

IX. *An Account of the Ganges and Burrampooter Rivers.* By James Rennell, *Esq. F. R. S.*; communicated by Joseph Banks, *Esq. P. R. S.*

Read January 25, 1781.

THE * Ganges and † Burrampooter Rivers, together with their numerous branches and adjuncts, intersect the country of Bengal in such a variety of directions, as to form the most compleat and easy inland navigation that can be conceived. So equally and admirably diffused are those natural canals, over a country that approaches nearly to a perfect plane, that, after excepting the lands contiguous to Burdwan, Birboom, &c. (which altogether do not constitute a sixth part of Bengal) we may fairly pronounce, that every other part of the country has, even in the dry season, some navigable stream within 25 miles at farthest, and more commonly within a third part of that distance.

It is supposed, that this inland navigation gives constant employment to 30,000 boatmen. Nor will it be wondered at, when it is known, that all the salt, and a large proportion of the

* The proper name of this river in the language of Hindoostan (or Indostan) is Pudda or Padda. It is also named Burra-Gonga, or the Great River; and Gonga, the River, by way of eminence; and from this, doubtless, the European names of the river are derived.

† The orthography of this word, as given here, is according to the common pronunciation in Bengal; but it is said to be written in the Sanscrit language, *Brahma-pootar*, which signifies the Son of Brahma.

food consumed by ten millions of people are conveyed by water within the kingdom of Bengal and its dependencies. To these must be added, the transport of the commercial exports and imports, probably to the amount of two millions sterling *per annum*; the interchange of manufactures and products throughout the whole country; the fisheries; and the article of travelling*.

These rivers, which a late ingenious gentleman aptly termed sisters and rivals (he might have said *twin* sisters, from the contiguity of their springs), exactly resemble each other in length of course; in bulk, until they approach the sea; in the smoothness and colour of their waters; in the appearance of their borders and islands; and, finally, in the height to which their floods rise with the periodical rains. Of the two, the Burrampooter is the largest; but the difference is not obvious to the eye. They are now well known to derive their sources from the vast mountains of Thibet †; from whence they proceed in opposite directions; the Ganges seeking the plains of Hindoostan (or Indoostan) by the west; and the Burrampooter by the east; both pursuing the early part of their course through rugged vallies and defiles, and seldom visiting the habitations of men. The Ganges, after wandering about 750 miles through these mountainous regions, issues forth a deity to the supersti-

* The embarkations made use of vary in bulk from 180 tons down to the size of a wherry. Those from 30 to 50 tons are reckoned the most eligible for transporting merchandize.

† These are amongst the highest of the mountains of the old hemisphere. I was not able to determine their height; but it may in some measure be guessed, by the circumstance of their rising considerably above the horizon, when viewed from the plains of Bengal, at the distance of 150 miles.

tious, yet gladdened, inhabitant of Hindoostan *. From Hurdwar (or Hurdoar) in latitude 30°, where it gushes through an opening in the mountains, it flows with a smooth navigable stream through delightful plains during the remainder of its course to the sea (which is about 1350 miles) diffusing plenty immediately by means of its living productions; and secondarily by enriching the adjacent lands, and affording an easy means of transport for the productions of its borders. In a military view, it opens a communication between the different posts, and serves in the capacity of a *military way* through the country; renders unnecessary the forming of magazines; and infinitely surpasses the celebrated inland navigation of North America, where the *carrying places* not only obstruct the progress of an army, but enable the adversary to determine his place and mode of attack with certainty.

In its course through the plains, it receives eleven rivers, some of which are equal to the Rhine, and none smaller than the

* The fabulous account of the origin of the Ganges (as communicated by my learned and ingenious friend C. W. BOUGHTON ROUSE, Esq.) is, that it flows out of the foot of Beshan * (from whence, say the Bramins, it has its name Padda; that word signifying foot in the Sanscrit language); and that in its course to the plains of Hindoostan it passes through an immense rock shaped like a Cow's-head.

The allegory is highly expressive of the veneration which the Hindoos have for this famous stream; and no less so of their gratitude to the Author of Nature for bestowing it: for it describes the blessing as flowing purely from his bounty and goodness.

The rock before mentioned has, I believe, never been visited by any European; and is even allowed by most of the natives to bear no resemblance to the object from whence it is denominated. However, as the effects of superstition do often long survive the illusions that gave it birth, the rock or cavern still preserves the name of *Gowmooky*, or Cow's-head.

* Beshan is the same with Vishnou, the PRESERVING DEITY.

Thames, besides as many others of lesser note. It is owing to this vast influx of streams, that the Ganges exceeds the Nile so greatly in point of magnitude, whilst the latter exceeds it in length of course by one-third. Indeed, the Ganges is inferior in this last respect, to many of the northern rivers of Asia; though I am inclined to think that it discharges as much or more water than any of them, because those rivers do not lie within the limits of the periodical rains*.

The bed of the Ganges is, as may be supposed, very unequal in point of width. From its first arrival in the plains at Hurd-

* The proportional lengths of course of some of the most noted rivers in the world are shewn nearly by the following numbers :

European Rivers.			
Thames,	-	-	1
Rhine,	-	-	$5\frac{1}{4}$
Danube,	-	-	7
Wolga,	-	-	$9\frac{1}{2}$
Asiatic rivers.			
Indus,	-	-	$5\frac{1}{2}$
Euphrates,	-	-	$8\frac{1}{2}$
Ganges,	-	-	$9\frac{1}{2}$
Burrampooter,	-	-	$9\frac{1}{2}$
Nou Kian, or Ava River,	-	-	$9\frac{1}{2}$
Jennifea,	-	-	10
Oby,	-	-	$10\frac{1}{2}$
Amoor,	-	-	11
Lena,	-	-	$11\frac{1}{2}$
Hoanho (of China),	-	-	$13\frac{1}{2}$
Kian Keu (of ditto),	-	-	$15\frac{1}{2}$
African river.			
Nile,	-	-	$12\frac{1}{2}$
American rivers.			
Mississipi,	-	-	8
Amazons,	-	-	$15\frac{3}{4}$

war, to the conflux of the Jumnah (the first river of note that joins it) its bed is generally from a mile to a mile and a quarter wide; and, compared with the latter part of its course, tolerably straight. From hence, downward, its course becomes more winding, and its bed consequently wider*, till, having alternately received the waters of the Gogra, Soane, and Gunduck, besides many smaller streams, its bed has attained its full width; although, during the remaining 600 miles of its course it receives many other principal streams. Within this space it is, in the narrowest parts of its bed, half a mile wide, and in the widest, three miles; and that, in places where no islands intervene. The stream within this bed is always either increasing or decreasing, according to the season. When at its lowest (which happens in April) the principal channel varies from 400 yards to a mile and a quarter; but is commonly about three quarters of a mile.

