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MADRAS RECORD OFFICE

Government of Madras

Public Works

DEPARTMENT

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Department,
Proceedings of the Madras Government, Public Works
18th April 1873.

No. 305. Read the following Circular letter from the Government of India, Public Works Department, (Buildings and Roads—Miscellaneous,) to the Governments of Madras, Bombay, Bengal, the North-Western Provinces, and the Punjab in the Public Works Department; the Chief Commissioners of the Central Provinces, Oudh, British Burmah, and Mysore and Coorg; the Resident at Hyderabad; the Agents to the Governor-General for Central India and Rajpootana; the Consulting Engineers to the Government of India for Guaranteed Railways, Calcutta, Lahore, and Lucknow; the Officiating Chief Engineer, Punjab Northern (State) Railway; the Engineer-in-Chief, Indus Valley (State) Railway; the Superintending Engineers, Delhi and Agra Districts, Rajpootana (State) Railway, Holkar, Neemuch, Northern Bengal, and West Rajpootana (State) Railways; dated Fort William, 26th February 1873, No. 11:—

I AM directed to forward for information the accompanying printed papers on the subject of the flood discharges of rivers, and to state that the Governor-General in Council desires that reports may be furnished in the form annexed as soon as reliable information of the kind specified has been obtained.

2. These reports should be submitted once a year after each rainy season.

(Signed) J. SCOTT,
Asst. Secy. to the Govt. of India.

Memorandum submitted to Captain J. G. FORBES, R. E., Officiating Superintending Engineer, Irrigation Works, Oudh, by T. E. HEAFORD, Esq., Executive Engineer, Irrigation Works, Oudh, on a Note on the "Flood discharges of rivers" by Lieut.-Colonel DICKENS, R. A., in No. 7 (Vol. 2) of Roorkee Professional Papers (May 1865), and on a Report relating to the "water way of the Sye Bridge" by Lieut.-Colonel HUTCHINSON, R. E., printed in No. 13 (Vol. 3) of Roorkee Professional Papers (November 1866), dated 17th February 1872.

No rule, however reliable experience may have proved it to be, should ever be absolutely relied on in estimating the water-way to be given to a proposed bridge. Nothing, I believe, can, and I am sure nothing should, ever relieve the Engineer of the duty of making himself thoroughly acquainted with the special circumstances of each case in which he has to act.

But it is desirable to have some formula which may be depended on for rough estimate, and which may be used as a general check against material error in the detailed design.

Colonel Dickens has attempted to make such a formula, and in a Note published in the *Roorkee Professional Papers* (May 1865), shows reason for estimating the maximum discharge of a river as equal to 825 times the cube of the fourth root of area of catchment basin, i. e.,

Let D = discharge at highest flood in cubic feet per second.

M = drainage area of river in square miles.

Then $D = 825 M^{\frac{3}{4}}$.

This rule is suggested by its author quite as much with a view of inviting discussion and further inquiry, as from faith in its general applicability, and the difficulties in the way of arriving at any satisfactory formula, are by no means lost sight of.

"Remembering," he very justly says, "all the differences of soil, declivity of drainage basin, and rain-fall, it is evident that such a formula cannot be anything better than a rough approximation."

of the Madras Government, Public Works Department,
18th April 1873.

This remark, forcible as it is, does not appear to me to go far enough. I think, for reasons which will hereafter appear, that rain-fall and declivity of drainage basin exercise so great an influence on the maximum flood discharge, that it is impossible to frame any rule based on drainage area only, which can be depended on even as a "rough approximation."

Of course, the most important element in the calculation is the area of catchment basin, that is to say, the area as such, irrespective of any other consideration, and supposing all other conditions equal. But in comparatively small areas it cannot be used directly as a factor in calculating a flood discharge.

It is, for instance, no uncommon event that a catchment basin of, say, 5 square miles, should, for an hour or so, be exposed all over to a very heavy fall of rain, but it is quite inconceivable that an abnormal rain-fall should at the same time descend all over an area of 500 square miles.

