

The greatest extream of a flood or tide that has been known at *Lynn*, appears to have been one on the second of *December* 1763, when the water flowed one inch deep in the compting house of Mr. *Elfdon* of *Lynn*, and left a very visible mark, which he shewed me. This mark should at high-water of some spring-tide, be transferred to the Custom-house, or some public place near the river, to which recourse may constantly be had. Though this is the largest tide we know of, yet there are accounts of several tides within a few inches as high as this; I do not therefore look upon the banks to be safe, unless they are proof against such another tide as this; and to this, as a standard, I would constantly refer: I cannot, however, look upon them as *proof*, unless they are made up at least one foot above the level of this mark, and maintained, after settlements, at the height of half a foot above the same. It is not, however, necessary, to preserve the same slope above the high-water-mark of equinoctial spring-tides to the extreamest height, as below that mark; because they will but seldom come to a stress; yet when they do, they must be *sufficient*, or they answer not the end.

In order to this, they ought to be three feet at least broad at the extream height; and at least three times as much broader at the level of the equinoctial spring-tide mark, as the extream height exceeds that height. The artificial banks below that mark should be at least four times as much broader, in their base or feat, upon the natural level of the ground, as the perpendicular height of the said extream tide-mark is above the natural level of the ground, whereon each part of the said bank respectively stands. These proportions will be very sufficient in the neighbourhood of *Lynn*, where the earth is good; but where the earth is loose, sandy or moory, the bases or feats and tops should be respectively broader.

These are the best methods that I know of putting the town and country in a state of security; every other attempt to lessen the tides themselves will not only be vain and fruitless; but even, if effected, hurtful to the general drainage and navigation of the country.

If the expense be objected to of making up the banks in this manner, I answer; that if we take the compass of a few years, it will be a great saving: but since this is the only permanent and secure method that I know of; if it is not worth while to put the properties into a state of security, then the proprietors must be contented to possess them in a state of insecurity:

After having declared it as my opinion, that every attempt to check the free influx and efflux of the tides (that is, while it remains an open river) is likely to be hurtful to the
scour

scour of the sea channel; it seems natural to be asked, if I do not look upon *Denver Sluice* in this light? I answer, that *Denver Sluice* is much too far up from the out-fall to work any considerable effect either way; but that the *natural* effect of it, as well as the hundred foot drain, so far as they operate on the harbour of *Lynn*, and sea channel below, must be rather beneficial; as may be demonstrated from a circumstance mentioned in *Badslade's* history, page 46, where, speaking of the river *Ouse*, he says, "The low-water-mark up the river is much lower in neap than in spring-tides; whereas down to seaward, the low-water-mark of a spring-tide is lower than that of a neap." This being the case, (which is not a peculiarity of this river,) it is evident that the spring-tide of flood, in the remote parts, could not get back again the same tide; but, instead of returning back, spent itself up the river, and in the fens, before that sluice was built; it is therefore, at that length, more useful to check the tide of flood, in order to give it a better recoil, than to suffer it to spend itself in the fens at the spring-tides, and languidly to return in the neaps; without power in itself to operate, or to co-operate with such a tide as would give it power. The cause, therefore, of the universal filing of the channel of the *Ouse*, after the first erection of *Denver Sluice*, and cutting the hundred foot river, so universally and loudly complained of, must be sought from other sources, than a *natural* tendency of these works to produce this effect: but as this will lead me into a fresh and large field of matter, not immediately conducing to the business in hand, I shall forbear the pursuit of this subject any further at present.

I cannot conclude my Report without observing, that it strikes me, that the surest, and I may add the cheapest, way of putting the ships into a state of *perfect* security, would be by building wet docks in the manner of *Liverpool*; for which, the situation of *Lynn* seems to afford a noble opportunity, particularly in the flat ground below the block-house.

Austhorpe,
14th September 1767.

J. SMEATON.

APPENDIX.

Containing an Extract from a Pamphlet printed in the Year 1742, said to be wrote by Mr. Elstobb; intituled, Some Thoughts on Mr. Roswell's and other Schemes, now proposed for amending Lynn Channel and Harbour; in a Letter to the Merchants, Owners, and Masters of Ships, belonging to the said Place.

