of all his professional brethren, as well as the consideration of all with whom he was brought into contact. His success was doubtless, in a great degree, to be ascribed to the soundness of his early mechanical experience, a fact which he never failed to impress upon all the younger Members of the profession. His loss will be sincerely felt by our Society, of which he has been so useful a member. His son, Mr. Joseph Cubitt, has succeeded his father in the Council. Let us hope that Sir William's memory may be kept alive amongst us by the works of his son.

No. 1,047.—"The Hooghly and the Mutla." By James Atkinson Longridge, M. Inst. C.E.[1]

During the discussion of the Paper on Indian Railways, which was brought before the Institution in the Session of 1859-60, by Mr. James John Berkley, M. Inst. C.E., the subject of the proposed establishment of a new port at the head of the Mutla, as an auxiliary to the present port of Calcutta, was briefly alluded to by the Author of the present Paper. The few remarks he then made led to the expression of a wish, on the part of the President, that he would "present a Paper to the Institution, embodying the results of his experience as to the local circumstances connected with the navigation of the Hooghly and the Mutla."[2] The magnitude of the subject, and the paucity of accurate observations on the hydrological features of the two rivers, have rendered the compliance with the wish thus expressed a somewhat difficult task; and although, in consequence, the Paper is not so complete as the Author could have desired, yet he has considered it his duty to present it to the Institution, in the hope that a profitable discussion may arise, on an interesting and important branch of professional practice.

The Author deems it desirable to divide the Paper into the following heads:—First, a statement of the commercial importance of the Port of Calcutta. Secondly, a brief account of the present mode of transport of the traffic to the port, and the modification of it, by works now in progress. Thirdly, a sketch of the physical features of the two outlets, the Hooghly and the Mutla. And, Fourthly, remarks on the past and present state of those rivers, as navigable channels.

The port of Calcutta is the emporium of the commerce of a great part of the peninsula of Hindoostan. Situated on the Hooghly,

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[1] The discussion upon this Paper extended over portions of two evenings, but an abstract of the whole is given consecutively.

[2] *Vide* Minutes of Proceedings Inst. C.E., vol. xix., pp. 620 and 623.

it communicates by inland navigation with the valley of the Ganges, which river, in a course of 1,500 miles, traverses Bengal and the North-western Provinces, until it reaches the confines of the Punjaub; while its confluent, the Brahmapootra, extending to the north-eastward, maintains an additional communication with the fertile districts of Silhet and Assam. An analysis of the official returns of the port of Calcutta, during the five years ending the 30th of April, 1861, gives an annual average of 979 vessels, importing 626,798 tons; and, for the same period, an annual average of 1,033 vessels, exporting 619,674 tons. These figures, however, can only be considered as an approximation to the total trade of the port. The amount of tonnage paying toll on the Eastern Canals was in 1856 about 1,700,000 tons, and in 1859 it was not less than 2,250,000 tons. This traffic is wholly dependent on water communication, and is conducted, under circumstances of great difficulty and danger, at considerable expense. The Author refrains from expressing any opinion on the policy of the late East India Company, or in reference to the extent which, under their rule, European enterprise might advantageously have been permitted directly to aid in the development of the productions of the country, and the facilities of its internal communications; but under present circumstances it may safely be asserted that, great as is the present trade of Eastern India, it might be considerably increased, if a wise policy should encourage, and allow full scope to, the capital and energy of Great Britain.

For about four months of the year, during the flood season, about one-third of the whole traffic to Calcutta enters the Hooghly from the Ganges by means of the three rivers, the Bhagiruttee, the Jellinghy, and the Matabanga. These rivers are generally designated the Nuddea rivers. They are in effect flood outlets of the Ganges, having their heads at Sooty, Jellinghy, and Sadaspore respectively. They run in a southerly direction, and by their union form the river Hooghly, about 45 miles above Calcutta. (Plate I. Sketch map of the Delta of the Ganges and of the Bay of Bengal.) During the dry season, from November to July, the Nuddea rivers are no longer navigable; and then the traffic descends the Ganges to the point where it meets the stream of traffic from the Brahmapootra. It afterwards proceeds, viâ Dacca, through the Sunderbunds navigation, to the head of the Mutla, whence, by the Biddiadhurree river, it reaches the Eastern Canal, and by means of it, the Circular Canal and Tolly's Canal, finally enters the Hooghly at Calcutta. (Plate I. Plan of the Hooghly and the Mutla.) The delays and obstructions in these navigations have frequently been brought under the notice of Government, and on the 15th February, 1853, Mr. Mactier, the deputy-collector of Furreedpore, reported on the subject as follows:—"In my tours through the

district, during the last and the present years, my attention was called by certain opulent merchants to the loss they sustained by delays and obstructions in the navigation of the various water-routes to Calcutta; and during my recent visit to that city, I did my best, while *en route*, to ascertain the cause of these delays and obstructions, and whether they could be remedied. My remarks refer to what is called the inner route, through the Sunderbunds, navigable for boats up to 1,000 maunds (about 38 tons). By this route an immense number of boats, carrying perishable cargoes, such as fruit, fish partially cured and alive, &c., proceed, and the delay of even a few hours in the arrival of such cargoes causes great loss; with cargoes of a less perishable nature, such as grain, oil, &c., time is a matter of consequence, as the quicker they arrive, the more voyages will the carriers be able to make, and the delay of a day may cost the merchants dear, as they lose what they call the bazaar, *i. e.*, what was dear one day falls greatly in price the next; however, as this is a matter of such obvious importance, it will be sufficient merely to call attention thereto."

Mr. Mactier then states, that the delays arise, first, from the want of towing-paths, and secondly, and principally, from the want of room in the canal between the salt-water lake and the Hooghly. In illustration he continues:—"At some short distance from the Dhappa toll-house, all the various passages through the Sunderbunds unite, and though there is difficulty in getting along, still it is practicable to move; but, after passing the toll-house the press commences; all along the northern side of the Balliaghatta Canal is a line of boats, sometimes double, unloading their cargoes into the warehouses on the northern bank; and at low water, although there is plenty of water in the canal, it is almost impossible for any but the smallest boat to move. In the Circular Canal it is clearer, but at about a quarter of a mile on the canal side of the lock leading to the Hooghly the crush, 'bedaud,' as the natives call it, again commences. To show the results of my own experience, I may state, that in going to Calcutta, my own boat, of about 250 maunds (9 tons), was detained from 5 A.M. to 3 P.M. in going from the Dhappa toll to the Hooghly, a distance of about 4 miles; and it was only by using my own influence with the boatmen of the various boats 'luggaoed' to the bank, that I got along at all. On my return I was from 1 P.M. to 1 A.M. in accomplishing the same distance, while the manjees of some large pulwars, who effected their deliverance from captivity at the same time, said it had taken them four days."[1]

[1] *Vide* "Selections from the Records of the Bengal Government," No xix pp. 54, 55.

These evils were in full force in 1857, when the Author, having frequently to pass through the canal, was sometimes four hours in reaching Dhappa, a distance of 2½ miles, in a small row boat, which, moreover, was in great danger of being crushed, owing to the large cargo boats coming to a deadlock. Upon one occasion he found the ordinary traffic suspended for an entire day, in order to permit of the passage of the Government opium boats. One of these stuck fast, in passing the Bulliaghatta Bridge, and a further delay of a tide, throughout the whole navigation, was the necessary consequence. So crowded is this part of the navigation, that it is no uncommon occurrence for the boats, about the time of high water, to become so closely wedged together that accidents occur, of such a serious character as frequently to result in the loss of many boats and cargoes. The average rate at which goods could be conveyed by this system of navigation is about 15 miles per day, a rate so slow, that it involves a serious loss of interest upon the capital of the merchant, owing to the time occupied in the transit of opium, indigo, and other merchandise of a valuable character.