This is strongly borne out by an examination of the daily rain-fall returns of the Oudh Stations during the heavy flood times of 1870. Excepting Gonda, which appears to be watered by rain-clouds, quite independent of those which water Southern and Central Oudh, the returns show that on days on which a particular station registers an unusually large rain-fall, the remaining stations register an amount considerably below the average.

A brook, therefore, draining 5 square miles, might have (in proportion to catchment basin) a very much larger duty to do at a given time than a river draining 5,000 square miles could possibly have.

It appeared to Colonel Dickens from the data at his disposal, that on an average the rain-fall drained off at one time varied inversely as the fourth root of the area. It will be seen further on that the very few reliable cases I can avail myself of seem to show that a still greater variation in proportion to area would better apply at least to the Oudh Rivers.

We have unhappily but few discharges of Oudh Rivers so accurately ascertained as to be of much service in this inquiry, but the results these few give I propose comparing with the result we should obtain from Colonel Dickens' rule.

The Jumwaree Nuddee, on emptying itself into the Suraen, has a drainage area of about 65 square miles. Two independent calculations make the flood discharge 2,627 and 2,496 cubic feet per second, respectively, say, 2,600 cubic feet.

Supposing discharge to vary as fourth root of area, and therefore using the factor $M^{\frac{1}{4}}$ it would appear that the co-efficient is 113, and not 825 as in the rule; representing an average rain-fall of .062 inch per hour carried off.

The flood discharge of the Suraen Nuddee just below the junction of its tributary, the Jumwaree, has also been twice calculated, results being 10,500 and 12,280 cubic feet. The area drained by these two rivers is 326 square miles. Assuming the larger figure of 12,280 to be correct, and using $M^{\frac{1}{4}}$ as before, the co-efficient is 148, not 825, equal to average of .059 inch rain-fall per hour carried off.

Careful observations have been made of the maximum flood discharge of the River Goomtee at Lucknow by several independent observers. Their results agree remarkably well, and the maximum flood discharge appears to be about 27,000 cubic feet per second. The area drained is 3,361 square miles, and calculated as before, the co-efficient is about 64, not 825, and represents an average rain-fall of .0125 inch carried off. This was at a time when the Lucknow gauge registered nearly $\frac{1}{4}$ inch per hour on an average of 24 hours.

The Ganges at Cawnpore drains an area of about 34,000 square miles, and should, by Colonel Dickens' rule, discharge a maximum of 2,060,000 cubic feet per second.

The actual discharge is found to be under 230,000 cubic feet, or, if $M^{\frac{1}{4}}$ be used as before, the co-efficient equals about 92 instead of 825, equal to average of .013 inch per hour of rain-fall carried off.

Works Department,
Proceedings of the Madras Government, Public Works Department,
18th April 1873.

Tabulating the above as under—

	Area.	D.
Jumwaree	65	113 $M^{\frac{1}{4}}$ (200 $M^{\frac{1}{4}}$)
" and Suraen	326	148 "
Goomtee	3,361	64 "
Ganges	34,000	92 "

it appears that when $M^{\frac{1}{4}}$ is used in calculation, a much larger co-efficient is required as the areas become smaller.

This is all the more clear if it be borne in mind that the Jumwaree has a much less rapid fall than the Suraen, and that, if it had the same declivity, the co-efficient would be probably quite 200.

Colonel Hutchinson, while Chief Engineer of Oudh, had occasion to apply the formula $825 M^{\frac{1}{4}}$.

He found that it gave a result much in excess of the actual flood discharge, and was led to try its application to several other cases in which the discharge was approximately ascertainable by using as basis of calculation the water-way of the bridges which had successfully withstood the severest floods.

His note on this matter has been made public in No. 13 (Vol. 3) of the *Roorkee Professional Papers*, and although discharges calculated merely from water-way of existing bridges (which might, or might not, be considerably in excess of actual requirements) and with an assumed velocity cannot be considered very reliable, they still show markedly that M does not adequately

represent the variations due to extension or diminution of area, and that $825 M^{\frac{1}{4}}$ is much too large a discharge for Oudh Rivers, as under.

I have not taken into consideration Colonel Hutchinson's case of the Goomtee at Sultanpore, as there appears to be a considerable error in the data.