GENTLEMEN,

THE present state of your channel is now not only become the common topic of conversation, but also the laudable care of the magistracy, whose ready disposition to do service to the town, is evidently manifested by the early steps they have taken in this affair; in consequence of which, Mr. Roswell, by order of the honourable the commissioners of the navy, has lately inspected the harbour and channel to seaward, down as low as the road, and has proposed a method, to remedy the evils, which he observed at present to attend them, and to prevent their growing bad for the future.

But as I think the remedy he proposes, will not remove the evils he complains of, but will rather increase them; so I cannot forbear giving you my sentiments thereupon, tho' without any design of depreciating that gentleman, who I doubt not is sufficiently judicious in things of this kind. But as he came an entire stranger to the place; and as I am informed, took but a transient view of it, and formed most of his sentiments, from the information of people, prejudiced in favour of particular notions and opinions concerning the thing, it is not to be wondered at, that he is so far wide of the matter.

His opinion it seems is, that *the badness of the channel to seaward, is owing to a bar of sand, lately grown up cross the east channel, about three miles below the crutch-point.* And he says, he is informed, that *the said crutch-point on the east, and the point on the west side of the harbour's mouth, formerly landlocked each other, by which means the harbour was preserved in a great measure from the fury of the north-west winds, and flood tides, was rendered safe, and the channel maintained deep and good; but by the continual force of the said winds and tides against the west point, and by the violent action and force of the south-west winds and ebb-tides, against the crutch-point, on the east side, both these points of land are now much shortened, and the harbour laid more open; so that the fury of the north-west winds tears down the marches, endangers the banks, and threatens the ruin of some of the lands on the east side of the river, between the block-house and the crutch; the consequence of which may be (he says) the entire loss of the harbour.* Besides, *since the points are thus become open, (I think he says), it occasions the flood to form an eddy, by which means the silt subsides, and has formed the bar which he so much complains of.*

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The remedy therefore which he proposes is, to *erect two jetties, or wooden piers, one on the west-point, to stretch over to the eastward; and the other on the crutch-point, to stretch itself to the westward; and so to landlock the harbour, as it formerly has been.*

By this means (says he) the harbour will be preserved from the violence of the north-west winds and flood tides, will be rendered safe and quiet, the east-channel recovered and the bar be scoured away.

This, gentlemen, is his opinion, and the remedy he proposes. And now, with all due submission, I shall beg leave to give you my sentiments thereon.

'Tis to be observed, that in the present state of the harbour and channel, there are but two evils which have fallen under his notice.

The first is a bar of sand on the east channel, three miles below these points, which bar he supposes to be lately grown up, and formed by means of an eddy in the flood tides, occasioned by the shortening or opening of the said points. But how the alteration of the state of these points could any way form such an eddy as to occasion a bank of sand in the channel, at three miles distance, is to me quite unconceivable. Besides, the bar is no new formed thing as he supposes, but is of old standing, as is well known to the gentlemen navigators; tho' 'tis not always in the same state, but often fluctuating and changing: being sometimes higher, sometimes lower, according as seasons have proved wet or dry, and the quantities of the ebbs and back-waters have been greater or less. Thus, in some very wet seasons, it has been almost worn away, and the channel for a while maintained good; and in dry seasons again, it grows up, and the channel becomes bad; which has lately been the state of it, tho' now by the increase of the back-waters 'tis already much mended. However, let the duration of it, and the formation of it be as they will, the removal of it is the thing.

And this I believe every one will agree must be effected, by the ebbs and back-waters, which should be convey'd as entirely, unitedly, and directly to it as possible, so that they may exert their whole undiminished force and power thereon, without meeting with any stops or impediments in their way. For the force of water in scouring away a sand, or deepening a channel, is always proportional to the quantity acting in a given time, and the vigour or force with which every equal part of that quantity does act. Thus, for instance, if a tun of water was to pass over a sand in a minute's time, and every gallon of that water exercised a force on that sand, which may be represented by 1 or unity, then the whole force exercised in a minute's time upon that sand, may be represented or expressed by

by the number 252. But if the quantity of the water acting in the same time be doubled, and the force with which every gallon acts, be doubled also, as it will be if the velocity of the current be doubled, then the force which the water exercises upon the sand in a minute's time will be four fold what it was before, and in this case may be expressed by the number 1008.

