



Government of Bombay
Public Works Department.

**Sukkur Barrage Canals Project,
1920.**

JOINT NOTES

BY

MR. F. ST. J. GEBBIE, C.I.E.,

~~Inspector General~~ of Irrigation in India,

and

MR. A. A. MUSTO, C.I.E., M. INST. C.E.,

~~Executive Engineer.~~

Replying to the criticisms of the Project in

- (a) The Lecture by MR. F. WOODS, C.I.E., before the Royal Society of Arts,
London (pages 13 to 73)
- (b) The Discussion and Correspondence thereon (pages 74 to 78)
- (c) The Letter dated 23rd August 1922 from SIR JOHN BENTON, K.C.I.E.,
to the Secretary of State for India (pages 79 to 83)

With *synopsis* of each subject, and of the reply to it:

(pages 1 to 12)

also

DR. SUMMERS' Articles in "The Pioneer"

of the 6th and 7th January 1922

(pages 84 to 101)

with

MR. MUSTO'S reply thereto

(pages 102 to 122)

**Synopsis of Note in reply to Mr. Woods' Lecture on
Sukkur Barrage.**

Royal Society
of Arts
Journal
No. 3641,
Page 705.

- | | |
|--|----------------------------|
| Deals with seasons of drought, and deficiency of water supply. | Paragraph
1. |
| This is answered on page 13 of the Note, where it is shown that such seasons occur frequently, and will be aggravated by the Sutlej Project withdrawals. | |
| Are descriptive of the irrigation of India, and of the Punjab in particular. No comments. | Paragraphs
2, 3 & 4. |
| Deal with the history and development of the Western Jumna Canal, which is quoted as an example of the dangers of water-logging, due to high intensity of winter cultivation. | Paragraphs
5 to 8. |
| This is answered on page 13 of the Note, where it is shown that the conditions were due to faulty design, and that winter irrigation is now increasing, relatively to the summer irrigation. | |
| Deals with the history of the Lower Chenab Canal. | Paragraph
9. |
| This is answered on page 13 of the Note. It is shown that this canal proves the necessity of a weir at Sukkur. | |
| Suggests that the lessons of practical experience should be used in the design of new works. | Paragraph
10. |
| Reply on page 13 shows this has been done in the Sukkur Barrage Project. | |
| Are descriptive of the geodesy of the Punjab and Sind. No comments. | Paragraphs
11 to 17. |
| Refer to canals of Madras, Behar and Egypt, and claims that their barrages are luxuries. | Paragraphs
18 & 19. |
| This is answered on pages 13 and 14, where it is shown that they are vital necessities. | |
| Is descriptive of Punjab Irrigation history. No comments. | Paragraph
20. |
| Explains Mr. Woods' reasons for criticising the Sukkur Project. No comments. | Paragraph
21. |
| Is descriptive of Sind and present irrigation statistics. No comments. | Paragraph
22. |
| Is a brief account of the Sukkur Project, and criticises the officer preparing the scheme. No comments. | Paragraph
23. |
| Compares Sind and Middle Egypt, and purports to show that Egypt has better natural drainage. | Paragraphs
24, 25 & 26. |
| This is answered on page 43 of the Note, where it is shown that the natural drainage of Sind is better than that of Egypt. | |

Paragraph
27.

Deals with the subject of water-logging, and alleges that the matter has received scant attention from those responsible for the Sukkur Project. Quotes a part only of what is said to be "almost the only reference to sub-soil water levels in the Project Report".

This is answered on page 14, where it is shown that there are 73 paragraphs in the Report (of which Mr. Woods quotes only half of one) dealing with this subject, and that a sum of Rs. 1,09,72,000 is provided in the estimates, for works to deal with sub-soil water levels. The subject is dealt with again on pages 26 and 27 and on pages 41 and 42 of this Note.

Paragraph
28.

Describes the original site selected for the Barrage at Sukkur, and states that all experts who have dealt with the subject, for the past 70 years, have rejected the idea of a weir as dangerous and unsatisfactory.

This is incorrect. The first proposal for a Barrage was made in 1902 by Mr. Dawson, and it was to be at the same site as that adopted in the 1911 Project, which was rejected as unsatisfactory.

States that the top of the Barrage gates in 1911 Project was kept at R. L. 192, in order to minimise obstruction to the river's flow.

This is answered on page 14 of the Note, where it is shown that the level of the top of the gates has nothing to do with obstruction to river flow, or danger to embankments, but was fixed at R. L. 192 in the 1911 Project, because that was the level Dr. Summers required for the Rohri Canal.