The catchment basin of the Goomtee at Lucknow is 3,361 square miles, it must be therefore very much more than 3,600 square miles at Sultanpore, which is some 80 miles lower down stream, in which distance, moreover, several important tributaries having large catchment basins are received by the—

	Area in Sq. M.	Discharge C. ft. per second.
River Lonee	120	127 $M^{\frac{1}{4}}$
" Sye at Bunnee	240	106 $M^{\frac{1}{4}}$
" " at Roy Bareilly	960	96 $M^{\frac{1}{4}}$

The co-efficient varying in an ill-defined ratio inversely as the area.

But although we find that the discharge varies inversely as $M^{\frac{1}{4}}$, that is to say, as M governed by some fractional index (whatever it may be) in relatively small areas, it by no means follows that the same index $\frac{1}{4}$ is applicable to very large areas. Indeed, it does not seem probable. Putting the streams I have drawn attention to, and those mentioned by Colonel Hutchinson, in one table, and in order of area, we have—

	Area in Sq. M.	Discharge.
Jumwaree	65	200 $M^{\frac{1}{4}}$
Lonee	120	127 "
Sye at Bunnee	240	106 "
Jumwaree and Suraen	326	148 "
Sye at Roy Bareilly	960	96 "
Goomtee at Lucknow	3,361	64 "
Ganges at Cawnpore	34,000	92 "

The discharge of the Sye and that of the Ganges (the latter having something like thirty-five

times the drainage area of the former) seems ascertainable by the same formula, and to be a little more than $90 M^{\frac{1}{2}}$. This may be only a coincidence, and it were idle to base a conclusion on such insufficient data, but I think it probable that the index $\frac{1}{2}$, which does not appear adequately to represent the variation in small areas, will be found ample in very large ones, and for this reason we have seen that, in rivers watered by one rain-cloud, the flood discharge per square mile drained decreased rapidly as the area increased, but there must be a limit to the application of the same ratio, whatever that ratio may be. This limit is the area generally watered by one rain-cloud only. A river draining 100 square miles will have at a given time a much smaller maximum fall of rain per square mile of its whole area than a brook draining 5 square miles, but the maximum rain-fall drained per square mile may be the same on a catchment basin of 1,000 square miles and on one of 10,000 square miles. The one may be watered by one rain-cloud, the other by ten.

I have been at some pains to construct, from the very limited data at my disposal, a table which might be generally applicable, however roughly, and this in several ways; by allowing the co-efficient to remain constant and altering the index of M , and by retaining $M^{\frac{1}{2}}$ as basis of calculation and making the co-efficient a variable quantity, dependent on the area, not in any definite ratio (in which case, of course, it would only be necessary to modify M 's index), but according to a somewhat arbitrary table, giving multipliers for areas within certain limits.

All these attempts have, however, proved but labour lost. As soon as it was sought to apply the calculation to streams differing either in declivity of catchment basin or in the rain-fall they had to carry off from those on which the table was based, the results were obviously incorrect, in some instances absurdly so.

A table, for instance, which gave a result agreeing very nearly with known discharges of the Goomtee at Lucknow (area 3,361 square miles) Suraen Nuddee (area 326) Ool Nuddee (area 324) Chooka Nuddee (area 8.7) and which appears to be tolerably comprehensive, gave, when applied to the Jugboora Nuddee (area 36 square miles), less than $\frac{1}{4}$ of the known flood discharge.

The reason lies on the surface. The average fall of the rivers mentioned is between 2 and 3 feet per mile; the fall of the Jugboora is nearly 40 feet per mile. In like manner, the same table which gave results within a small percentage of actual measurements in many cases, including that of the Suraen Nuddee, gave in the case of its affluent the Jumwarri, a result which differs by nearly one-third from the true flood discharge. Here also the discrepancy is no doubt due to difference in rate of fall of ground; the rain-fall over the catchment basin, and the nature of the soil being, as far as I can ascertain, much the same in both cases.

Although it is, as appears to me, impracticable to make a rule for estimating the flood discharge of rivers from the area of catchment basin only, it may be possible to frame one in terms of area, declivity, and rain-fall, which should have a practical value. To attain this desirable object, however, it would be necessary to collect a considerable number of facts, and to proceed methodically in analysis of them.