What then can we think of this gentleman's jetties, which, instead of conveying the back-waters and ebbs directly to the bar without obstruction, must necessarily divert them from it, and turn them over to the westward, giving them such a course as will direct them much more into the west channel, and cause them to strike more directly against the breast sand than at present, and so both lessen the quantity acting, and also the force with which every proportional part does act; so that if the bar increases and grows upon us now, we may then expect the decay of the east channel will be much accelerated; for sure 'tis not a little absurd to imagine, that turning the course of the ebb-water more to the westward, can promote the removal of a sand which lies in the east channel, or any way deepen or mend that. Too much of the ebb-water does already go down the west-channel, which lies too directly in its present course; but if its direction be changed still more to the westward, as it certainly will be by these jetties, then the principal part of the ebb-water will be turned into that channel, and other flade ways, which can afford it a passage to the westward; and the east channel will be almost deserted, and left almost dry every ebb, and consequently in a little time would choak up, and be entirely lost.

So far then is the method this gentleman proposes from being a certain remedy to the east channel, that in all probability it will be the utter destruction of it. And thus much for the first evil he complains of.

The other evil is, the washing away of the marshes, and the danger of drowning the lands on the east side.

This (I shall beg leave to observe) is a thing which more immediately concerns the land-owners than this corporation. The security of their estates is certainly as much their own proper concern, as the security of those on the west side is the proper concern of the owners of them. But (says this gentleman) *the drowning of these lands will be the ruin of your harbour.*

This I must confess I do by no means apprehend. Suppose that two or three hundred acres of these lands were every tide laid under water, not one gallon the less water would flow up the river than does at this present, and all the waters, which would then cover these

these lands in the time of flood, would be an additional quantity to return in the time of ebb, which would certainly very much help to scour away the bar, and maintain a good channel. But suppose that the security of the harbour does depend upon the preservation of these lands, are these jetties like to be effectual for that purpose? I conceive not. 'Tis true, they will lessen the beat of the tides during the time of high-water, which by the opening of these points, when the north-west wind blows, is now very great, and washes away the surface, and turf of the land very fast; this I say would be in a great measure prevented. But then the flood-tide would be carried continually and directly into the crutch-bite, and so would the ebb also; and by the continual and violent action of both, the lower shores would be ground away, and the bite extended more and more to the eastward, and the lands and banks will be as effectually ruined by the undermining of the shores, as by the wash and beat of the waters upon the surface; tho' perhaps not altogether in so short a time.

Now, as I think this will certainly be the consequence of this scheme, so I thought it an incumbent duty to apprize you of it, that you, whose interests depend upon the preservation of the navigation of this port, may make proper representations against it.

I know some gentlemen are mightily alarmed at the wearing away and opening of the two foremention'd points, as if the ruin of the harbour must immediately ensue, and as if the goodness of the channel entirely depended upon the projecting or extending of these points. But it may be remembered, that some years ago, while *Denver* sluice was standing, and the reception of the flood lessen'd, and the back-waters prevented from coming down, the quantity of the ebbs was then so small, that it was all carried off by the west-channel, and the east-channel was so deserted, that at low water it was left almost dry, which made it soon grow so shallow, that at the time of high water, there was not water sufficient for any loaden ships, all which were forced to go round at the back of the sands, and come through the west channel up to town; and at that time these points were both far extended, and landlocked the harbour. 'Tis therefore very evident, that the goodness of the channel does not depend upon the extension of these points, nor do I apprehend that there is such imminent danger from the opening of them, as some are inclined to think.

The channel is now in as good a state as it commonly has been in for some years. And if we should in a little time have a continued wet season, which may happen, it will quickly be much mended. And I think it is much the better way, to trust to nature for a remedy, than to execute at a great expense such schemes as in all probability will be very pernicious and hurtful to the channel.