In 1857 the Author instituted a careful inquiry as to the actual cost of transport of merchandise to Calcutta; and he considers that the figures given in the following table may be taken as close approximations to the actual rates:—

Character of Merchandise, and where from.	Distance carried.	Rate per Ton per Mile.		
		For Transport.	Insurance & Interest.	Total.
	Miles.	*d.*	*d.*	*d.*
Rice from Dacca	267	0·371	0·140	0·511
Jute do.	267	0·404	0·388	0·792
Rice from Buckergunge . .	270	0·423	0·206	0·629
Average	268	0·400	0·244	0·644

It may be interesting to examine, how far the railways in the district, when completed, will be able to compete with the inland navigation. For this purpose the Author selects the East Indian Railway, intercepting the Ganges traffic at Rajmahal, and the Eastern Bengal Railway meeting it at Kooshtee. The relative cost of carriage to Calcutta, he assumes, will be as follows:—

	Distance.	Rate.	Total Cost.	
	Miles.	*d.*	*s.*	*d.*
From Rajmahal *viâ* the Nuddea Rivers. . .	300	0·644	16	1
„ *viâ* the Sunderbunds . . .	529	0·644	28	4
„ By East Indian Railway . .	200	1·125	18	9
From Kooshtee *viâ* Nuddea Rivers. . . .	247	0·644	13	3
„ *viâ* Sundberbunds	377	0·644	20	3
„ By Eastern Bengal Railway .	110	1·125	10	4

Hence, taking the proportion of traffic passing by the Nuddea rivers, at about one-third of the whole, the average cost of carriage per ton would probably be :—

	By Water.		By Rail.	
	s.	*d.*	*s.*	*d.*
Rajmahal to Calcutta . . .	24	3	18	9
Kooshtee to Calcutta . . .	17	11	10	4

Thus showing, on the ordinary traffic, a saving of 20 per cent. and 40 per cent. respectively, in favour of the rail, exclusive of the advantages of a safe and speedy transit of hours, instead of weeks, which, in the case of the more valuable class of goods, will further enhance the benefit derived from the railway communication.

There can be but little doubt that the Hooghly was formerly one of the principal mouths of the Ganges, but at present it communicates with that great river only by the three Nuddea rivers. The positions of the exits of these rivers from the Ganges are subject to great variation, owing to the soft nature of the banks rendering them unable to resist the action of the waters in the flood season. It will be unnecessary to enter into the details of these changes; but some idea may be formed of their extent, when it is stated that between 1824 and 1852, the head of the Bhagiruttee was shifted 14 miles to the south-eastward, and that during the same period, the Ganges shifted that part of its course many miles. The depth of water at the exits of the rivers from the Ganges varies with the time of the year, and also from one year to another; and sometimes, as in 1853, the three rivers are almost closed. The following are the results of a series of observations of the maximum and minimum depths from 1840 to 1853, inclusive :—

	Bhagiruttee.		Jellinghy.		Matabanga.	
	Ft.	In.	Ft.	In.	Ft.	In.
Least depth in dry season .	3	9	5	0	1	8
	to		to		to	
	0	0	0	0	0	0
Greatest depth in rainy season	32	3	30	0	27	0
	to		to		to	
	12	0	18	10	17	6

The quantity of water from the Ganges discharged by these rivers varies greatly. It has been stated by Major Lang, the former superintendent, that in a high flood, it amounted to 200,000 cubic feet per second, whilst in the month of March, it did not exceed 5,000 cubic feet per second, of which a large portion was derived from filtration.

The Bhagiruttee and Jellinghy unite at Nuddea, about 75 miles above Calcutta; and they are joined at Chogdah, about 23 miles lower down, by the Matabanga, from whence the united rivers form the Hooghly. At Calcutta the Hooghly is about 800 yards

wide, and from thence downwards its width increases gradually to about 1,800 yards at the lower part of Fulta Reach. It is there joined on the right bank by the Damoodah River, which formerly flowed into the Hooghly at Naiserai, about 35 miles above Calcutta. After leaving the hills it runs for many miles of its course through spreading plains, above the level of which, as is usual with such rivers, it gradually raises its bed. In the year 1763, notwithstanding the natives had previously constructed embankments along the side of its elevated channel, the Damoodah burst its banks at Selimabad, and rushing down in a southerly direction excavated for itself its present outlet, which, entering the Hooghly at right angles, effected, as will hereafter be noticed, a serious deterioration in the navigable channel of that river. The Damoodah runs through a course of about 320 miles, and drains an extent of about 7,000 square miles. In the dry season its supply of fresh water is inconsiderable, but during floods it discharges into the Hooghly a vast volume of water, highly charged with silt. Its maximum flood discharge, measured about 20 miles above Burdwan, is nearly 600,000 cubic feet per second; but at Omptah, about 75 miles lower down, the channel is so small, as to be incapable of passing more than 76,000 cubic feet per second. The difference flows over the right bank, and flooding the intervening country, finds its exit eventually by the Roopnarain, another river which joins the Hooghly about 5 miles below the outlet of the Damoodah. The Roopnarain has a course of nearly 230 miles, and a drainage area of about 500 square miles. Its characteristic features are much the same as those of the Damoodah. At the junction of the Roopnarain, the Hooghly makes an acute-angled bend to the eastward, for a distance of about 9 miles, to Diamond Harbour. Here it bends again to the south-west for about 10 miles to Culpee, at which place its high-water bed attains a width of $2\frac{3}{4}$ miles. Below Culpee the estuary assumes a south-westerly direction, and rapidly widens. On the right bank, at about 10 miles below Culpee, it is entered by a comparatively small river, the Huldea, opposite to which on the left bank is Channel Creek, which forms the north-east boundary of Saugor Island, and is the route by which the steamers from Calcutta, being unable to pass through the eastern canals, enter the Sunderbunds on their way to the Ganges. The high-water width of the estuary at this point is $6\frac{1}{2}$ miles. From thence it still pursues a southerly direction, and the distance between its shores continues increasing until, at Saugor Island, its width is about 17 miles. Below Saugor Island are the sea channels of the estuary, which are greatly encumbered with sandbanks. At the southern extremities of the sands, called the Sandheads, vessels receive and discharge the river pilots, and taking the lower floating light as the limit of the river navigation, the total distance from the sea to Calcutta is about 140 miles.