The Government of India having the Meteorological, the Surveying and the Engineering Departments in its own hands, and spread over a very wide field, has peculiar facilities for conducting such an investigation. If I might be allowed to suggest the course the investigation should take, it would be this:—Narrowing at first the field of inquiry, and taking, for instance, Oudh (Oudh is suggested as being better known and levelled over for the Sardah Canal project than most districts of the same size) and rejecting nuddees flowing in divisions such as Gonda, in which the rain-fall differs in character and quantity from the general average; rejecting also all hill streams and others having unusual declivity of catchment basin; in short, confining the inquiry to districts in which the general conditions of soil, slope and rain-fall are as much alike as may be, let the Engineers of several districts (or an Engineer specially appointed for the purpose) be instructed to fix upon suitable sites near the mouths of all rivers of any importance. Where practicable, these sites should be fixed at points at which the streams keep within their banks, even in

the highest floods. To take at each of these points a cross section of the river or brook, a longitudinal section, say, $\frac{1}{4}$ mile up and down stream, to fix a B. M., for reference in the neighbourhood, and to direct the Chowkeedar of the nearest village to mark, during the rainy season, the point the highest flood reaches by a notch on a tree or by a stout peg.

Possibly, it may not even be necessary to wait till next high floods before collecting information; in many cases the villagers may be able to point out the height to which the last high floods rose with sufficient accuracy.

The flood discharges can now be calculated, and the levels taken for the Sardah Canal Project will furnish the water-shed lines, and therefore, correct areas of the several catchment basins.

A number of cases collected at a small cost will be available; by collecting them, the ratio of area to flood discharge will be determined.

A comparison of the result so obtained with streams flowing where the rain-fall is similar, but where the declivities are very different, will lead us to an approximate measure of the influence which slope exercises on the discharge.

A further comparison with districts subject to a much larger or much smaller rain-fall would guide us to the value of the third factor in the formula.

I understand that accurate surveys and levels of most parts of India are either complete or in progress. Rain gauges are established at most stations; the data of area, declivity and rain-fall are, therefore, as readily available as area only, and calculations based on these three items must be more reliable than those based on one term only; but even now the result can be no more than a rough approximation.

The nature of the soil, for instance, materially affects the maximum flood discharge. I have never heard exception taken to the comparative absorption of rain-fall by different soils as furnished by Professor Rankine. A corresponding allowance in calculation, where the nature of the soil is known, would ensure additional accuracy.

Difference in the nature of the river-bed likewise affects the discharge, not so much, however, as to make it worth noticing in a rough empirical rule, but there is another consideration which I think will be found sufficiently important to be worth bearing in mind, particularly in cases where the river valley is a long one. It is the direction of the stream. If at right angles to direction of the prevailing winds, the rain-clouds will but water one or more comparatively narrow belts across the catchment basin at a given time; if parallel to the usual course of the rain-clouds, these may sweep all up the valley, discharging, without respite to the draining channel, a vast quantity of water. A general formula, purporting to furnish the maximum flood discharge, will probably require a considerably larger co-efficient in the latter case than in the former.

Memorandum by Captain J. G. FORBES, R. E., Officiating Superintending Engineer, Sardah Canal, on Catchment Basins of Streams in Oudh, dated 3rd August 1871.

In July 1865 Government of India called for a report on the catchment basins and discharges of rivers in Oudh. Executive Engineers were accordingly ordered to take measurements of streams, etc., and the result of their observations is given in the accompanying Memorandum A. Nothing reliable was obtained tending to prove or disprove the correctness of Colonel Dickens' formula for ascertaining the discharges of rivers from their catchment basins (which, apparently, was the object of Government of India's reference); and in 1869 the question was referred to the Irrigation Department in Oudh.

2. Observations were accordingly taken in the rainy season of 1870, and an accurate map made of the catchment basins of the different rivers and streams in Oudh. The data thus obtained were made over to Mr. Heaford, Executive Engineer, Irrigation Department, and the result of the

It was found correct in many instances in the Central Provinces. W. MAXWELL, Col. observations is shown in his memorandum, from which it will be seen that the co-efficient of 825 as used by Colonel Dickens is too large for rivers in Oudh, although

it is fairly applicable to hill torrents with steep declivities of bed.