The Ganges is fordable in some places above the conflux of the Jumnah, but the navigation is never interrupted. Below that, the channel is of considerable depth, for the additional streams bring a greater accession of depth than width. At 500 miles from the sea, the channel is thirty feet deep when the river is at its lowest; and it continues at least this depth to the sea, where the sudden expansion of the stream deprives it of the force necessary to sweep away the bars of sand and mud thrown across it by the strong southerly winds; so that the principal branch of the Ganges cannot be entered by large vessels.

About 220 miles from the sea (but 300 reckoning the windings of the river) commences the head of the Delta of the Ganges, which is considerably more than twice the area of that of the Nile. The two westernmost branches, named the

* This will be explained when the windings of the river are treated of.

Coffimbuzar and Jellinghy Rivers, unite and form what is afterwards named the Hoogly River, which is the port of Calcutta, and the only branch of the Ganges that is commonly navigated by ships *. The Coffimbuzar River is almost dry from October to May; and the Jellinghy River (although a stream runs in it the whole year) is in some years unnavigable during two or three of the dryest months; so that the only subordinate branch of the Ganges, that is at all times navigable, is the Chundnah River, which separates at Moddapour, and terminates in the Hooringotta.

That part of the Delta bordering on the sea, is composed of a labyrinth of rivers and creeks, all of which are salt, except those that immediately communicate with the principal arm of the Ganges. This tract, known by the name of the Woods, or Sunderbunds, is in extent equal to the principality of Wales; and is so completely enveloped in woods, and infested with Tygers, that if any attempts have ever been made to clear it (as is reported) they have hitherto miscarried. Its numerous canals are so disposed as to form a compleat inland navigation throughout and across the lower part of the Delta, without either the delay of going round the head of it, or the hazard of putting to sea. Here salt, in quantities equal to the whole consumption of Bengal and its dependencies, is made

* The Hoogly River, or westernmost branch of the Ganges, has a much deeper outlet to the sea than the principal branch. Probably this may be owing to its precipitating a less quantity of mud than the other; the quantity of the Ganges water discharged here being less than in the other in the proportion of one to six. From the difficulties that occur in navigating the entrance of the Hoogly River, many are led to suppose, that the channels are shallow. The difficulties, however, arise from bringing the ships across some of the sand-banks, which project so far into the sea, that the channels between them cannot easily be traced from without.

and transported with equal facility: and here also is found an inexhaustible store of timber for boat-building. The breadth of the lower part of this Delta is upwards of 180 miles; to which, if we add that of the two branches of the river that bound it, we shall have about 200 miles for the distance to which the Ganges expands its branches at its junction with the sea.

It has been observed before, that the course of this river, from Hurdwar to the sea, is through an uniform plain, or, at least, what appears such to the eye: for, the declivity is much too small to be perceptible. A section of the ground, parallel to one of its branches, in length 60 miles, was taken by order of Mr. HASTINGS; and it was found to have about nine inches descent in each mile, reckoning in a straight line, and allowance being made for the curvature of the earth. But the windings of the river were so great, as to reduce the declivity on which the water ran, to less than four inches *per* mile: and by a comparison of the velocity of the stream at the place of experiment with that in other places, I have no reason to suppose, that its general descent exceeds it*.



The medium rate of motion of the Ganges is less than three miles an hour in the dry months. In the wet season, and during the draining off of the waters from the inundated lands, the current runs from five to six miles an hour; but there are instances of its running seven, and even eight miles, in particular situations, and under certain circumstances. I have an

* M. DE CONDAMINE found the descent of the river Amazons, in a straight course of about 1860 miles, to be about 1020 English feet, or $6\frac{1}{2}$ inches in a mile. If we allow for the windings, it comes out nearly the same as the Ganges (which winds about $1\frac{1}{2}$ mile in three, taking its whole course through the plains), namely, about 4 inches in a mile.

experiment of my own on record, in which my boat was carried 56 miles in eight hours; and that against so strong a wind, that the boat had evidently no progressive motion through the water.

When we consider, that the velocity of the stream is three miles in one season, and five or more in the other, on the same descent of four inches *per* mile; and, that the motion of the inundation is only half a mile *per* hour, on a much greater descent; no further proof is required how small the proportion of velocity is, that the descent communicates. It is then, to the impetus originating at the spring head, or at the place where adventitious waters are poured in, and successively communicated to every part of the stream, that we are principally to attribute the velocity, which is greater or lesser, according to the quantity of water poured in.

In common, there is found on one side of the river an almost perpendicular bank, more or less elevated above the stream, according to the season, and with deep water near it: and on the opposite side a bank, shelving away so gradually as to occasion shallow water at some distance from the margin. This is more particularly the case in the most winding parts of the river, because the very operation of winding produces the steep and shelving banks*: for the current is always strongest on the external side of the curve formed by the serpentine course of the river; and its continual action on the banks

* Hence it is, that the section of a river, that winds through a loose soil, approaches nearly to an obtuse angled-triangle, one of whose sides is exceedingly short and disproportioned to the other two . But when a river perseveres in a straight course, the section becomes nearly the half of an ellipsis divided longitudinally .

either

either undermines them *, or washes them down. In places where the current is remarkably rapid, or the soil uncommonly loose, such tracts of land are swept away in the course of one season, as would astonish those who have not been eyewitnesses to the magnitude and force of the mighty streams occasioned by the periodical rains of the tropical regions. This necessarily produces a gradual change in the course of the river; what is lost on one side being gained on the other, by the mere operation of the stream: for the fallen pieces of the bank dissolve quickly into muddy sand, which is hurried away by the current along the border of the channel to the point from whence the river turns off to form the next reach, where the stream growing weak, it finds a resting place, and helps to form a shelving bank, which commences at the point, and extends downwards, along the side of the succeeding reach.

To account for the slackness of the current at the point, it is necessary to observe, that the strongest part of it, instead of turning short round the point, preserves for some time the direction given it by the last steep bank, and is accordingly thrown obliquely across the bed of the river to the bay on the opposite side, and pursues its course along it, till the intervention of another point again obliges it to change sides.

In those few parts of the river that are straight, the banks undergo the least alteration †, as the current runs parallel to

* In the dry season some of these banks are more than 30 feet high, and often fall down in pieces of many tons weight, and occasion so sudden and violent an agitation of the water, as sometimes to sink large boats that happen to be near the shore.

† It is more than probable, that the straight parts owe their existence to the tenacity of the soil of which their banks are composed. Whatever the cause may be, the effect very clearly points out such situations as the properest for placing towns in.

them ; but the least inflection of course has the effect of throwing the current against the bank ; and if this happens in a part where the soil is composed of loose sand, it produces in time a serpentine winding.