Having given the preceding general description of the river, the Author will now lay before the Institution such details as he considers essential to the formation of an opinion as to the state of its navigable channel; his information being chiefly derived from the printed reports of a Committee appointed by Government in 1853, to inquire into the state of the river; consisting of—Captain Divie Robertson, officiating Superintendent of Marine; H. Piddington, Esq., and T. T. Mackenzie, Esq. These gentlemen were directed to ascertain "the state of the River Hooghly, particularly whether it has deteriorated for purposes of navigation, what has been the nature and progress of the deterioration, to what causes it is owing, whether it is likely to continue, and if so, whether any approximate guess can be formed as to the period at which ships of large burthen may be expected to resort by preference to the Mutla, supposing the head of that river to be connected with Calcutta either by a railway or a ship canal."[1] The Committee sat for forty-nine days, and examined twenty-six witnesses, of whom seventeen were pilots, four commanders of steam-tugs, two commanders of river-steamers, and three Government officials. These witnesses on some points differed materially; but this is not surprising, as the Committee state that, "The periodical surveys of the river, up to a comparatively recent period, were taken by the primitive mode of sailing a number of pilot-vessels in line through the several channels, sounding, as they went, the existence of new obstacles, or of changes in the old banks being ascertained by the grounding of the vessels on them."[2]

The first channel entered by inward-bound vessels is called the Eastern Channel, and is situated between the Saugor Sand and the Eastern Sea Reef. It has a low-water depth of from $3\frac{1}{2}$ fathoms to 6 fathoms, but it has a middle ground at its northern end. Some of the witnesses state, that within their experience, the tails of the sands have extended nearly 6 miles to the southward. Proceeding upwards, the Gaspar Channel to the east, and the Thornhill Channel to the west, running parallel to each other, and leading up to Saugor Roads, are the next in order. It is stated, that in 1781, the Gaspar Channel had $4\frac{1}{4}$ fathoms in it at low water. About the beginning of the present century it became closed, and was only again buoyed off towards the end of 1817. Previously to its reopening, although the lower end remained filled up, there was a depth of 17 feet, or 18 feet at the upper end. In 1836 there was a depth of 3 fathoms in it, and in 1852 a depth of $2\frac{3}{4}$ fathoms. The Thornhill Channel has also closed and reopened

[1] "Reports and Proceedings and Appendix of the Committee appointed by Government to Inquire into the State of the River Hooghly." Calcutta, 1854, p. 1.
[2] *Ibid.*

during the present century. It was first discovered in 1806, and had then a bar at the lower end, which had from $2\frac{1}{4}$ fathoms, to $2\frac{3}{4}$ fathoms, upon it. This channel also closed in 1819, or 1820. It again opened out, and was buoyed off in 1837, having then 20 feet on the lower bar. In 1844 the channel had nothing less than 3 fathoms in it, but in 1854 the depth on the southern bar was only from $2\frac{1}{4}$ fathoms, to $2\frac{5}{8}$ fathoms. Saugor Roads is a good channel, with abundance of water and room for the purposes of navigation, but within the memory of the senior pilots, the soundings at its upper end have decreased not less than 2 fathoms. Lloyd's Channel is the next in order, and leads up to the Cowcolly, or lower Kedgeree Roads. It was first discovered and buoyed off in 1816. It had then from 11 feet, to 12 feet, at the lower entrance, and $3\frac{1}{2}$ fathoms up to its head. The depth of water in it has since fluctuated exceedingly. At present it is 11 feet, or 12 feet, deep throughout, but it is gradually shoaling. Cowcolly Roads is a channel with deep water; but it has, however, shoaled considerably as well as narrowed. At Kedgeree Green, where formerly there was commodious anchorage for large ships, only small vessels can now go in. The amount of shoaling within the experience of the present pilots is stated to be about 2 fathoms. After leaving Lloyd's Channel, the deep water keeps along the western shore up to the entrance of the Auckland Channel, which, together with its continuation, Mud Point Channel, bears over to the eastern shore. These two last-named channels have varied considerably in their condition. From 1843 to 1848 the Auckland Channel was reported to be in a bad state. It then improved, and for the three years preceding 1853, was stationary. Since 1848 the Auckland and Mud Point channels have been in a better condition than ever previously known to the witnesses. Above the Mud Point Channel are the inner and outer Rangafullah channels. The inner channel formerly ran close to the Culpee shore, and was in use up to 1847 from the earliest period to which the evidence before the Committee reached. It was a good channel, but narrow; it began to fill up at Middle Point about 1834, or 1835, and closed about 1847. It afterwards re-opened, and then finally closed as it at present remains. The outer channel is a better and a wider channel than the inner. It closed, however, about 1845; but has again opened, and is now in use. It is subject to great and rapid changes, and has a middle ground with only 13 feet, or 14 feet, of water upon it, which is constantly shifting. In 1853 the worst part of the channel was only from 10 feet, to 11 feet, deep, and throughout there was no anchorage. In 1836 an island sprang up on the west side of the channel, but it began to waste away in 1840, and had disappeared altogether in 1842. The next channel in succession is Culpee Roads. This has not been subject to any great variation; its present depth averages about $5\frac{1}{2}$ fathoms.

About 2½ miles above Culpee, the river narrows to a width of about 1½ mile, and then turns round in a westerly direction. On the concave side of this bend is Diamond Harbour, where, in former days, the ships of the East India Company loaded and unloaded their cargoes. It is distant in a direct line about 32 miles from Calcutta, with which place it has, at various times, been proposed to connect it by means of a railway or ship canal. At present, it is almost unused as a harbour. Four of the witnesses examined, stated that it had shoaled considerably, but the majority were of opinion that no change of importance had taken place. Between Diamond Harbour, and Hooghly Point, the safe navigation of the river is impeded by what are called the Kookerehatty Lumps. These are formations of hard sand, which at times are very troublesome, and especially so in the months of September and October, owing to their shifting about in the Channel, from side to side, under the influence of the periodical freshes and strong flood tides. The navigation of this part of the river, in consequence, requires constant care. The lumps, however, can be avoided, as there is always a channel to be found on one, or the other side of them. There does not appear to have been any material change in the average capacity, or physical condition of this portion of the river during the last forty years. Above the lumps is the Hooghly Sand, running east and west. The channel round the south side of it is deep and good up to the mouth of the Roopnarain. It is generally believed that the Hooghly Sand has remained unchanged, with the exception of a trifling extension, upwards, or downwards, when exposed during the rainy season, to the alternating action of the river freshes and strong flood tides. There is a channel at the north side of the Hooghly Sand, frequently used by vessels of light draft. This channel opens and closes periodically, in accordance with the condition of the James and Mary Reach immediately above it, opening with the western gut, or channel of that reach, and closing when the eastern gut is opened out. The character of this channel, when open, does not seem to have varied. At the commencement of the James and Mary Reach, the River Roopnarain joins the Hooghly, nearly at right angles. Between this point and the outlet of the Damoodah River, where this reach terminates, the bed of the Hooghly is much obstructed by banks and other formations of sand. Both these affluents have much the character of mountain torrents: during the dry season the volume of water from them is comparatively small; but during the sudden freshes caused by the rains, their waters, heavily charged with earthy matter, rush down, and materially affect the character of the channels of the James and Mary Reach, and thereby render it the most dangerous portion of the navigation. The James and Mary Sand occupies the lower portion of this reach, having on the two

sides of it the guts, or channels, to which reference has just been made.

As a rule, these channels never have a navigable depth at the same time. Some of the witnesses speak to one, or two years within their experience, when they were open together, but with an insufficient depth in each. The eastern gut is opened by the freshes of the wet season, when the flood tides are weak, at which time the united waters of the Damoodah and Hooghly, direct the force of the strong ebb-tides, down the left bank of the latter river. The free flow of the water being impeded by the rush of water below from the Roopnarain, almost at right angles, an eddy is formed, the silt is deposited, and the western gut is filled up. On the other hand, the western gut is reopened by the strong flood tides of the south-west monsoon during the action of which the Mukreeputty Lumps, joining on to the Hooghly Sand, form a bar across, and close the south entrance of the eastern gut. The western gut is subject to continual fluctuations as to the position of the deepest water, and both channels show important differences in soundings, at similar periods, in different years.