Proceedings of the Madras Government, Public Works Department,
18th April 1873.

3. The map accompanying Mr. Heaford's Memorandum shows the areas of catchment basins of rivers and streams in Oudh, from which map the following tabular statement, showing the total area drained by the Rivers Sye and Goomtee, is prepared:—

River Goomtee.		Area of catchment basin of river and tributaries—		Square miles.	
River Goomtee, from source to Lucknow.	Jokonai	...	...	...	118
	Matee, tributary of Kutna	...	...	...	19
	Vurelee,	...	...	...	50
	Kutna	...	...	...	454
	Kutna and tributaries...	...	...	...	523
	Jumwaree, tributary of Suraen	...	...	...	65
	Goon,	...	...	...	193
	Pirae,	...	...	...	140
	Beitha,	...	...	...	134
	Suraen	...	...	...	381
River Goomtee, from Lucknow to junction of Sye.	Suraen and tributaries	...	...	...	913
	Bunguwan } tributaries	...	...	...	94
	Choocha } of Goomtee	...	...	...	74
	Do.	...	...	...	89
	Goomtee from above tributaries to Lucknow	...	...	...	1,550
River Goomtee, from Lucknow to junction of Sye.	Total of Goomtee and tributaries to Lucknow	...	...	...	3,361
	Keth, tributary of Goomtee	...	...	...	314
	Karee of Kulianee	...	...	...	141
	Kulianee, main stream	...	...	...	717
	Kulianee and tributary	...	...	...	858
River Goomtee, from Lucknow to junction of Sye.	Goomtee (right bank, etc.,) between Lucknow and junction of Sye	...	...	...	1,972
	Total of Goomtee and tributaries from Lucknow to junction of Sye	...	...	...	3,174
	Grand total of Goomtee from source to junction of Sye	...	...	...	6,535
	Catchment basin of Sye	...	...	...	4,215
	Grand total area drained by Goomtee and Sye	...	...	...	10,750

4. The discharges computed by Mr. Heaford are the following, namely:—

	M.	D.	
	Square miles.	Cubic feet.	
Jumwaree Nuddee	65	2,600	200 M ³
Lonee	120	4,600	127 "
Sye at Bunnee...	240	12,000	106 "
Jumwaree and Suraen	326	12,280	96 "
Sye at Roy Bareilly	960	16,500	64 "
Goomtee at Lucknow	3,361	27,000	92 "
Ganges at Cawnpore	34,000	2,30,000	

5. In addition to the above, the discharge of the River Kulianee, at a spot where the drainage area is 670 square miles, was found to be 17,753 cubic feet per second, or equivalent to 135 M³.

6. Colonel Dickens' formula of 825 M³ is, however, fairly applicable to mountain torrents running down slopes from 15 to 40 feet per mile. For it gives for the Jugboora torrent which runs into the Sardah a discharge of 12,125 cubic feet as against a calculated discharge of 12,975 cubic feet. Similarly, for the Raneepoor and Puttree torrents, which run into the Ganges, the discharges by the formula are 14,334 and 19,965 cubic feet, whereas Sir Proby Cautley estimated them at 14,520 and 22,587 cubic feet, respectively. Again, the Kaleekoonduslee torrent running

Proceedings of the Madras Government, Public Works Department,
18th April 1873.

into the Sutlej was calculated by Colonel Crofton as discharging 10,237 cubic feet. Colonel Dickens' formula would give it as 10,966.

Mr. Heaford's Memorandum is very valuable, and all Captain Forbes' and Colonel Maxwell's remarks should, I think, be published. But it may be desirable that I should add a few words on the intention and scope of the formula to be published with them.

It was not intended that my formula for the calculation of flood discharges should supersede measurements. If a good record, or even reliable traditional knowledge of the heights of extreme floods for a sufficiently long series of years exists for any river, that would be a determination of the extreme flood rise altogether satisfactory, and which would require no formula. If such a determination were in all cases available, the formula would be quite useless.