It is evident, that the repeated additions made to the shelving bank before mentioned, become in time an encroachment on the channel of the river ; and this is again counter-balanced by the depredations made on the opposite steep bank, the fragments of which, either bring about a repetition of the circumstances above recited, or form a bank or shallow in the midst of the channel. Thus a steep and a shelving bank are alternately formed in the crooked parts of the river (the steep one being the *indented* side, and the shelving one the *projecting*) ; and thus, a continual fluctuation of course is induced in all the winding parts of the river ; each meander having a perpetual tendency to deviate more and more from the line of the general course of the river, by eating deeper into the bays, and at the same time adding to the points, till either the opposite bays meet, or the stream breaks through the narrow isthmus, and restores a temporary straightness to the channel.

Several of the windings of the Ganges and its branches are fast approaching to this state ; and in others, it actually exists at present. The experience of these changes should operate against attempting canals of any length, in the higher parts of the country ; and I much doubt, if any in the lower parts would long continue navigable. During eleven years of my residence in Bengal, the outlet or head of the Jellinghy River was gradually removed three quarters of a mile farther down : and by two surveys of a part of the adjacent bank of the Ganges, taken about the distance of nine years from each other, it appeared that the breadth of an English mile and a half had been
taken

taken away. This is, however, the most rapid change that I have noticed; a mile in ten or twelve years being the usual rate of incroachment, in places where the current strikes with the greatest force, namely, where two adjoining reaches approach nearest to a right angle. In such situations it not unfrequently excavates gulfs * of considerable length within the bank. These gulfs are in the direction of the strongest parts of the stream; and are, in fact, the *young shoots* (if I may so express myself) which in time strike out and become branches of the river; for we generally find them at those turnings that have the smallest angles †.

Two causes, widely different from each other, occasion the meandering courses of rivers; the one, the irregularity of the ground through which they run, which obliges them to wander in quest of a declivity; the other, the looseness of the soil, which yields to the friction of the border of the stream. The meanders in the first case, are, of course, as digressive and irregular as the surface they are projected on: but, in the latter, they are so far reducible to rule, that rivers of unequal bulk will, under similar circumstances, take a circuit to wind in, whose extent is in proportion to their respective breadths: for I have observed, that

* The Count DE BUFFON advises the digging of such gulfs in the banks of ordinary rivers, with a view to divert the current, when bridges or other buildings are endangered by it.

† The courses of these branches at the efflux, generally, if not always, become retrograde to the course of the river: for, a sand bank accumulating at the upper point of separation, gives an oblique direction upwards, to the stream, which would otherwise run out at right angles. This sand bank being always on the increase, occasions a corrosion of the opposite bank; and by this means all, or most of the outlets have a progressive motion downwards; as I have before remarked of the Jellinghy River, in the foregoing page.

when a branch of the Ganges is fallen so low as to occupy only a part of its bed, it no longer continues in the line of its old course; but works itself a new channel, which winds from side to side across the former one. I have observed too, that in two streams, of equal size, that which has the slowest current has also the smallest windings: for as these (in the present case) are solely owing to the depredations made on the banks by the force of the current; so the extent of these depredations, or, in other words, the dimensions of the windings, will be determined by the degree of force acting on the banks.

The windings of the Ganges in the plains, are, doubtless, owing to the looseness of the soil: and (I think) the proof of it is, that they are perpetually changing; which those, originally induced by an inequality of surface, can seldom, or never do*.

I can easily suppose, that if the Ganges was turned into a straight canal, cut through the ground it now traverses in the most winding parts of its course, its straightness would be of short duration. Some yielding part of the bank, or that which happened to be the most strongly acted on, would first be corroded or dissolved: thus a bay or cavity would be formed in the side of the bank. This begets an inflection of the current, which, falling obliquely on the side of the bay, corrodes it incessantly. When the current has passed the innermost part of the bay, it receives a new direction, and is thrown

* It has been remarked, that the courses of rivers become more winding as they approach the sea. This, I believe, will only hold good in such as take the latter part of their course through a sandy soil. In the Ganges, and other rivers subject to considerable variations in the bulk of their streams, the best marks of the vicinity of the sea are, the lowness of the river banks, and the increasing muddiness of the shallows in its bed.

obliquely

obliquely towards the opposite side of the canal, depositing in its way the matter excavated from the bay, and which begins to form a shallow or bank contiguous to the border of the canal. Here then is the origin of such windings as owe their existence to the nature of the soil. The bay, so corroded, in time becomes large enough to give a new direction to the body of the canal: and the matter excavated from the bay is so disposed as to assist in throwing the current against the opposite bank, where a process, similar to that I have been describing, will be begun.

The action of the current on the bank will also have the effect of deepening the border of the channel near it; and this again increases the velocity of the current in that part. Thus would the canal gradually take a new form, till it became what the river now is. Even when the windings have lessened the descent one half, we still find the current too powerful for the banks to withstand it.

There are not wanting instances of a total change of course in some of the Bengal rivers*. The Cofa River (equal to the Rhine) once ran by Purneah, and joined the Ganges opposite Rajemal. Its junction is now 45 miles higher up. Gour, the ancient capital of Bengal, stood on the banks of the Ganges.

Appearances favour very strongly the opinion, that the Ganges had its former bed in the tract now occupied by the lakes and morasses between Nattore and Jaffiergunge, striking out of its present course at Bauleah, and passing by Pootyah. With an equal degree of probability (favoured by tradition) we may trace its supposed course by Dacca, to a junction with the Burrampooter or Megna near Fringybazar; where the accumu-

* The Mootyjyl lake is one of the windings of a former channel of the Cofimbuzar River.

lation of two such mighty streams probably scooped out the present amazing bed of the Megna*.

In tracing the sea coast of the Delta, we find no less than eight openings; each of which, without hesitation, one pronounces to have been in its time the principal mouth of the Ganges. Nor is the occasional deviation of the principal branch, probably, the only cause of fluctuation in the dimensions of the Delta. One observes, that the Deltas of capital rivers (the tropical ones particularly) encroach upon the sea. Now, is not this owing to the mud and sand brought down by the rivers, and gradually deposited, from the remotest ages down to the present time? The rivers, we know, are loaded with mud and sand at their entrance into the sea; and we also know, that the sea recovers its transparency at the distance of twenty leagues from the coast; which can only arise from the waters having precipitated their earthy particles within that space. The sand and mud banks at this time, extend twenty miles off some of the islands in the mouths of the Ganges and Burrampooter; and in many places rise within a few feet of the surface. Some future generation will probably see these banks rise above water, and succeeding ones possess and cultivate them! Next to earthquakes, perhaps the floods of the tropical rivers produce the quickest alterations in the face of our globe. Extensive islands are formed in the channel of the Ganges, during a period far short of that of a man's life; so that the whole process lies

* Megna and Burrampooter are names belonging to the same river in different parts of its course. The Megna falls into the Burrampooter; and, though a much smaller river, communicates its name to the other during the rest of its course.

within the compass of his observation *. Some of these islands, four or five miles in extent, are formed at the angular turnings of the river, and were originally large sand banks thrown up round the points (in the manner before described) but afterwards insulated by breaches of the river. Others are formed in the straight parts of the river, and in the middle of the stream; and owe their origin to some obstruction lurking at the bottom. Whether this be the fragments of the river bank; a large tree swept down from it; or a sunken boat; it is sufficient for a foundation: and a heap of sand is quickly collected below it. This accumulates amazingly fast: in the course of a few years it peeps above water, and having now usurped a considerable portion of the channel, the river borrows on each side to supply the deficiency in its bed; and in such parts of the river we always find steep banks on both sides †. Each periodical flood brings an addition of matter to this growing island; increasing it in height as well as extension, until its top is perfectly on a level with the banks that include it: and at that period of its growth it has mould enough on it for the purposes of cultivation, which is owing to the mud left on it when the waters subside, and is indeed a part of the œconomy which nature observes in fertilizing the lands in general.