This matter is again referred to on page 82 of the Note.

Paragraph
29.

Deals again with the height of the Barrage gates, and alleges that the designers have misunderstood the problems in connection with afflux and backwater.

This technical matter is fully dealt with on pages 15 to 18 of the Note, where it is shown that the problem has been fully understood, and provided for in the Project.

Mr. Woods also states that the river water level at *Bhakkar*, *i.e.*, above the gorge, is on the average, at or above, 194.5, throughout June to September period, and that therefore the authors of the Project may have felt bound to hold the water to this level *at all times*, if they were to claim to be improving the condition of the canals. The *average* water level for 72 years, at this point, was below 194.5, in June and September, and in many years very much below it, so that even if the Barrage only maintained a constant level of 194.5 at *Bhakkar*, throughout the 4 months, June to September, it would create a great improvement. Actually it will maintain this level, at all times, at a place 3 miles below *Bhakkar*, where the natural level is $1\frac{1}{2}$ feet lower than at *Bhakkar*.

Paragraphs
30 and 31.

Give some Hydraulic Data of the Indus near the Barrage site.
No comments.

Criticises the design of the Barrage, and attempts to show that silt must accumulate in the approach channels to R. L. 184, *i.e.*, 2 feet above the masonry sill of the regulators, and that therefore silt must be carried into the canals. Paragraph 32.

The actual conditions which would occur, and the hypothetical conditions Mr. Woods assumes, are fully investigated on pages 18 to 21 of the Note, and it is shown that the conditions he assumes are impossible, and that the actual conditions will be quite satisfactory for exclusion of heavy silt from the canals.

Criticises the design of the Rohri Canal (1920 Project) on the assumption that the value of "N," adopted therein, is too low. Paragraph 33.

This highly technical point is fully discussed on pages 64 and 65 of the Note, where it is clearly shown that there is ample justification, from actual experience and experiment in Sind, for the value adopted. The authority for its adoption is given on page 21 of the Note.

Mr. Woods makes other assumptions in this paragraph, which are discussed, and shown to be incorrect, on page 22.

Suggests that the Full Supply Level of the canals must be lowered several feet. Paragraph 34.

It is shown on page 22 that this suggestion would be useless, even if the conditions assumed were to actually occur. It has already been shown on pages 18 to 21 that they will not occur.

Claims that there is no justification in past experience for the ratio of winter to summer crops adopted in the Project. Paragraph 35.

The reply on page 22 shows there is ample justification for an even higher ratio. The statistics quoted on page 46 also confirm this.

Alleges that sufficient use is not made of the water available in the summer season. Paragraph 36.

The reply on page 22 shows that the maximum economic increase of summer cultivation has been provided for, and aggregates an increase of 600,000 acres per annum.

Advances the claims of other portions of Sind, and of the Punjab, to a share of the winter flow of the river. Paragraph 37.

This question is discussed on page 22 of the Note.

Criticises the Note written by the Hon'ble Mr. H. S. Lawrence to show the value of the assured supply to be given by the Barrage Canals, especially in a bad year like 1918-19. Purports to prove that, even on the Perennial Canals of the Punjab, the cultivation falls as heavily, in a year of bad rainfall, as it does at present in Sind. Journal No. 3642, Page 719, Paragraph 38.

The whole argument is deliberately dishonest, and based on a misrepresentation of facts.

On pages 23 to 26 it is shown that Mr. Woods obscures the real issue, *viz.*, that crops in Sind are independent of rainfall, and depend

solely on the level of the river. Whereas in the Punjab the crops depend largely on the heavy rainfall, even in the areas served by Perennial Canals, and the area of cultivation assessed is often limited by the capacity of those canals in the winter season. It is shown also that Mr. Woods deliberately chooses different years, for his comparison of Punjab figures, to those used for the comparison of Sind figures, and omits to explain the essentially different factors which govern the cases.

He also mis-quotes, and befogs, the whole of Mr. Lawrence's statements. The argument in favour of the Sukkur Canals is shown to be far stronger than Mr. Lawrence put it.

Paragraph 39. Is a précis of his succeeding arguments in the Appendices to the lecture.

Each of these appendices is dealt with separately in this Note.

Paragraph 40. Gives a financial forecast for the Sukkur Project, based on all Mr. Woods' inaccurate assumptions, which are dealt with in other sections. He limits the possible extension of irrigation to 3,700,000 acres, ultimately, owing to assumed water-logging. This is discussed on pages 26 and 27 of the Note.

Paragraph 41. Suggests an "alternative" to the Sukkur Project of 1920.