To the north of the James and Mary Bank there is only one channel up to Fulta Point; but as far as Nynan Point it is narrowed by the Nynan Lumps, which are very troublesome from their sudden and unexpected changes. Above Nynan Point the channel is broad and deep. Although the channels of the James and Mary Reach have always been considered as among the worst and most dangerous in the river, there were great differences of opinion between the witnesses as to their present, as compared with their former condition. Fifteen of them considered, that, on an average of seven years, there was no change for the worse, and eight were of a contrary opinion. From Fulta Point to Calcutta, the river consists of a series of curved reaches, with deep but narrow channels on the concave bends. In this division of the river there appears no evidence of any permanent deterioration. Periodical changes take place; the navigation being generally worst in September, October, and November, during the subsidence of the freshes, and shortly after their termination, the principal obstruction in the way of vessels ascending, being the shelves on the convex side of the channel, called respectively Fulta Sand, Royapore Sand, and Moyapore Flat.

In forming a summary of the preceding details, the river may be divided into three sections:—First, from Calcutta to Fulta House, a distance of about 34 miles, with an average high-water width of 1,300 yards; it consists of a series of deep but narrow channels, separated by bars at the points of inflection of the curved reaches. In this part of the river the navigation, though tedious and troublesome, is not dangerous; and though subject to periodical changes, the depth of water does not appear to have suffered any

permanent diminution. Secondly, from Fulta House to Culpee, a distance of 24 miles, in which the high-water width widens out from 1 mile to $2\frac{3}{4}$ miles. This section embraces the junction of the Damoodah and Roopnarain rivers on the right bank, and the dangerous James and Mary Reach. The Channels in it are subject to great and sudden changes, the tides and eddies are strong, and sands shifting. There appears to be evidence of some permanent decrease in its depth, though not yet to such an extent as to have a serious effect on the navigation. Thirdly, from Culpee to the Sand Heads, a distance of 37 miles, in which the river widens out from $2\frac{3}{4}$ miles at Culpee to 17 miles at Saugor Point. This section contains many dangerous places, and the evidence goes to show, that there has been a decided and serious shoaling of the water in the channels, and that a prolongation seawards of the tails of the sands has taken place, to an extent of not less than six miles, within the last fifty years.

The information which the Author has been enabled to obtain in reference to the tidal phenomena of the Hooghly, is extremely scanty. The only tidal register which appears to have been kept, is that of the times and heights of high water and low water at Kidderpore Dockyard near Calcutta. The Author has made an analysis of the observations recorded in it during the twelve-months, from the 1st of July, 1843, to the 30th of June, 1844, from which he arrives at the following results:—First, that the duration of the flood was three hours during the freshes of the rainy season, and four hours during the dry season; and that the ebb lasted from eight hours to nine hours. Secondly, that the mean rise of tide, on an average of three days, commencing with each quarter of the moon, was, during the dry season, from October to February, both inclusive, at spring tides, 11 ft. $1\frac{1}{2}$ in.; at neap tides, 7 ft. 0 in.; and from April to August, both inclusive; at spring tides, 12 ft. 2 in.; and at neap tides, 7 ft. 5 in. Thirdly, that during the north-east monsoon, from the middle of September to the middle of March, the night tides were higher than the day tides; whilst from the middle of March to the middle of September, when the north-west monsoon prevailed, the day tides were higher than the night tides; the maximum differences between the day and night tides, being severally, in the month of December, 1 ft. 10 in., and in the month of June, 1 ft. 2 in. Thus, it appears, that the variation of the tidal range at Kidderpore, between the dry season and the freshes is comparatively small, not exceeding 1 foot at springs, and 5 inches at neaps. This is somewhat remarkable, as, according to the season, the actual level of the surface of high water varies from 20 ft. 10 in. to 12 ft. 10 in. above datum, and that of low water from 7 ft. 6 in. to 3 ft. 0 in. It might be expected, that the volume of fresh water pouring down from the Nuddea River, the Damoodah, and the Roop-

narain, would so far drive back the tidal flow as to prevent the rise at Calcutta; but such is not the case, the range being actually greater during the freshes, than during the dry season. The increased range in the wet season is probably due to the action of the monsoons. The south-west monsoons, assisting the tidal flow during the season of the freshes, and the north-east monsoon keeping it back during the dry season. At the Sand Heads, the rise of tide at springs is said to be 9 feet at the lower floating light, and from 12 feet, to 14 feet, at the upper floating light, but the Author is not aware that these measurements have been determined in a trustworthy manner. It is high water at full and change, at the Sand Heads at 9h. 0m., and at Kidderpore at 2h. 30m., thus giving the mean velocity of the tidal wave between these places as 26¼ miles per hour. The following Table shows the comparative velocity of the tidal wave, as compiled from the best information which the Author has been enabled to obtain:—

VELOCITY OF THE TIDAL WAVE IN THE HOOGHLY.

PLACES.	Distance between in Miles.	Velocity in Miles per Hour.	PLACES.	Distance between in Miles.	Velocity in Miles per Hour.
Lower Floating Light .			Entrance of Roopnarain		
Cowcolly	66	44	Kirmalpore	9¼	8½
Silver Creek. . . .	13	26	Moyapore	11	22
Culpee	9	18	Budge Budge . . .	5¼	21
Diamond Harbour . .	8½	17	Akra	5½	22
Entrance of Roopnarain	8½	17	Fort William . . .	9	18

The tidal streams in the sea channels leading to the river set round the compass thus: The first quarter flood runs W.N.W., round by north, to E.N.E. at last Quarter; the first quarter ebb runs E.S.E., round by south, to W.S.W. at last quarter. The maximum velocities of the flood and ebb streams are attained at the directions of N.N.W. and S.S.E. respectively, and they vary from 2 knots, to 3 knots, at springs, to, from 1 knot, to 1½ knot, at neaps. In the river the tidal streams vary in strength in different parts of the channel, and in accordance with the different seasons. In some places and at certain times, the velocity of the tidal stream is as much as 7 miles, or 8 miles an hour, whilst on the other hand, during the freshes, the ships at Calcutta will sometimes scarcely swing at their moorings. In the dry season, the upward tidal stream can be observed as far as Culna, about 56 miles above Calcutta. Above Culna, the current is constantly downwards, although there is a slight tidal rise perceptible at Nuddea, 78 miles above Calcutta.

The Hooghly is supposed to discharge about one-sixth of the waters of the Ganges; but from the small amount of existing infor-

mation, it is impossible to make more than a rough approximation to the total quantity which it receives. During the dry season it is comparatively insignificant, being derived principally from filtration for several months of the year. Major Lang, when superintendent of the Nuddea Rivers, estimated the supply which they conveyed from the Ganges as about 200,000 cubic feet per second in August, and as not exceeding 5,000 cubic feet per second in March, a considerable portion of the latter quantity being derived from filtration. The Author assumes, that the actual quantity directly discharged from the Ganges into the Hooghly, varies from 200,000 cubic feet per second to 2,000 cubic feet per second; and that the variation in this quantity, corresponding to any given period of the year, is some function of the corresponding height of the Ganges. He further assumes that the velocity of the stream, issuing from the Ganges, will be as the square root of the head of water, and that the area of the exit channel, owing to the form of the banks, will be nearly as the depth, and consequently, that the discharge will be, nearly as the depth, multiplied by the square root of the depth; or, in other words, the supply from the Nuddea Rivers will be, as the square root of the cube of the depth of water, in the portion of the Ganges adjacent to their exit channels. From the data furnished by Major Rennell in his account of that river, the Author has prepared a diagram (Plate 1, fig. 1) showing the rise of the Ganges throughout the year at Jellinghy; and from this it appears that the average height and the discharge, as calculated on the preceding hypothesis, for each month in the year, would be as shown in the following Table:—

TABLE showing the estimated DISCHARGE from the GANGES into the NUDDEA RIVERS during the YEAR.