But in the vast majority of cases, the Engineer who has to get up a project has no such record for the greater part of the streams he has to cross. He has only two or three seasons, if so much, in which to make his measurements, and extreme floods only occur at intervals of 10, 20, or even more years. What he has to do in the matter of measuring then is to examine the traditions of flood rise in regard to rivers near towns and villages, and, with the aid of his instruments, to deduce the water-way in these cases. For all the other streams, his measurements are in most cases absolutely insufficient.

The use of the formula is to enable the Engineer to transfer the experience of the few well-authenticated cases he can find to all the other streams he has to deal with. Having got the drainage areas, he gets from these few cases his co-efficient; and having got also the drainage areas in the other cases, he applies the co-efficient, and gets the extreme flood discharge of each stream from the formula. Then he compares the flood discharges so got with what measurements he has, and with the knowledge he may have picked up of the relative heaviness of the rains, or of any particular storms compared with average seasons.

He finally assumes an extreme flood discharge such as may appear safe and not unreasonable from the combined evidence of his measurements and his information as to the floods, and the formula.

This is the way in which the formula is intended to be used; and I think, if used in this way, it will always be useful and safe. But it is much to be desired that every opportunity should be taken of testing and amending the formula, and that the observations and results should be published.

What the formula is intended to do is to supply empirically a law of diminution of the proportion of extreme flood discharge to actual rain-fall. This proportion depends on absorption, and hence on declivity and soil, as well as on the chances, which increase as the area increases, against a very heavy fall of rain taking place equally over the whole drainage area. It is impossible to calculate these causes and their effects, and it is, therefore, right to arrive at a safe result by getting as many instances as possible of their effects in the gross. The object is to arrive at an extreme result so as to be safe in the structures which have to carry off waters in flood. Hence the more instances we can record and compare, the better.

23rd November 1872.

C. H. D.

Memorandum by Consulting Engineer to the Government of India for State Railways.

It has, I believe, always been understood that the formula of Colonel Dickens was not intended to supersede measurement or careful observation of Engineers, but to aid the Engineer in forming for himself some approximate guide (based on the experience and recorded results of a district) in determining the water-way when paucity of local information renders it otherwise difficult to judge of the amount of water-way required.

In this respect it is valuable, and in some districts the recorded results have agreed very closely with both the formula and co-efficient adopted by Colonel Dickens, but it is manifestly impossible that either the co-efficient or the general formula can be made universally applicable to all districts in which the declivity, the rainfall, and the Geological features vary.

Engineers of the Madras Government, Public Works Department,
18th April 1873.

Take for example an extreme case, the River Guggur, where it crosses the Sindh, Punjab and Delhi Railway; it is of very large volume, spanned by several openings of 100 feet each, and yet further down, with a largely increased drainage area, its volume gradually diminishes until at length it is altogether lost. To such a case the formula is, of course, quite inapplicable; and to some of the districts of Rajpootana it would be extremely difficult of application; but this does not prevent its general utility, and as a standard to which all information may be reduced, it is essentially valuable.

In this view I recommend the collection in a tabular form of a mass of information from all parts of India respecting the flood discharge, declivity of rivers, the drainage area, its rain-fall, and Geological feature. When this has been obtained and reduced to one standard, I think it will not be difficult to deduce valuable results from it.

The points to be aimed at are—

- 1st.—To obtain a general co-efficient for each district as a rough approximation.
- 2nd.—To obtain a co-efficient for rain-fall of differing intensity.
- 3rd.—To obtain a co-efficient for different Geological formations.
- 4th.—For different declivities.

5th.—To deduce the relative proportion of the drainage area that may be considered to be effective in areas of varying magnitude.

6th.—To determine the deduction that may be made in rivers running through districts of a porous formation.

Doubtless it will be difficult to do this accurately, but I think we may obtain most useful data to assist us in arriving at conclusions, but even then the results cannot be expected to supersede careful measurements and observations.

11th January 1873.

G. L. M.

I would add that not only the co-efficient but the formula itself requires to be tested and modified if necessary on a wider experience.

18th January 1873.