Whilst the river is forming new islands in one part, it is sweeping away old ones in other parts. In the progress of this destructive operation, we have opportunities of observing, by means of the sections of the falling bank, the regular distri-

* Accordingly, the laws respecting alluvion are ascertained with great precision.

† This evidently points out the means for preventing encroachments on a river bank in the straight parts of its course, *viz.* to remove the shallows in the middle of its channel.

bution of the several strata of sand and earths, lying above one another in the order in which they decrease in gravity. As they can only owe this disposition to the agency of the stream that deposited them, it would appear, that these substances are suspended at different heights in the stream, according to their respective gravities. We never find a stratum of earth under one of sand; for the muddy particles float nearest the surface*. I have counted seven distinct strata in a section of one of these islands. Indeed, not only the islands, but most of the river banks wear the same appearance: for as the river is always changing its present bed, and verging towards the site of some former one now obliterated, this must necessarily be the case.

As a strong presumptive proof of the wandering of the Ganges from the one side of the Delta to the other, I must observe, that there is no appearance of *virgin* earth between the Tiperah Hills on the east, and the province of Burdwan on the west; nor on the north till we arrive at Dacca and Bauleah. In all the sections of the numerous creeks and rivers in the Delta, nothing appears but sand and black mould in regular strata, till we arrive at the clay that forms the lower part of their beds. There is not any substance so coarse as gravel either in the Delta or nearer the sea than 400 miles †, where a rocky point, a part of the base of the neighbouring hills, projects into the river: but out of the vicinity of the great rivers the soil is either red, yellow, or of a deep brown.

* A glass of water taken out of the Ganges, when at its height, yields about one part in four of mud. No wonder then that the subsiding waters should quickly form a stratum of earth; or that the Delta should encroach upon the sea!

† At Oudanulla.

I come now to the particulars of the annual swelling and overflowing of the Ganges*.

It appears to owe its increase as much to the rain water that falls in the mountains contiguous to its source, and to the sources of the great northern rivers that fall into it, as to that which falls in the plains of Hindoostan; for it rises fifteen feet and a half out of thirty-two (the sum total of its rising) by the latter end of June: and it is well known, that the rainy season does not begin in most of the flat countries till about that time. In the mountains it begins early in † April; and by the latter end of that month, when the rain-water has reached Bengal, the rivers begin to rise, but by very slow degrees; for the increase is only about an inch *per* day for the first fortnight. It then gradually augments to two and three inches before any

* An opinion has long prevailed, that the swelling of the Ganges, previous to the commencement of the rainy season in the flat countries, is in a great measure owing to the melting of the snow in the mountains. I will not go so far as totally to disallow the fact; but can by no means suppose, that the quantity of snow water bears any proportion to the increase of the river.

† The vast collection of vapours, wafted from the sea by the southerly or south-west monsoon, are suddenly stopped by the lofty ridge of mountains that runs from east to west through Thibet. It is obvious, that the accumulation and condensation of these vapours, must first happen in the neighbourhood of the obstacle; and successively in places more remote, as fresh supplies arrive to fill the atmosphere. Hence the priority of commencement of the rainy season in places that lie nearest the mountains.

All the rivers that are situated within the limits of the monsoons, or shifting trade winds, are subject to overflowings at annually stated periods, like the Ganges: and these periods return during the season of the southerly wind, that being the only wind which brings vapours from the sea; and this being periodical, the falls of rain must necessarily be so too.

The northerly wind, which blows only over the land, is dry; for no rain (except casual showers) falls during the continuance of that monsoon.

quantity

quantity of rain falls in the flat countries; and when the rain becomes general, the increase on a medium is five inches *per* day. By the latter end of July all the lower parts of Bengal, contiguous to the Ganges and Burrampooter, are overflowed, and form an inundation of more than a hundred miles in width; nothing appearing but villages and trees, excepting very rarely the top of an elevated spot (the artificial mound of some deserted village) appearing like an island.

The inundations in Bengal differ from those in Egypt in this particular, that the Nile owes its floods *entirely* to the rain-water that falls in the mountains near its source; but the inundations in Bengal are as much occasioned by the rain that falls there, as by the waters of the Ganges; and as a proof of it, the lands in general are overflowed to a considerable height long before the bed of the river is filled. It must be remarked, that the ground adjacent to the river bank, to the extent of some miles, is considerably higher than the rest of the country*, and serves to separate the waters of the inundation from those of the river until it overflows. This high ground is in some seasons covered a foot or more; but the height of the inundation within, varies, of course, according to the irregularities of the ground, and is in some places twelve feet.

Even when the inundation becomes general, the river still shews itself, as well by the grass and reeds on its banks, as by its rapid and muddy stream; for the water of the inundation acquires a blackish hue, by having been so long stagnant

* This property of the bank is well accounted for by Count BUFFON, who imputes it to the precipitation of mud made by the waters of the river, when it overflows. The inundation, says he, purifies itself as it flows over the plain; so that the precipitation must be greatest on the parts nearest to the margin of the river.

amongst grafs and other vegetables : nor does it ever lose this tinge, which is a proof of the predominancy of the rain water over that of the river ; as the slow rate of motion of the inundation (which does not exceed half a mile *per* hour) is of the remarkable flatness of the country.

There are particular tracts of land, which, from the nature of their culture, and species of productions, require less moisture than others ; and yet, by the lowness of their situation, would remain too long inundated, were they not guarded by dikes or dams, from so copious an inundation as would otherwise happen from the great elevation of the surface of the river above them. These dikes are kept up at an enormous expence ; and yet do not always succeed, for want of tenacity in the soil of which they are composed.