Month.	Rise of Ganges above lowest level in Feet.	Cubic Feet of Water per Second.	Total Cubic Feet in the Month.
January....	3	7,600	20,355,840,000
February...	2	3,700	8,951,040,000
March.....	1	2,000	5,356,800,000
April.....	0¼	2,000	5.184,000,000
May.....	3	6,760	18,105,984,000
June.....	11	46,100	119,491,200,000
July.....	22	130,000	348,192,000,000
August....	29	200,000	535,680,000,000
September..	23	144,000	273,248,000,000
October....	14	68,100	181,998,040,000
November..	8	29,900	77,500,800,000
December..	4	14,000	37,497,600,000
Cubic Feet discharged Annually			163,561,304,000

[1] *Vide* Appendix to Memoir of A Map of Hindoostan. By James Rennell, F.R.S. London, 1793. Page 351, *et seq.*

It may therefore be estimated, that the quantity of fresh water passing into the Hooghly from the Ganges, through the Nuddea rivers, is upwards of 60,000 millions of cubic yards per annum; and as, in the absence of more complete information, it has been stated to the Author, that the amount brought down by the Damoodah and Roopnarain rivers is at least equal to that from the Nuddea rivers, he assumes, that the fresh water passing down the lower channels of the Hooghly is upwards of 120,000 millions of cubic yards per annum. Could this amount of water be conveyed to sea, as a limpid stream of uniform volume, it might perhaps exercise some beneficial influence on the channels through which it ran. The fact however is, that the greatest quantity of it passes down during the inundations, when the rivers of Bengal are highly charged with sediment. In considering its effects, it therefore becomes of importance, to form some estimate of the quantity of solid matter with which this water is charged.

From experiments made, in 1842, by Mr. Piddington, at Calcutta, it was ascertained, that the amount of silt held in suspension in the waters of the Hooghly, at noon on the first day of each month—supposing the silt to be measured when dried to the consistency of a sun-dried brick—was as follows:—

In January,	1 part in	3,519	In July,	1 part in	1,687
„ February,	„	2,717	„ August,	„	1,494
„ March,	„	857	„ September	„	1,672
„ April,	„	695	„ October,	„	5,087
„ May,	„	964	„ November,	„	1,910
„ June,	„	615	„ December,	„	2,443

Applying these results to the average monthly discharge of the Nuddea Rivers, as estimated in the calculated table (page 14), the amount of solid matter which they bring down in each month would be:—

	Cubic Feet.		Cubic Feet.
In January,	5,781,710	In July,	206,337,818
„ February,	3,294,456	„ August,	358,554,217
„ March,	6,250,642	„ September,	163,425,837
„ April,	7,458,992	„ October,	35,777,086
„ May,	18,782,141	„ November,	40,576,335
„ June,	194,294,634	„ December,	11,255,668

Hence the Author calculates, that not less than 39,000,000 cubic yards of solid matter are carried down each year, into the river and the sea channels of the Hooghly below Calcutta, and an equal quantity from the Damoodah and Roopnarain rivers, so that 78,000,000 cubic yards of solid earth are probably deposited yearly in the Hooghly and its estuary. How much of this is deposited seaward of Saugor Island it is impossible to say; but the existence of so

large a mass of silt in the water makes it easy to account for the observed seaward prolongation of the tails of the sands, and also for the shoaling of the lower reaches of the river, where, owing to the greater width, the current is slackened, and deposit takes place.

It may be argued, that the data, upon which the preceding calculations are based, are insufficient to warrant the results which the Author has deduced from them; and it may further be said, that the observations of the amount of silt, held in suspension at Calcutta, do not afford the means of judging, whether any of that silt is carried down to the sea channels of the river, inasmuch, as if the land water were perfectly limpid, there would, at all times, be mud held in suspension in the tideway at Calcutta, from the constant disturbance of the shores and bottom of the channel, which the flood and ebb streams occasion. But to these objections the Author would reply, that in each twenty-four hours the quantity of water passing Calcutta downwards, exceeds the quantity passing upwards, by the amount of fresh water received from the Nuddea Rivers, and that this excess is carried seaward, charged with silt to the extent determined by Mr. Piddington's experiments. The only conditions under which this water, or the earthy matter which it contains, could return, would be, that the flood stream had such an increased velocity above the ebb, as would enable it to hold this extra matter in suspension. But this assumption will not bear examination, for it is during the freshes, that by far the greater proportion of the land water passes down, and then, as already noticed, the flood tide is so feeble, that often the ships at Calcutta will scarcely swing to the stream. To show, that the Author's estimate of the amount of solid matter conveyed to the sea, by the Hooghly, is not exaggerated, he may mention, that it is stated, that in the year 1792 one of the mouths of Bhagiruttee was filled up, by the deposit from the Ganges, to the level of the adjacent country, in the course of a week, although its channel was 5 miles long, and must have contained 900 millions of cubic feet. Major Rennell estimated that in the flood season the Ganges, from whence its waters are derived, contains one-fourth part mud in its water, and, on the authority of Captain Sherwill, it is stated, that the annual deposit in the Bay of Bengal, from the Ganges and the Brahmapootra, amounted to 1,500 millions of cubic yards.

The delta of the Ganges, is considered by Major Rennell, to commence at the exit of the Nuddea Rivers, a distance of about 220 miles from the sea, in a direct line, but 300 miles, reckoned by the windings of the river. Its lower part is a labyrinth of tidal creeks, and its coast line extends from 180 miles to 200 miles. The average fall of the delta, taking the shortest distance to the sea, is

said to be about 9 inches per mile; and the surface fall of the Ganges in dry seasons, measuring along its course, is about 4 inches per mile. The stream of the Ganges varies in velocity from 3 miles per hour in the dry season, to 5 miles per hour, or 6 miles per hour in the rainy season; and in particular situations and circumstances it attains a velocity of 7 miles per hours, or 8 miles per hour. The soil of the delta of the Ganges consists of loamy sand and black mud.[1] It is unable to resist the action of the stream, and hence the course of the river is subject to great variations, and its banks are perpetually changing.

Below Calcutta the lands adjoining the Hooghly are on an average about a foot below the level of low water spring tides, but immediately adjacent to the river the banks are in many places several feet higher than the general surface of the country. This is also a characteristic feature of the principal Sunderbund creeks, evidently pointing to their origin, and to their having once served as outlets to the silt-charged flood-waters of the Ganges, which, in like manner, when passing down these creeks, as their volume swelled above the level of their beds, slackened their velocity at the sides of the widened stream, and deposited their earthy burthen in the eddies formed along the adjacent foreshores, thus gradually raising them above the level of the neighbouring lands, a process which, frequently repeated, eventually ended in diminishing the capacity of their channels, and successively disqualified each outlet for the office it had originally performed. On the sea-coast of the Delta there are eight openings, each of which has in turn probably served as the chief mouth of the Ganges. Of these the Hooghly is the most westerly, and the Mutla—the third from the west—is about 40 miles to the eastward of the Hooghly.

The Mutla is a tidal inlet of the sea rather than a river, inasmuch as it is not subject to floods, and, the fresh water entering, it is entirely confined to a small portion, which drains off the adjoining lands during the wet season. The principal rivers, or rather tidal creeks, with which it communicates are the Biddiadhurree and the Attara Banka at its head, the Edoo Creek and the Hoogledee about eleven miles lower down, and the Barnchoppy and Biddah Rivers at Cattalee. The two first-named form part of the inland navigation for country boats through the Sunderbunds to Calcutta, while the two last are in the route of the steamers which descend the Hooghly to Channel Creek, and which pass eastward by these creeks through the Sunderbunds to the Ganges, and, excepting the short period when the Nuddea rivers are open, the

[1] In 1814 a boring was made near the Hooghly at Calcutta, in search of fresh water. This boring was carried through sands and clays to a depth of 140 feet, when it was left off in coarse grey sand, but no water was found.

whole of the traffic to Calcutta from the Ganges passes across the Mutla.