C. H. D.

*Proceedings of the Madras Government, Public Works Department,
18th April 1873.*

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
<i>Rain-fall in Oudh for 1868.</i>													
Baraitch .. .. .	.....	.....	.....	.....	.....	6·9	19·6	13·7	6·4	.....	.....	0·1	46·6
Barra Bunkee ...	.....	.....	.....	.....	.....	3·6	5·6	3·9	11·6	.....	.....	.....	24·7
Fyzabad .. .. .	.....	.....	.....	.....	.....	6·1	6·85	6·6	13·5	.....	.....	.....	33·05
Gondah .. .. .	.....	.....	.....	.....	.....	9·4	9·6	12·5	5·3	.....	.....	.....	36·8
Hurdui .. .. .	.....	.....	.....	.....	.....	2·3	5·7	1·4	1·8	.....	.....	.....	11·2
Lucknow .. .. .	.....	.....	.....	.....	.....	3·0	6·8	2·9	7·8	.....	.....	.....	20·5
Kheree... .. .	.....	.....	.....	.....	.....	9·3	4·3	4·	10·2	.....	.....	0·030	28·73
Oonao .. .. .	.....	.....	.....	.....	.....	1·1	3·75	1·25	6·6	0·1	.....	.....	12·8
Pertabgurh .. .	.....	.....	.....	.....	.....	2·3	12·7	4·7	9·7	.....	.....	.....	29·4
Roy Bareilly .. .	.....	.....	.....	.....	.....	3·4	9·75	2·4	11·1	.....	.....	.....	26·65
Seetapoor .. ..	.....	.....	.....	.....	.....	2·9	13·7	4·22	4·8	.....	.....	.....	25·62
Sultanpoor .. .	.....	.....	.....	.....	.....	3·5	11·5	5·7	4·7	.....	.....	.....	25·4
<i>Rain-fall in Oudh for 1869.</i>													
Baraitch	0·5	0·4	0·1	.....	.....	3·3	6·5	10·7	5·8	6·4	.....	0·5	34·2
Barra Bunkee ...	0·2	.....	0·3	.....	.....	2·3	5·4	4·1	9·0	4·4	.....	1·5	27·2
Fyzabad	0·125	.....	0·675	.....	.....	2·8	15·6	10·0	10·9	7·4	.....	0·3	47·800
Gondah	0·2	.....	.....	.....	.....	2·4	10·05	6·8	7·7	11·5	.....	0·6	39·25
Hurdui	0·15	.....	0·4	.....	.....	0·5	5·9	1·7	10·4	5·8	.....	2·4	27·75
Lucknow	0·1	.....	0·2	.....	.....	.....	14·9	3·9	12·7	4·1	.....	1·3	37·2
Kheree	0·7	.....	0·4	.....	.....	0·1	3·2	7·5	5·1	5·6	.....	0·5	25·9
Oonao	0·05	.....	0·6	.....	.....	2·6	10·2	4·5	13·7	6·6	.....	0·7	38·95
Pertabgurh .. .	0·1	.....	0·8	.....	.....	2·2	14·8	4·1	15·7	14·2	.....	.....	51·9
Roy Bareilly .. .	.....	.....	1·1	.....	.....	0·5	10·0	8·4	7·2	8·5	.....	0·3	36·0
Seetapoor	0·45	.....	0·3	.....	.....	0·2	3·3	8·7	2·9	4·9	.....	Not received.	20·75
Sultanpoor .. .	0·1	.....	0·5	.....	.....	4·7	15·4	4·7	10·7	5·2	.....	0·3	41·6
<i>Rain-fall in Oudh for 1870.</i>													
Baraitch .. .. .	.....	0·6	0·8	0·5	0·3	8·2	32·7	.....	.....	.....	.....	.....	43·1
Barra Bunkee ...	.....	.....	.....	.....	.....	.....	Not received.	.....	.....	.....	.....	.....	.....
Fyzabad .. .. .	.....	0·1	0·8	.....	0·3	9·2	36·1	.....	.....	.....	.....	.....	46·5
Gondah .. .. .	.....	0·4	1·1	.....	.....	6·5	24·4	.....	.....	.....	.....	.....	32·4

Proceedings of the Madras Government, Public Works Department,
18th April 1873.