During the swollen state of the river, the tide totally loses its effect of counteracting the stream ; and in a great measure that of ebbing and flowing, except very near the sea. It is not uncommon for a strong wind, that blows up the river for any continuance, to swell the waters two feet above the ordinary level at that season : and such accidents have occasioned the loss of whole crops of rice*. A very tragical event happened at Luckipour † in 1763, by a strong gale of wind conspiring with a high spring tide, at a season when the periodical flood was within a foot and half of its highest pitch. It is said that the waters rose six feet above the ordinary level. Certain it is, that

* The rice I speak of is of a particular kind ; for the growth of its stalk keeps pace with the increase of the flood at ordinary times, but is destroyed by a too sudden rise of the water. The harvest is often reaped in boats. There is also a kind of grass which overtops the flood in the same manner, and at a small distance has the appearance of a field of the richest verdure.

† This place is situated about fifty miles from the sea.

the inhabitants of a considerable district, with their houses and cattle, were totally swept away; and, to aggravate their distresses, it happened in a part of the country which scarce produces a single tree for a drowning man to escape to.

Embarkations of every kind traverse the inundation: those bound upwards, availing themselves of a direct course and still water, at a season when every stream rushes like a torrent. The wind too, which at this season blows regularly from the south-east *, favours their progress; inasmuch, that a voyage, which takes up nine or ten days by the course of the river when confined within its banks, is now effected in six. Husbandry and grazing are both suspended; and the peasant traverses in his boat, those fields which in another season he was wont to plow; happy that the elevated site of the river banks place the herbage they contain, within his reach, otherwise his cattle must perish.

The following is a table of the gradual increase of the Ganges and its branches, according to observations made at Jellinghy and Dacca.

At Jellinghy.		At Dacca.	
	Ft. In.	Ft. In.	
In May it rose	6 0	2 4	
June	9 6	4 6	
July	12 6	5 6	
In the first half of August	4 0	1 11	
	<hr/>	<hr/>	
	32 0	14 3	
	<hr/>	<hr/>	

* Although in the gulf or bay of Bengal the monsoon blows from the S.S.W. and S.W. yet in the eastern and northern parts of Bengal it blows from the S.E. or E.S.E.

These observations were made in a season, when the waters rose rather higher than usual; so that we may take 31 feet for the medium of the increase.

The inundation is nearly at a stand for some days preceding the middle of August, when it begins to run off; for although great quantities of rain fall in the flat countries, during August and September, yet, by a partial cessation of the rains in the mountains, there happens a deficiency in the supplies necessary to keep up the inundation*. The quantity of the daily decrease of the river is nearly in the following proportion: during the latter half of August, and all September, from three to four inches; from September to the end of November, it gradually lessens from three inches to an inch and a half; and from November to the latter end of April, it is only half an inch *per* day at a medium. These proportions must be understood to relate to such parts of the river as are removed from the influence of the tides; of which more will be said by and by. The decrease of the inundation does not always keep pace with that of the river, by reason of the height of the banks; but after the beginning of October, when the rain has nearly ceased, the remainder of the inundation goes off quickly by evaporation, leaving the lands highly manured, and in a state fit to receive the seed, after the simple operation of plowing.

There is a circumstance attending the increase of the Ganges, and which, I believe, is little known or attended to; because few people have made experiments on the heights to which the

* I have stated the middle of August for the period when the waters begin to run off; and in general it happens with more regularity than the vicissitudes of the seasons do. But there are exceptions to it; for in the year 1774 the rivers kept up for near a month after the usual time.

periodical flood rises in different places. The circumstance I allude to, is, the difference of the quantity of the increase (as expressed in the foregoing table) in places more or less remote from the sea. It is a fact, confirmed by repeated experiments, that from about the place where the tide commences, to the sea, the height of the periodical increase diminishes gradually, until it totally disappears at the point of confluence. Indeed, this is perfectly conformable to the known laws of fluids: the Ocean preserves the same level at all seasons (under similar circumstances of tide) and necessarily influences the level of all the waters that communicate with it, unless precipitated in the form of a cataract. Could we suppose, for a moment, that the increased column of water, of 31 feet perpendicular, was continued all the way to the sea, by some preternatural agency: whenever that agency was removed, the head of the column would diffuse itself over the Ocean, and the remaining parts would follow, from as far back as the influence of the Ocean extended; forming a slope, whose perpendicular height would be 31 feet. This is the precise state in which we find it. At the point of junction with the sea, the height is the same in both seasons at equal times of the tide. At Luckipour there is a difference of about six feet between the heights in the different seasons; at Dacca, and places adjacent, 14; and near Cusfee, 31 feet. Here then is a regular slope; for the distances between the places bear a proportion to the respective heights. This slope must add to the rapidity of the stream; for, supposing the descent to have been originally four inches *per* mile, this will increase it to about five and an half. Cusfee is about 240 miles from the sea, by the course of the river; and the surface of the river there, during the dry season, is about 80 feet

feet above the level of the sea at high water*. Thus far does the Ocean manifest its dominion in both seasons: in the one by the ebbing and flowing of its tides; and in the other by depressing the periodical flood, till the surface of it coincides as nearly with its own, as the descent of the channel of the river will admit †.

Similar circumstances take place in the Jellinghy, Hoogly, and Burrampooter Rivers; and, I suppose, in all others that are subject either to periodical or occasional swellings.

Not only does the flood diminish near the sea, but the river banks diminish in the same proportion; so that in the dry season the height of the periodical flood may be known by that of the bank.

I am aware of an objection that may be made to the above solution; which is, that the lowness of the banks in places near the sea, is the true reason why the floods do not attain so considerable a height, as in places farther removed from it, and where the banks are high; for that the river, wanting a bank to confine it, diffuses itself over the surface of the country. In

* The tides in the River Amazons are perceptible at 600 miles above its mouth; but at an elevation of only 90 feet, according to M. DE CONDAMINE. It remains to be told what the state of the river was at the time of making the experiment; because the land-floods have the effect of shortening the limits of the tide's way.

† The Count DE BUFFON has slightly mentioned this circumstance attending the swelling of rivers; but imputes it to the increased velocity of the current, as the river approaches the sea: which, says he, carries off the inundation so quick, as to abate its height. Now (with the utmost deference to so great an authority) I could never perceive, that the current, either in the Ganges, or any other river, was stronger near the sea than at a distance from it. Even if we admit an acceleration of the current during the ebb tide, the flux retards it in so considerable a degree, as at least to counter-balance the effects produced by the temporary increase of velocity.

answer to this, I shall observe, that it is proved by experiment, that at any given time, the quantity of the increase in different places, bears a just proportion to the sum total of the increase in each place respectively: or, in other words, that when the river has risen three feet at Dacca, where the whole rising is about 14 feet; it will have rose upwards of six feet and a half at Cusfee, where it rises 31 feet in all.

The quantity of water discharged by the Ganges, in one second of time, during the dry season, is 80,000 cubic feet; but in the place where the experiment was made, the river, when full, has thrice the volume of water in it; and its motion is also accelerated in the proportion of 5 to 3: so that the quantity discharged in a second at that season is 405,000 cubic feet. If we take the medium the whole year through, it will be nearly 180,000 cubic feet in a second.