The banks of the Mutla are low, and in this respect, as well as in the nature of the soil through which it passes, it may be said to be almost identical in its features with the Hooghly. But there are no bars or shifting sands in its channel, and it is free from the bore, which at times is so destructive in the Hooghly. It has a considerable depth, varying in different localities from 4 fathoms to 27 fathoms; and Lieutenant Ward, I.N., who surveyed it in 1853, reported on this point as follows:—"The least water in the channel I find to be 4 fathoms at low-water spring tides; there is therefore nothing to prevent vessels of the largest tonnage proceeding up the river at all times."[1] In the previous part of his Report he says:—"I find that no material changes have taken place in the river since surveyed in 1839. In the upper part, or that portion from the Manik Khaul to the Attara Banka, there appears to be no alteration; from the Manik Khaul to the sea does not appear to have been so minutely surveyed, in consequence there appears a difference in the surveys; the banks at the Sand Heads remain the same, with the exception that the bar formerly existing in the Eastern Channel has apparently been washed away. The banks at the Sand Heads are formed of a very fine sand, of a greyish colour; in the channels the bottom is a stiff blue mud, affording good anchoring ground: the banks in the river are also of sand, but with a coating of very soft mud. It is high water on the full and change at the Sand Heads at 9 hours, and at the head of the river at 11 hours 45 minutes. The rise and fall at Sand Heads 10 feet, at mouth of the river it is 12 feet; and at the head of the river it is 14½ feet. The tides run with a velocity of 4¼ miles per hour during the springs, and of about 2 miles per hour on the neaps."

The entrance to the Mutla is easy of access, and in the Sailing Instructions published by order of the Government, it is stated, that a stranger with Ward's chart could, with attention, conduct his ship in safety without a pilot, up to Cattalee, where there is excellent and safe anchorage. Its sea entrance channel lies between the Roymutla and the Bangadoony Sands. The total distance from the tail of these sands to the head of the Mutla at Attara Banka is 93 miles, and from the same point to the lower end of Bulcherry Island, where the channel of the estuary becomes confined between its high-water margins, 27 miles; a distance which may be favourably contrasted with the corresponding distances on the Hooghly, namely, that of the tail of the eastern sea-reef from the

[1] *Vide* "Report of C. V. Ward, Lieut.-Commanding H. Co.'s S.V. 'Krishna.'" Selections from the Records of the Bengal Government, No. xix. p. 107.

south end of Saugor Island, which is 50 miles. Passing upwards from Bulcherry Island, the channel of the Mutla runs nearly north, in almost a straight line, for a distance of 25 miles up to Cattalee Reach. Here it bends in a westerly direction for $5\frac{3}{4}$ miles, thus resembling in a remarkable manner the form of the Hooghly, from Diamond Harbour to the Roopnarain. At the end of this reach it again assumes a northerly direction for nearly 18 miles to the junction of the Hoogledee Creek, where it again turns westward for about 3 miles, and finally takes a north-easterly course to the head of the river, where it joins the Biddiadhurree Creek leading to Calcutta, and the Attara Banka, leading westward through the Sunderbunds. At the head of the river, where it is proposed to establish the new port, there is space for two hundred and forty ships, and in the Edoo Creek, for six hundred ships of the largest size, still leaving ample room for other vessels to swing in the stream.

The Author will now compare the two rivers, the Hooghly and the Mutla, in regard to their facilities for navigation, and their general hydrological features. In the Hooghly the river navigation extends from Calcutta, to Middleton Point at the lower end of Saugor Island, a distance of 99 miles, while the distance from the head of the Mutla to the river entrance at the south end of Bulcherry Island is only 65 miles, thus showing a gain of 34 miles, or about one-third, in favour of the Mutla.

Next, as to the depth of water:—By referring to the sections of the two rivers (Plate I.), if a standard of 24 feet at low water be assumed, it will be seen, that in the Mutla there are no shoals; whereas in the Hooghly there are six, of a length, in the aggregate, of upwards of 14 miles, and with a low-water depth upon them of from 15 feet to 18 feet only. To give a standard depth of 30 feet at low water, the Mutla would require deepening, at four places, to an extent varying from zero to 6 feet; whilst in the Hooghly the length to be deepened would be nearly 26 miles, and the depth to be excavated would be from zero to 15 feet. Again, in the Hooghly, the lowermost shoal is 63 miles from the uppermost, whereas, in the Mutla, taking even the 30 feet standard, the shoals, which are much less in extent, are all contained within a distance of 30 miles; or, if the first and the last, which are inconsiderable and might easily be removed, be neglected, then the only existing shoal would be comprised in a distance of $3\frac{3}{4}$ miles. It is further obvious, that the one shoal in the Mutla would be of little consequence, as compared with the six shoals in the Hooghly, separated as they are by intervals of miles from each other. In the former case, a vessel with the aid of steam might choose the time of tide, and having passed over the shoal, proceed to sea

without further obstruction; whereas in the Hooghly, a vessel can only pass one, or two shoals in each tide, and she must then anchor, while waiting for the tide again to carry her over the next shoal, and so on, until she has succeeded in reaching the sea.

As an instance of the delay attendant upon the navigation of the Hooghly, the Author will refer to his experience, as a passenger down the river, in the Peninsula and Oriental steamer 'Bentinck.' She was drawing 19 feet 2 inches only, and left Garden Reach, Calcutta, at 6 h. 0 m. A.M. on the 9th of April, 1857. The moon being at the full, the tides, spring tides; and the weather fine throughout the passage. On arriving at Ootabarea Reach, she was obliged to anchor for two hours, waiting for water over the Moyapore Sand. At 10 h. 15 m. A.M., she started again; at 1 h. 30 m. P.M., she passed the James and Mary Shoal, and at 2 h. 45 m. P.M., anchored again at Culpee, where, as the navigation of the Hooghly could only be carried on by daylight, she remained until 8 h. 45 m. A.M., on the 10th. She then proceeded on her downward voyage, and in consequence of there not being sufficient water through the Gaspar Channel, anchored in Saugor Roads, at 2 h. 25 m. P.M. on the morning of the 11th. She left Saugor Roads, and the pilot quitted the ship at 11 h. 40 m. A.M. Thus fifty-four hours were occupied in reaching the sea, notwithstanding the favourable conditions under which the passage was made. Similar delays, not only occasion a great loss of time and money, but, also involve serious risks; as it often happens, that vessels cannot anchor with safety, in the places where they are required to wait, for the tide to carry them over the succeeding shoals. Outward-bound vessels have frequently been delayed in the Hooghly, for two, or three weeks, from these causes; and in contrasting the capabilities of the two rivers, it may be stated generally, that whereas, a ship drawing 24 feet could only get to sea from Calcutta, by the aid of steam, and under the most favourable circumstances, in from three to four days, or during the south-west monsoon in five days, the same vessel could at all times get to sea from the head of the Mutla, in from eight hours, to ten hours. By the adoption of the Mutla, it is believed, that two days could be saved, in the time of the postal and passenger service, between this country and Calcutta. In the Author's Report on the Calcutta and South Eastern Railway (1857), he entered fully into the comparative charges of the two ports, and the result showed a saving of £587. 10*s.* on each voyage of a ship of 1,000 tons, in favour of the Mutla, or about 11*s.* 9*d.* a ton.