Some

Some gentlemen it seems do plainly discover the impropriety of Mr. *Rosewell's* scheme, but yet think something ought to be done for the preservation of the lands, and the amendment of the channel, and therefore are for erecting a jetty cross the crutch-bite, all along the east side, towards the block-house; and another jetty on the west-point, to extend this point more over to the eastward.

The first, certainly, so long as it stands, if made sufficiently, high, will be a great security to the marshes, and lands on the east side, and would prevent both flood and ebb from encroaching on that side, and likewise assist them in scouring away that pernicious point of sand, which extends itself from the west point, so far over to the eastward, into the crutch-bite, for though the turf and vegetable soil at the west point are much washed away and shortened, the sand stretching from that point is by that means much lengthened, and determines both the flood and ebb more over to the eastward than before; and so far will it be from doing service to the channel, to extend that point, that if the vegetable soil was only secured in its present limitations, and the point of sand intirely scoured away, it would certainly be much better for the channel, for then the ebb would not be so inclinable to go down the west channel, but would proceed more directly to the bar, and act upon it with much greater force than now, and consequently keep it lower, and maintain the east channel better; and then perhaps the west channel might gradually grow up. And happy would it be for *Lynn*, if that channel was intirely stopped up, for it is the quantity of ebb that goes down that channel, that so weakens the current in the east channel, that instead of scouring away the points of sand which project into it, it is stopped and retarded by them, and formed into vortices and eddies, which throw more and more silt upon them, and in some places (as at the bar) extend them quite cross the channel; for it is by this means, and by the flood-tide coming up the west channel, and forming an eddy at its entrance into the east channel, that the bar so much complained of is formed: for it is observable that this bar lies not far below the mouth of the west channel, just about the place where one might expect such eddies would occasion it.

A jetty therefore at the west point, seems to me quite wrong, and I think will be very hurtful. If therefore a jetty must be erected, I would advise it, not upon the west point, but about a furlong to the westward of it, to extend itself to the northward, along the east part of the breast sand. This would allow the ebb to scour away the sand, that stretches from the west point and turn it more directly down the east channel, towards the bar; and would at the same time very much secure the east side from the violence of the westerly and north-west winds, and be a great shelter to the harbour too from these winds.

And

And if the west channel could be stopped up, by the sinking of old hulks loaded with stones, or any other means, so that the ebbs might be prevented from taking their course that way, we might then have great hopes of maintaining the east channel, in a much better state than it has ever yet been in.

But as some gentlemen are apt to imagine, that a jetty on the west point, by turning the ebb-water more over to the eastward, will direct it more into the east channel, it must be acknowledged that it would have this effect, if this channel were situate to the eastward of that point. But the east channel itself is situate far to the westward of that point, and consequently the more the ebb is carried to the eastward by the jetty on its south side, the more westerly must be its direction on its north side, to arrive at that channel; and when once it has received this westerly direction, the west channel and other side ways lie so fair to receive it, that in all probability very little of it will go down the east channel.

The way then to direct it down the east channel, is not to turn it more to the east at the west point, it going far much to the eastward at that place already; but the way must be to let that point of sand wear away, that it may take its course more in a direct line for that channel. Some may object, that the wearing away of that point will lay the harbour more open, and make it more turbulent and unsafe than at present. But in answer to this, a jetty from the west marsh, to extend northward, along the east part of the breast sand, will in a great measure prevent that. However, it is to be observed, that the security of the harbour, and the goodness of the channel, are two different things, and what procures one, may be pernicious to the other. The goodness of the channel will be promoted by the quantity of water that comes into it, and flows through it, but the greater the quantity of water, the greater the agitation, and the more turbulent. On the contrary, the less the quantity of water, the less the agitation, and the quieter the harbour, but then the worse the channel. When such works are undertaken, therefore, the end and purpose should be well considered, and things inconsistent in themselves should not be pursued at the same time.