THE Burrampooter, which has its source from the opposite side of the same mountains that give rise to the Ganges, first takes its course eastward (or directly opposite to that of the Ganges) through the country of Thibet, where it is named Sanpoo or Zanciu, which bears the same interpretation as the Gongga of Hindoostan: namely, the River. The course of it through Thibet, as given by Father DU HALDE, and formed into a map by Mr. D'ANVILLE, though sufficiently exact for the purposes of general geography, is not particular enough to ascertain the precise length of its course. After winding with a rapid current through Thibet, it washes the border of the territory of Lassa (in which is the residence of the grand Lama) and then deviating from an east to a south-east course, it approaches within 220 miles of Yunan, the westernmost province of

of China. Here it appears, as if undetermined whether to attempt a passage to the sea by the Gulf of Siam, or by that of Bengal; but seemingly determining on the latter, it turns suddenly to the west through Affam, and enters Bengal on the north-east. I have not been able to learn the exact place where it changes its name; but as the people of Affam call it Burrampoot, it would appear, that it takes this name on its entering Affam. After its entry into Bengal, it makes a circuit round the western point of the Garrow Mountains; and then, altering its course to south, it meets the Ganges about 40 miles from the sea.

Father DU HALDE expresses his doubts concerning the course that the Sanpoo takes after leaving Thibet, and only supposes generally that it falls into the gulf of Bengal. M. D'ANVILLE, his geographer, with great reason supposed the Sanpoo and Ava River to be the same: and in this he was justified by the information which his materials afforded him: for the Burrampooter was represented to him, as one of the inferior streams that contributed its waters to the Ganges, and not as its equal or superior; and this was sufficient to direct his researches, after the mouth of the Sanpoo River, to some other quarter. The Ava River, as well from its bulk, as the bent of its course for some hundred miles above its mouth, appeared to him to be a continuation of the river in question: and it was accordingly described as such in his maps, the authority of which was justly esteemed as decisive; and, till the year 1765, the Burrampooter, as a capital river, was unknown in Europe.

On tracing this river in 1765, I was no less surprized, at finding it rather larger than the Ganges, than at its course previous to its entering Bengal. This I found to be from the east; although all the former accounts represented it as from the north:

north: and this unexpected discovery soon led to enquiries, which furnished me with an account of its general course to within 100 miles of the place where DU HALDE left the Sanpoo. I could no longer doubt, that the Burrampooter and Sanpoo were one and the same river: and to this was added the positive assurances of the Affamers, "That *their* river came "from the north-west, through the Bootan mountains." And to place it beyond a doubt, that the Sanpoo River is not the same with the river of Ava, but that this last is the great Nou Kian of Yunan; I have in my possession a manuscript draught of the Ava River, to within 150 miles of the place where DU HALDE leaves the Nou Kian, in its course towards Ava; together with very authentic information that this river (named Irabattey by the people of Ava) is navigable from the city of Ava into the province of Yunan in China*.

The Burrampooter, during a course of 400 miles through Bengal, bears so intimate a resemblance to the Ganges, except in one particular, that one description may serve for both. The exception I mean is, that, during the last 60 miles before its junction with the Ganges, it forms a stream which is regularly from four to five miles wide, and but for its freshness might pass for an arm of the sea. Common description fails in an attempt to convey an adequate idea of the grandeur of this magnificent object; for,

— Scarce the muse

Dares stretch her wing o'er this enormous mass
Of rushing water; to whose dread expanse,
Continuous depth, and wond'rous length of course,

* The courses of the Burrampooter and Ganges, as well as that of the Ava River from Yunan to the sea, will shortly be described in a large sheet map of Hindoostan.

Our floods are rills ———
 Thus pouring on, it proudly seeks the deep,
 Whose vanquish'd tide, recoiling from the shock,
 Yields to this liquid weight ———

THOMSON'S Seasons.

I have already endeavoured to account for the singular breadth of the Megna, by supposing that the Ganges once joined it where the Iffamutty now does; and that their joint waters scooped out its present bed. The present junction of these two mighty rivers below Luckipour, produces a body of running fresh water, hardly to be equalled in the old hemisphere, and, perhaps, not exceeded in the new. It now forms a gulf interspersed with islands, some of which rival, in size and fertility, our Isle of Wight. The water at ordinary times is hardly brackish at the extremities of these islands; and, in the rainy season, the sea (or at least the surface of it) is perfectly fresh to the distance of many leagues out.

The *Bore* (which is known to be a sudden and abrupt influx of the tide into a river or narrow strait) prevails in the principal branches of the Ganges, and in the Megna; but the Hoogly River, and the passages between the islands and sands situated in the gulf, formed by the confluence of the Ganges and Megna, are more subject to it than the other rivers. This may be owing partly, to their having greater embouchures in proportion to their channels, than the others have, by which means a larger proportion of tide is forced through a passage comparatively smaller; and partly, to there being no capital openings near them, to draw off any considerable portion of the accumulating tide. In the Hoogly or Calcutta River, the *Bore* commences at Hoogly Point (the place where the river first contracts itself)