With regard to the more prominent points involved in the comparison of the two rivers, it has already been noticed, that they both run through a precisely similar country; that both are remarkably alike in their courses, and that both are subject to

the same tides; yet, that one is dangerous and difficult, whilst the other is safe and convenient for navigation. Whence does this difference arise?—The physical distinctions are, that in the Hooghly there is a vast, though greatly varying, supply of fresh water, acting simultaneously with the tidal flow; whereas in the Mutla there is tidal water alone,—and not only that which fills its own bed twice in every twenty-five hours, but also, the tidal water which passes through it, while flowing into, and ebbing from the great reservoir channels of the Biddiadhurree and the Attara Banka, as well as to, and from, their branches, and the other Sunderbund Creeks. These are the distinctions in the conditions of the Hooghly, and the Mutla, to which, in the Author's opinion, are due the differences in their state as navigable channels. The result appears to him conclusive as to the value of tidal water alone, as compared with fresh water and tidal scour combined. By tidal scour alone, there is a deep and unchanging channel, free from bars and shifting sands. By the combined action of fresh water and tidal scour, there are shoals, shifting sands, variable channels, and a gradual, and it may even be said, a rapid shoaling of the lower channels of the estuary. The Author brings his views on these points prominently before the Institution, because he is aware, that during the discussion of the subject in the locality, one member of the Hooghly Committee, Mr. Piddington, a gentleman of well-known ability, entertained a contrary impression, attaching the greatest importance to the fresh water, as an agent of improvement, and looking to the increase of its quantity, as the chief and effectual means of remedying the present defective state of the Hooghly. Owing to differences of opinion, Mr. Piddington reported separately from his colleagues, and in concluding his Report says:—"I am earnestly desirous of drawing the special attention of Government (without, as I hope, overstepping my functions as a Member of the Committee) to, *First*, my remarks above (p. xvi. to xix.) on the deficiency in the nautical education of the junior members of the Pilot Service: *Secondly*, to the importance of obtaining for as long a period in the year as possible, a good supply from the purer waters of the Ganges to the feeders of the turbid Hooghly, to aid the downward sweep of the tides; and, *Thirdly*, to the advantages in point of celerity and safety, which might arise to the navigation of the river throughout, from any well-contrived and economical plan for stirring the mud and sands at the more difficult crossing places. With these efforts on our part, which I respectfully submit are naturally, and some of them indeed urgently, called for—and homely and self evident as a few simple efforts for the amelioration of the channels may appear, they are in truth scientific means of the first order, as seconding and carrying out the evident processes

of nature: with these endeavours, then, intelligently directed and perseveringly carried on, I trust that, under Providence, it may yet be a far distant time ere our noble river will become more dangerous, or less navigable, for vessels of great burden, whether under sail or with steam, than it has been during any part of the present century."[1] Some of the witnesses appeared to participate in these opinions, and particularly Major Lang, the then Superintendent of the Nuddea rivers, that officer in his evidence having said:—"It is during the freshes, when the supply of water by the Nuddea rivers is very abundant, and when these rivers are well opened throughout, that the waterway of the Hooghly is made, and year after year preserved." The Author believes the views of Major Lang to be erroneous. It is not only the detritus brought into the Hooghly, by the fresh water from the Nuddea rivers, and that brought down by the Damoodah and the Roopnarain, that is prejudicial; but the action of the fresh water itself, which, when running in conjunction with, or in opposition to, the tidal streams, leads to the shifting of the sands, and the variation of the channels. A strong illustration of the correctness of this position is afforded, in the effects of the tides, and the upland waters, upon the sand-banks and channels, of the James and Mar Reach, which have already been detailed in a preceding part of this Paper.[2]

With reference to the suggestions put forward by Mr. Piddington, the Author will not say, that remedial measures could not be adopted; but he believes, that their effect would be small, and their expense very great. Moreover, he considers, that the effect of the proposed system of increasing the amount of fresh water, and of dredging, or raking over the shoals, would only increase the amount of deposit, and occasion the sands in the upper channel to shift, to a greater extent than at present. He, however, believes that an improvement might be effected, in the upper portion of the river, by turning the waters of the Damoodah from their present channel into that of the Roopnarain, which could easily be done, by making a cut of 4 miles in length, from near Bagnan, in a direction a little to the west of south. In view of the leading features of the James and Mary Shoal, the Author has arrived at the conclusion, that it owes its origin to the conflicting and varying influences of the freshes and tides, and particularly to the action of the Damoodah River. It has already been stated, that previously to the year 1762, that river joined the Hooghly above Calcutta. Had any records been in existence, it would have been interesting

[1] *Vide* "Reports, with Proceedings and Appendix, of the Committee appointed by Government to Inquire into the State of the River Hooghly." Calcutta, 1854.
[2] *Vide ante*, p. 10 *et seq.*

to have compared the past and the present state of the James and Mary Reach. There is, however, in Calcutta a well-authenticated tradition, that the James and Mary Shoal was formed in consequence of the change in the outlet of the Damoodah, and the Author has no doubt but that such was the case, for it appears evident, that if it were not for the discharge of the Damoodah, the set of the flood and ebb tide in the James and Mary Reach would, at all seasons, be along the western shore, and that a deep and permanent channel, on that side of the river, would be the necessary result. In considering the proposed change, a doubt may be felt, as to the effect of the increased volume of water discharged by the Roopnarain upon the Hooghly Sand, and the channels on each side of it. The Author therefore hopes that such members of the profession as have specially studied these subjects, will favour the Institution with their views on that point; his personal opinion being, that while the diversion of the Damoodah would effect a great improvement, in the removal of the James and Mary Shoal, it would not occasion any detrimental effect to the river below, and that the result would be, that the flood and ebb tide from the Roopnarain would then have a straight course, and that the Mukreeputty lumps being swept away by the ebb from the Hooghly, a fair way would be opened, into the then permanent western channel.

In the lower part of the river, the Author regards engineering works, as hopeless. The first effort of the river Engineer is to confine the flood and ebb tide to the same channel. How far works with that object could be executed, and how far, if executed, they would be effective, in an estuary from 7 miles, to 17 miles in width, and at what cost, it is impossible to say; but it may be confidently affirmed, that the risk of failure would be great, the expenditure of money large, and that the only certain result would be a considerable increase in the, already heavy, port-charges of the Hooghly.

In conclusion, respecting the presumed rivalry between the old port of Calcutta, and the new one of the Mutla, the Author cannot do better, than quote from the Report which he made in 1857, to the Directors of the Calcutta and South Eastern Railway Company, in which he said:—"It is feared by many, and perhaps with some show of truth, that the transference of a large portion of the trade of Calcutta to the Mutla would seriously depreciate the value of private property in Calcutta. But even if this were so, it could only arise from the country at large being greatly benefited by the creation of a new and admirable port. If it were not a public benefit, the trade would not be attracted there. If it be a public benefit, then private interests must not stand in the way. But, after all, is it so certain that Calcutta would be ruined by opening out the Mutla? For my own part I do not think it would be so. The trade of India is striding onward—it has done so under all its

antiquated conditions. New facilities are at length being afforded to it. The railway system has been introduced, and so far as it has gone, has more than realized the most sanguine expectations of its promoters. It is only in its infancy. Within a few years, the vast system of the East Indian Railway, and probably the Eastern of Bengal Railway, extending upwards to the north-eastern districts of Bengal, will pour in an enormously increasing stream of traffic to Calcutta; and I doubt not that, ere many years are over, this trade will have obtained a development that will amply reward the proprietors of the new system of communication, afford an abundant business for both ports, and confer an incalculable benefit upon this magnificent country."[1]

The Paper is illustrated by a series of diagrams, from which Plate 1 has been compiled.