However, it is not to be expected, that these, or any other means, can render the channel *constantly* and *unchangeably* good, so long as its course lies betwixt and amongst such loose and moveable sands. A rage of winds and tides, or an extraordinary time, either of drought or rain, will occasion great alterations in it, sometimes for the better and sometimes for the worse, because even when the back waters are the strongest, and so the most likely to preserve a good channel, they will sometimes scour away the sands in one place, and let them drop in another place, where they may be more prejudicial to the channel than before; and thus will the state of the channel be always liable to changes and alterations.

VOL. III.

D

WELLS HARBOUR.

(See the Plan, Plate I. of this volume, Fig. 2.)

The REPORT of JOHN SMEATON, Engineer, upon the State and Condition of *Wells* Harbour in the County of *Norfolk*, and how far the same may be affected by the Imbankment of the Slade Marshes.

HAVING carefully inspected the present Condition of the Harbour of Wells in the county of Norfolk, and the Slade Marshes, and other premises, the object of a suit wherein Sir Martin Brown Folkes Baronet, and Robert Hales Esq. were plaintiffs, against George Chad Esq. and other defendants, and having also carefully inspected the several Plans and Papers that have been produced in evidence in the said cause, the following facts drawn from my own view of the premises, and in part from the evidence produced, appear to me to be very well ascertained and agreed upon.

1st. That the harbour of Wells has of late years grown into a worse state than it formerly was in, and particularly since the imbankments that took place in and about the year 1719; and,

2d. That for remedy of the complaints that then subsisted in the harbour, in the year 1738, a work was constructed that had the name of Freestone's Sluice, so called from the projector or builder thereof, whose name was *Freestone*.

3d. That this work had a beneficial effect in scouring away the mud and sand that annoyed the Harbour and channel from the mouth of the said sluice, down as far as the Pool.

4th. That at that time, that part of the channel called the *Pool* was so deep, that at low water two or three tiers of vessels could lie afloat, and swing round.

5th. That in the year 1758, the last imbankment was erected, which is the matter now complained of, and is the object of the present suit.

6th. That

6th. That the extent of ground inclosed, and defended by the said imbankment, is nearly 17 acres in the East Marshes, and 47 in the Slade Marshes, together making about 64 acres, besides and interspersed in which are creeks formerly and now containing water to the amount of about three acres, making altogether a surface of about 67 acres, or thereabouts.

7th. That besides the above, there is not only a much greater quantity of imbanked lands, which was chiefly taken in about the year 1719, but still a much greater quantity than all the imbanked land put together, still remaining unimbanked, over all which the spring tides usually flowed before the imbankment, but the neap tides rarely, and which now is the case with the greatest part of the unimbanked marshes.

8th. That no fresh water river makes its way to sea through the channel of the harbour of Wells, nor indeed any considerable quantity of fresh water of any denomination; and that not only the channel that forms the harbour, but the several branches and creeks into which it is divided (as is particularly distinguished in the map made by Beiderman under the direction of Mr. Mylne) are all supplied with sea water on tide of flood, which reflowing back to the sea on tide of ebb, thereby forms a *back water* and produces a *scour* that tends to keep the channel of the harbour open.

9th. That in the year 1765, Freestone's Sluice having been originally constructed in a slight manner with fascines, stakes, piles, &c. the mouth thereof was so much widened, that its effect having been for some time past greatly impaired, another was built upon a new site, which when erected, reproduced the same effect, as to clearing the harbour and channel down to the Pool.

10th. That the sluice of 1765 which had been constructed with greater strength and care than that of Freestone, though upon the same model, in the year 1777 was found to have been nearly destroyed by worms; on which occasion Mr. Wooler was called in to advise the commissioners, who reported his advice to build a new sluice in a new situation, upon a new construction, and with such materials as the worm could not touch.

11th. That on account of the expense estimated by Mr. Wooler at £2,000, this work was not undertaken, but in lieu thereof, proceedings were gone into that terminated in the present litigation; on supposition on the part of the commissioners, the defendants, that the taking down the East Marsh Bank, whereby the tides would be readmitted upon the surface of the 67 acres before mentioned, would reduce the state and condition of the harbour in every respect, or in all the most material respects, to what it was before the erection of that Bank in 1758.

12th. That however, the Sluice since Mr. Wooler's report has been repaired, and it appeared at the time of my view to be of the same construction that it had formerly been, according