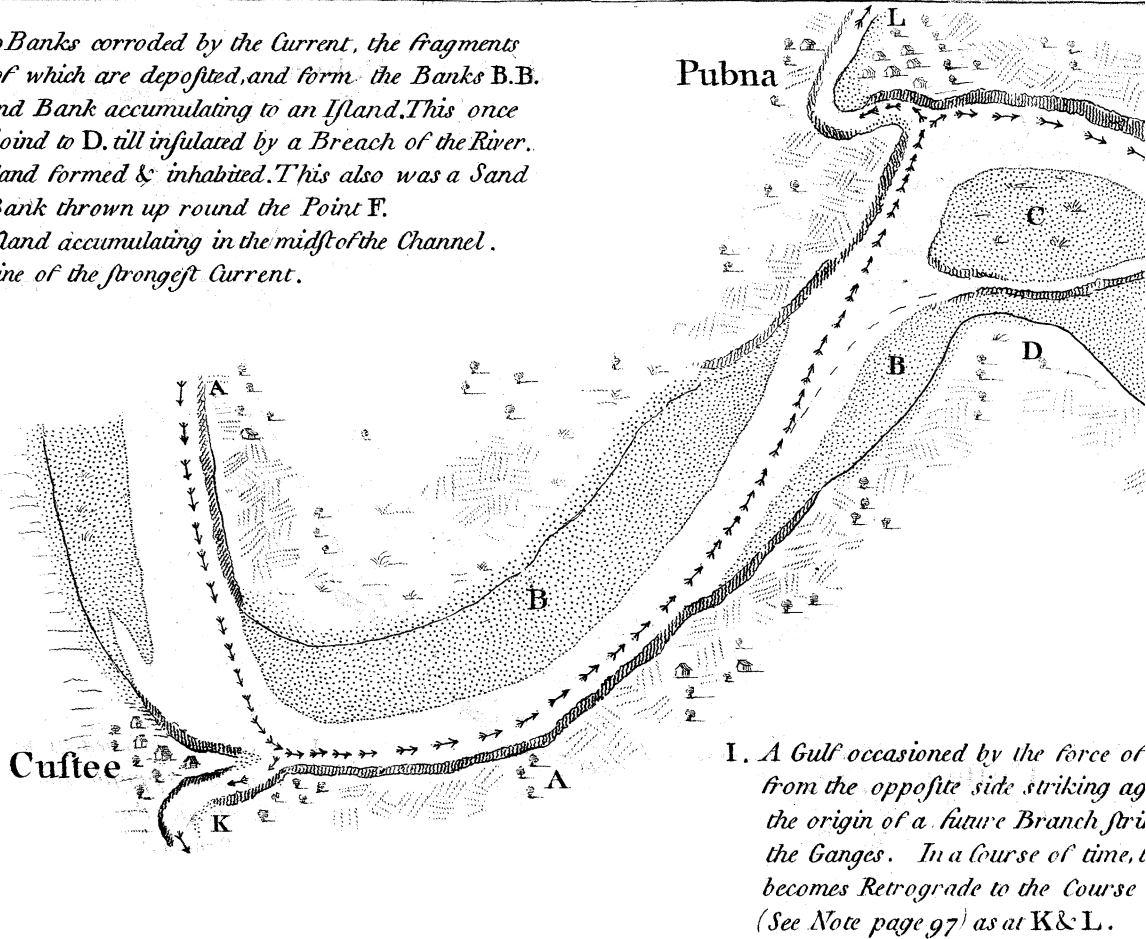
and is perceptible above Hoogly Town; and so quick is its motion, that it hardly employs four hours in travelling from one to the other, although the distance is near 70 miles. At Calcutta, it sometimes occasions an instantaneous rise of five feet: and both here, and in every other part of its track, the boats, on its approach, immediately quit the shore, and make for safety to the middle of the river.

In the channels, between the islands in the mouth of the Megna, &c. the height of the *Bore* is said to exceed twelve feet; and is so terrific in its appearance, and dangerous in its consequences, that no boat will venture to pass at spring tide. After the tide is fairly past the islands, no vestige of a *Bore* is seen, which may be owing to the great width of the Megna, in comparison with the passages between the islands; but the effects of it are visible, enough by the sudden rising of the tides.



PLAN of part of the Course of the GANGES, to explain

- A.A. Steep Banks corroded by the Current, the fragments of which are deposited, and form the Banks B.B.
- C. A Sand Bank accumulating to an Island. This once joined to D, till insulated by a Breach of the River.
- E. An Island formed & inhabited. This also was a Sand Bank thrown up round the Point F.
- G. An Island accumulating in the midst of the Channel.
- H. The line of the strongest Current.



I. A Gulf occasioned by the force of from the opposite side striking ag the origin of a future Branch, stri the Ganges. In a course of time, t becomes Retrograde to the Course (See Note page 97) as at K & L.

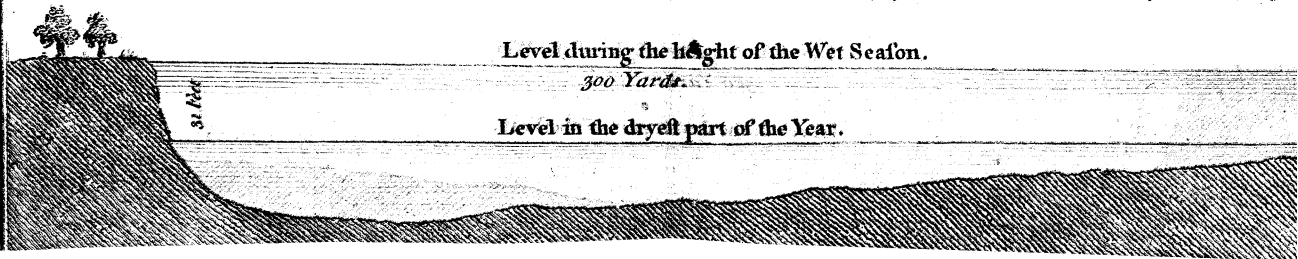
SECTION of a Branch of the GANGES, as a furth

N.B. This is exactly similar to the Section of the winding parts of the Gange

Level during the height of the Wet Season.

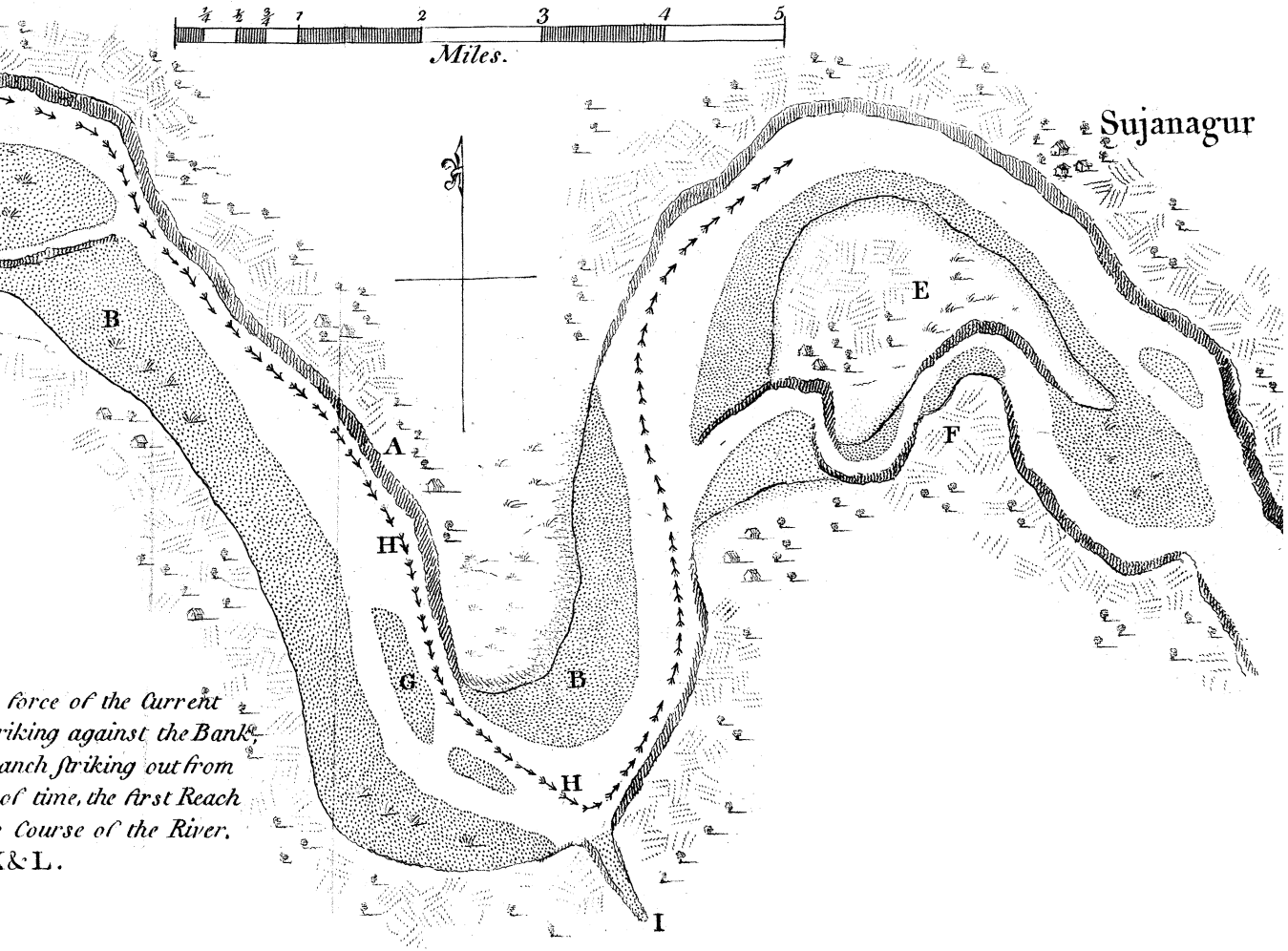
300 Yards.