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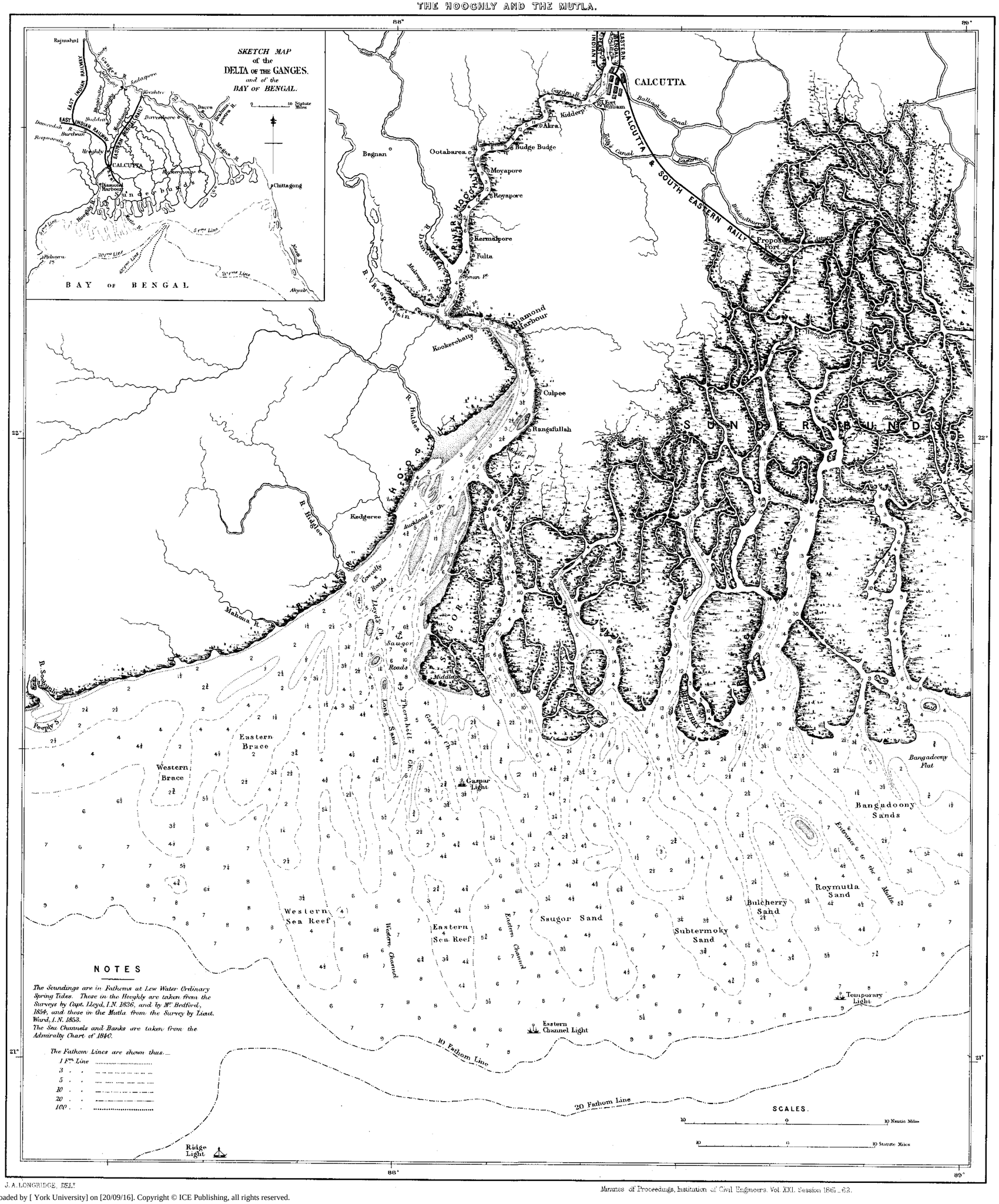
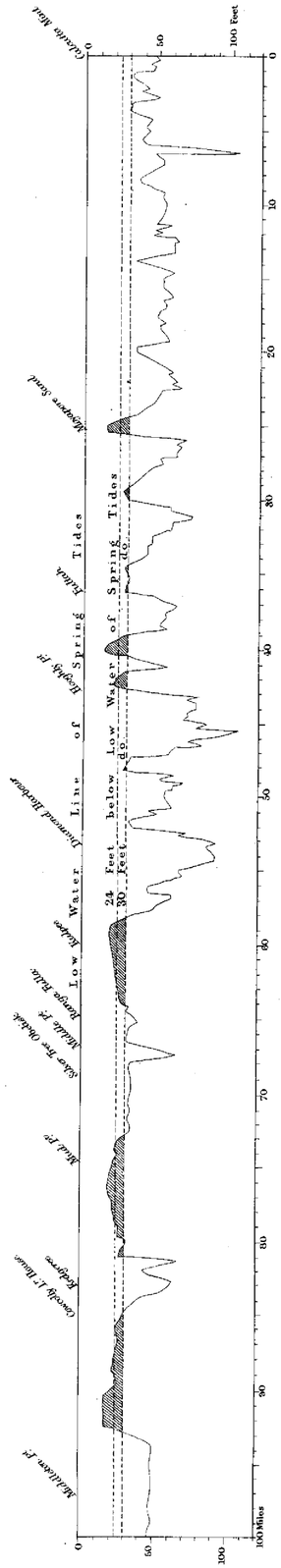
[1] *Vide* "Report on the Calcutta and South Eastern Railway, from Calcutta to the River Mutla and the extension eastwards to Dacca and the Burmese provinces." By James A. Longridge. Page 20.

[Mr. J. A. LONGRIDGE,





N.B. *The portions of the Longitudinal Sections of the Hooghly and the Mutla shaded thus show the depth and extent of the dredging which is required for the formation in each River of a Low Water Channel of 30 Feet in depth.*

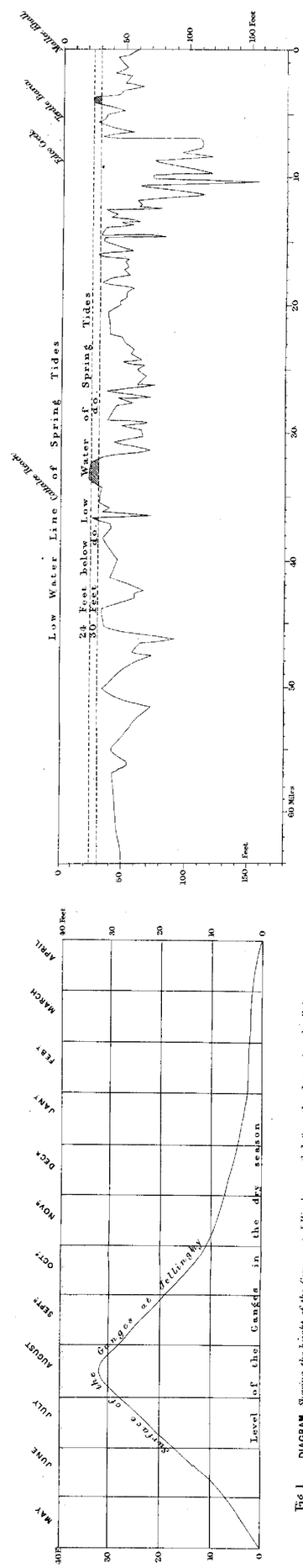


Fig. 1.— DIAGRAM *Shewing the height of the Ganges at Jellinghy; compiled from the data given by Major Rennel, F.R.S. in his 'Memoir of a Map of Hindoostan,' p. pp. 331. 2. 3.*

J. A. LONGRIDGE, DEL.

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