lessening of the cost was also another reason for his reducing the size of the lock, the depth of water, &c.

So very desirable was it, in the opinion of Mr. Chapman, to adopt the plan No. 1, that he again pressed the consideration of the subject, in another long Report in the following year, 1804, making a further modification of it, by shortening the length of the canal, and placing the entrance lock at the head of Freston Reach, instead of at the former place. It appears, however, that after this Report had been read before a full meeting of the committee of subscribers, on the eve of a public meeting of the inhabitants, the opinion was so general, that the improvements, as shown by plan No. 2, would be all that the trade required at the time, and could, with propriety, be undertaken, that Mr. Chapman, by way of post-script to his Report, writes:—

“From the bent of public opinion appearing to me to be in favour of simply deepening the river and cutting off some of the bends, * * it appears to me clearly advisable not to bring forward my Report at the general meeting to-morrow, because by creating a secession from those who are in favour of the only plan likely to be carried into effect, it may prevent anything whatever being done. Although I still decidedly prefer the plan recommended, yet the other will, undoubtedly, be an improvement of material moment to the present state of your navigation.”

In the following year, 1805, an Act of Parliament for improving the river was obtained.

The Author feels it may be considered, that in this communication, he has made extracts of unnecessary length from the Reports of Mr. Chapman; but his object has been to give a prominent place to the views of that Engineer. It is only due to him to state, as will subsequently appear, that in his plans and Reports, he clearly expressed his views of the works that should be undertaken to improve the port and river, and these plans have, with certain modifications, been approved and acted upon by succeeding Engineers.

After the passing of the Act, the first work of importance

undertaken by the Commissioners, was the excavation of a new channel, so as to cut off the awkward bend, A, by Cliff Reach; (Plate 1.) To facilitate the operations, Mr. Chapman availed himself of one of those indispensable appliances for the improvement of rivers, the steam dredger. Judging from a Report by him, upon first setting the engine to work in May, 1806, it is believed, that this was one of the earliest dredgers worked by steam. Since its introduction, the port has always possessed an engine of the kind, and to its operation during so many years, the river owes its present improved condition.

About the year 1819 a new channel, B, (Plate 1,) was cut through Round Ooze, by which the necessity of using the circuitous and difficult channel by John's Ness, was avoided; and in the year 1821, under the advice and superintendence of Sir William Cubitt, (Past-President Inst. C.E.,) a new channel, C, (Plate 1,) was cut, from the upper end of Lime Kiln Reach to the lower end of Hog Island Reach.

The works undertaken by the Commissioners had so far improved the channel of the river, that in 1826, vessels drawing about 11 feet of water, could reach the quays at spring tides. Notwithstanding the necessary outlay for these works, the Commissioners had also saved, at this period, from the revenue of the port and river, the sum of £25,000, which enabled them to effect further improvements. Powers were obtained in 1837, under the Act of 1 Vic., cap. 74, to make a wet dock, and the works were immediately commenced under the direction and superintendence of the late Mr. H. R. Palmer, by the authority of the Dock Commissioners, who were also intrusted, under the Act, with the management of the river. At the commencement of the year 1842, the works were sufficiently advanced to maintain the float. Upon the retirement of Mr. Palmer in that year, the Author succeeded him, and has since held the appointment.

In 1845, the cutting for a new channel, D, (Plate 1,) through Black Ooze was commenced, and it was completed in 1847. The curves from Cliff Reach to the Upper Hearth Point, the Lower Hearth Point, and also Wherstead Reach Point, where awkward projections existed, have all been considerably reduced. The channel from the lock of the wet dock to the deeper water near Downham Reach, has been dredged to a level bottom, nearly a foot lower than the top of the lock cill; and all the shoals are removed, as soon as possible, after their discovery. The effect of these continuous and combined operations through a series of years, has been, to give a clear depth of water from the sea to the wet dock, of 16 feet 4 inches, at average spring tides, and an average low-water depth of not less than 3 feet 3 inches throughout the channel, from the dock to the sea.

It may be observed, that when the wet dock was opened in 1842, vessels of about 13 feet draught, could reach the dock at average spring tides. Since that period, it has been an object, not only to increase the depth of water by dredging, but also to regularise, by degrees, the course of the channel, thereby making it less difficult to navigate, and at the same time, giving greater freedom for the flow and ebb of the tide. This is very important; for upon the tidal operations, the preservation of the river entirely depends, and every available means have been adopted, to encourage the easy flowing of the tide, to enlarge the area which receives it, and to prevent any encroachment upon the space it covers, particularly in the upper part of the river. The water from the sea is very clear, and leaves no perceptible deposit. But near the town, an increasing deposit is taking place, on account of the sewage being improperly discharged into the river by the corporate authorities, against the remonstrances of the Dock Commissioners.

The following are the particulars of the tides of the Orwell, taken from the Admiralty Survey of 1844 :—

	High Water, F. and C.		Rise and Fall.			High Water, F. and C.		Rise and Fall.	
	H.	M.	Ft.	In.		H.	M.	Ft.	In.
Harwich . . .	12	0	11	6	Mulberry Middle. Ipswich Dock .	12	27	12	2
Pin Mill . . .	12	20	11	11		12	35	13	7

At Ipswich Dock, the average rise of neap tides is 8 feet 8 inches. The average depths upon the lock cill, are :—

	Ft.	In.		Ft.	In.
High water, spring tide . .	16	4	Low water, spring tide . .	3	3
" neap tide . . .	13	5	" neap tide . . .	4	9
Mean high water of all tides	14	10	Mean low water of all tides	4	2

The rate of spring tides, within two miles, or three miles of Ipswich, is about $1\frac{3}{4}$ knot per hour. The periods of duration of the flood and ebb tides at Ipswich Dock are very nearly equal, and the stationary state of the tide at low water is of short duration, and seldom perceptible.

The port has but one dock, the area of which is about 33 acres; it is accessible on all sides, and the quays are connected with the railway. The length of the lock between the gates is 150 feet, and the width is 45 feet.

The cost of the wet dock and of the works connected with it, has been about £130,000. The money was borrowed on the security of the dues, at a fixed rate of interest which has been punctually paid, and a balance is annually left in favour of the port.

The Commissioners of the port, in whom the governing powers are vested, are chosen and elected in the manner prescribed by

the Act of Parliament, 1 Vic., cap. 74, clause 14. They annually elect a Managing Committee, which meets regularly every month, (formerly every fortnight,) and oftener, when requisite. Their proceedings are carefully recorded and are submitted, monthly, to the general body of the Commissioners, for their approval and decision. It may be observed, that although the Managing Committee is annually chosen, it has resulted in the same Chairman and Committee being re-appointed, with some few and unavoidable changes in the latter. These continuous services have been attended with no small advantage to the port.

Before closing this Paper, there is one point to which the Author would call attention, as it interests the port of Ipswich, and may be followed with advantage by other ports similarly circumstanced. The soil raised during the improvements of the river is supplied to vessels, as ballast, realising by its sale, very nearly the expense of obtaining it.

The result of the treatment of the river has been, to increase the depth of water at Ipswich quays, from 8 feet, before the commencement of the works, to 16 feet 4 inches, or more than double, since their completion. At the former period, the tonnage of the registered vessels belonging to the port, was about 7,000 tons; at the present time, it amounts to 16,274 tons.

The Paper is accompanied by an Appendix, containing Reports of Mr. W. Chapman, Mr. H. R. Palmer, and Mr. G. Hurwood, as well as statements of accounts, showing the income and expenditure at different periods; and by three Plans illustrating Mr. Chapman's Reports.

[Mr. PETER BRUFF,