Station.	January.	Febru- ary.	March.	April.	May.	June.	July.	August.	Septem- ber.	October.	Novem- ber.	Decem- ber.	Total.
				<i>Rain-fall in Oudh for 1870.—(Concluded.)</i>									
Hurdai	...	...	1.3	0.9	...	9.45	5.5	...	...	...	...	...	17.15
Lucknow	...	0.2	1.4	0.6	0.2	9.1	14.7	...	...	...	...	...	26.2
Khera	...	0.3	1.3	0.7	0.3	11.7	13.0	...	...	...	...	...	27.3
Oonao	...	0.2	1.0	...	...	9.0	6.7	...	...	...	...	...	16.9
Pertabgarh	...	...	1.6	0.6	0.4	5.3	27.0	...	...	...	...	...	34.9
Roy Bareilly	...	0.2	0.8	0.3	0.1	5.7	14.6	...	...	...	...	...	21.7
Seetapoor	...	0.5	...	0.25	...	15.3	13.6	...	...	...	...	...	29.65
Sultanpore	...	...	1.0	0.9	0.4	7.1	21.1	...	...	...	...	...	30.5

Proceedings of the Madras Government, Public Works Department,
18th April 1873.

No. 306. ORDER THEREON, 18th April 1873, No. 1,132.

CIVIL WORKS, No. 23.

COMMUNICATED to the Chief Engineer
for Irrigation and Inspecting Engineer
for Ports and Communications.

(True Extract.)

Colonel, R.E.,
Secretary to Government.

To the Chief Engineer for Irrigation.
,, Inspecting Engineer for Ports and Communications.

Exd. E. C. Shunker.

GOVERNMENT OF INDIA.
PUBLIC WORKS DEPARTMENT.

BUILDINGS & ROADS.
Miscellaneous.

To

THE GOVERNMENTS OF MADRAS, BOMBAY,
BENGAL, THE NORTH WESTERN PROVIN-
CES, AND THE PUNJAB, IN THE PUBLIC
WORKS DEPARTMENT.

THE CHIEF COMMISSIONERS OF THE CENTRAL
PROVINCES, OUDH, BRITISH BURMAH,
AND MYSORE AND COORG.

THE RESIDENT AT HYDERABAD.

THE AGENTS TO THE GOVERNOR GENERAL
FOR CENTRAL INDIA AND RAJPOOTANA.

THE CONSULTING ENGINEERS TO THE GOV-
ERNMENT OF INDIA FOR GUARANTEED
RAILWAYS, CALCUTTA, LAHORE, AND
LUCKNOW.

THE OFFICIATING CHIEF ENGINEER, PUNJAB
NORTHERN (STATE) RAILWAY.

THE ENGINEER-IN-CHIEF, INDUS VALLEY
(STATE) RAILWAY.

THE SUPERINTENDING ENGINEERS, DELHI
AND AGRA DISTRICTS, RAJPOOTANA
(STATE) RAILWAY, HOLKAR, NEEMUCH,
NORTHERN BENGAL, AND WEST RAJ-
POOTANA (STATE) RAILWAYS.

CIRCULAR No. 11 PUBLIC WORKS.

Dated February 26, 1873.

Received *March 15*.

Forwards printed papers on the subject
of the flood discharges of rivers, and calls
for reports in the form annexed as soon as
reliable information of the kind specified
has been obtained.

P. W. D. Press—28-2-72—710.

1 *1724*

Full Month 1873

*Communicated to the Chief Engineer for Irrigation and
Superintending Engineer for Ports and Communications.*

W. L.

W. L.

*to Mr. A. Engineer for Irrigation
Superintending Engineer for Ports and Communications*

Recd 21-4-73.

N-305-6.

With the order

1/2/74

Govt. of 1873 Madras

PUBLIC WORKS.

To The Chief Eng. for
Irrigation

Dated

Recd.

Encl. /

G. O. 18th April No. 1132.

To 3057306

Head discharges of rivers.

Circular from the Govt.
India forwarding papers
^{regarding}
~~the subject~~ of the

Head discharges of
rivers and calling for
reports on the subject,
and of the Officers
concerned.