Level in the dryest part of the Year.



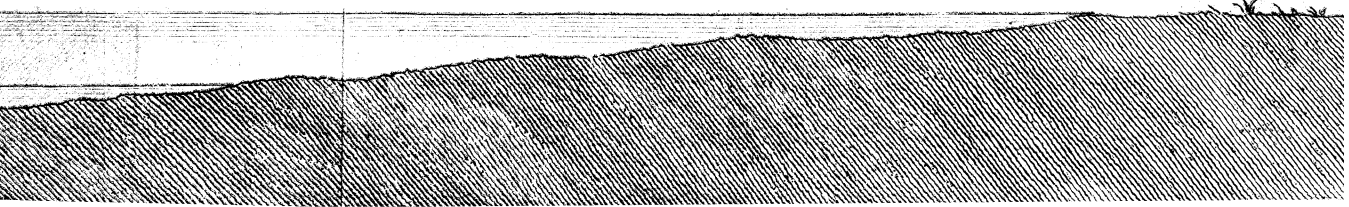
explain the nature of the steep and shelving Banks, &c.

Philos. Trans. Vol. LXXI. Tab. IV. p. 11.



force of the Current
striking against the Bank,
branch striking out from
of time, the first Reach
Course of the River.
& L.

a further explanation of the steep and shelving Banks.
the Ganges itself; except in the article of width.



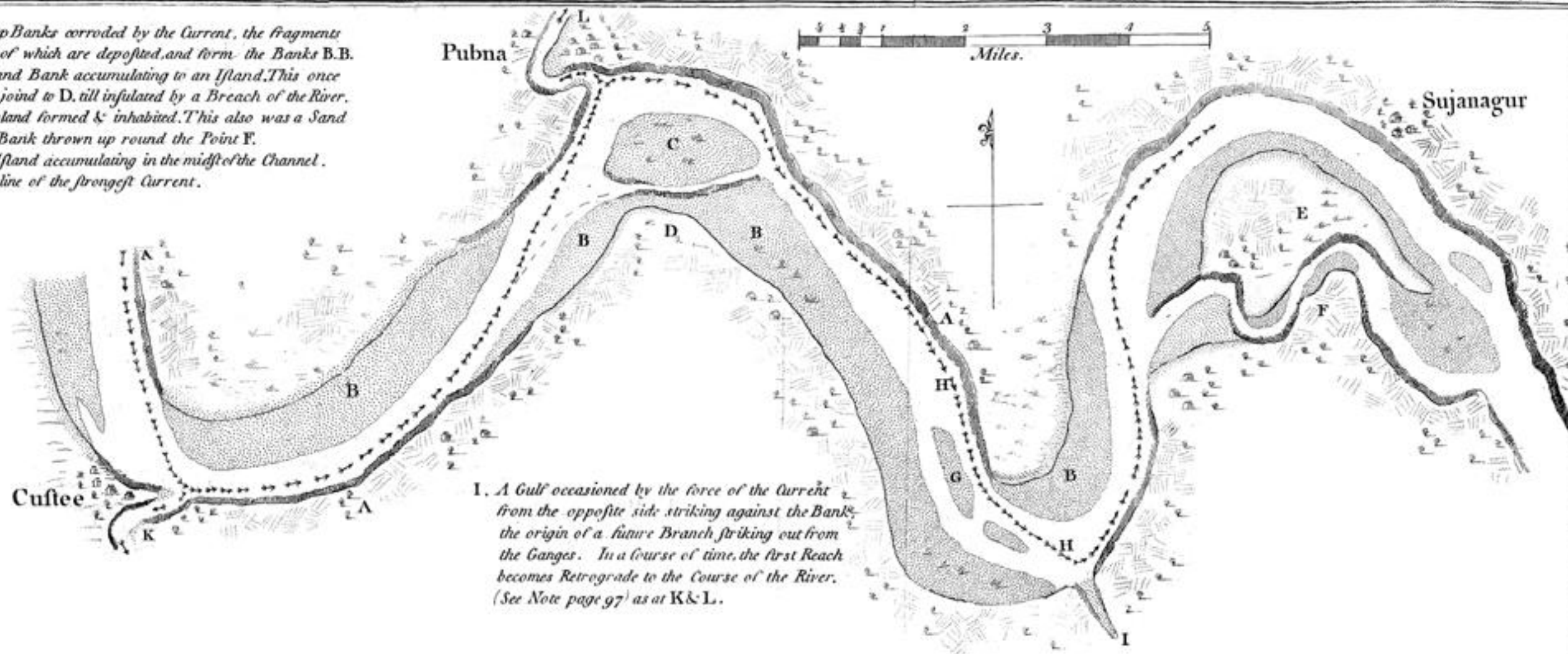
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PLAN of part of the Course of the GANGES, to explain the nature of the steep and shelving Banks, &c.

Philos. Trans. Vol. LXXI. Tab. IV. p. 114.

- A.A. Steep Banks corroded by the Current, the fragments of which are deposited, and form the Banks B.B.*
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I. A Gulf occasioned by the force of the Current from the opposite side striking against the Bank, the origin of a future Branch striking out from the Ganges. In a course of time, the first Reach becomes Retrograde to the Course of the River. (See Note page 97) as at K & L.

SECTION of a Branch of the GANGES, as a further explanation of the steep and shelving Banks.

N.B. This is exactly similar to the Section of the winding parts of the Ganges itself, except in the article of width.