The reply on page 28 shows that this is not an alternative to the Project, but is merely an alternative to one part of it, and entirely neglects the remainder.

Mr. Woods declares definitely that *he would have no Barrage at all.*

He gives examples of existing canals in the Punjab, North-West Frontier Province, and Behar, to show that a Barrage is unnecessary.

These examples are discussed on pages 28 and 29 and it is shown that every one of them fails to prove his contention, and on the contrary, they all support the case for a Barrage at Sukkur.

The details of the alternative design for the Rohri Canal, given by Mr. Woods, are examined on pages 30 to 32, and it is shown from actual recorded data, that the whole design is quite impossible and unworkable.

In his alternative design Mr. Woods selects the new Barrage site, as the point of off-take of his canal. It is shown that by doing so he has taken advantage of the very great superiority of this site, as compared with the original site, though he has denied this superiority.

On page 31 is shown how Mr. Woods deliberately neglects all difficulties to his own suggestion, by omitting, in one calculation, the silt which he shows in another, and to remove which no means exist, nor can be provided by him, without a Barrage.

Appendix A. Mr. Woods discusses the culturable and gross areas, commanded by the Sukkur Project, and compares the percentage of former to latter, with the corresponding percentages in the Punjab and Madras. Argues that the figures for the Sind Barrage Zone, *viz.*, 87 per cent. of gross

are taken too high. Refers to previous estimate made by Mr. W. H. Lucas in 1909, and suggests that present increased figure is due to difference of opinion of two equal experts.

Reply, on page 33, shows that the comparisons with Punjab and Madras are useless, and Mr. Woods' deductions therefrom are illogical. Shows that figure for culturable area, now adopted, is the summary of a detailed soil survey of the whole area, made by specially trained men; whereas that of Mr. Lucas was merely a guess-work estimate, based on his general knowledge of the country.

Mr. Woods compares the tract to be irrigated, on the Thar Canal in the Sukkur Project, to that in the Thal Project of the Punjab, and argues that the percentage of culturable to gross area should be the same in both.

Reply on pages 33 and 34 shows that whereas the Thal Project actually irrigates in the sandy desert described, the Thar Canal nowhere enters this sort of country, but is bounded by it, and merely takes its name from it.

Mr. Woods discusses the final intensity of irrigation, provided for in the Sukkur Project, and compares it with actual intensities in the Punjab. His figures show that, on the Lower Chenab Canal, the actual intensity attained is 70 per cent. of gross area, as against 71 per cent. estimated, for *final* intensity, in designing the Sukkur Canals. In the first place, the intensities he quotes, for Perennial Canals in the Punjab, are not correct for recent years, as is shown in pages 40 and 41 of this Note. Actually, intensities varying from 76·5 per cent., to 70·7 per cent. have been obtained on the Upper Bari Doab, and Lower Chenab Canals, during the past two years. But he contends that owing to rise of sub-soil water level in the Lower Chenab area, the Punjab cultivators have ceased to take water in the winter season.

Appendix B,
Section 1.

He makes similar statements in regard to the Upper Chenab, the Lower Bari Doab, and the Lower Jhelum Canals.

On pages 35 to 39 of the Note, extracts are given from the Administration Reports of the Punjab Irrigation Department, which completely disprove his assertions, in regard to each canal, and which show, on the contrary, that irrigation on all these systems is steadily increasing, and is limited only by the amount of water available in the canals, and by the rainfall, on which, even in the perennial areas of the Punjab, the area of crops sown greatly depends. The Sind Canals are designed to make cultivation entirely independent of rainfall, on which no crops can be raised in Sind.

WATER-LOGGING.—Mr. Woods again reverts to this subject and states it is the winter irrigation, principally, which causes water-logging, and that in the Punjab they do not allow perennial irrigation where the sub-soil water level is less than 25 feet below the surface. He argues that the same rules should apply in Sind.

Section 2.

On pages 41 and 42 it is pointed out, that the rainfall in the Punjab is largely instrumental in raising the sub-soil water level, and that the rainfall of Sind is only about $\frac{1}{4}$ to $\frac{1}{8}$ th of the Punjab rainfall; while the new Sind canals are designed not to interfere with drainage, as many Punjab canals do interfere. It is shown that, if his rule were applied to Madras, all winter irrigation would cease; but every drop of water available is used there.

Section 3. PRESERVATION OF WELL IRRIGATION.—He states that perennial irrigation is not permitted in the Punjab, on areas irrigated to any extent by wells.

It is shown on page 42 that the Punjab Government now provides perennial irrigation in the areas served by wells. Moreover the area irrigated on wells in the Sind Barrage Zone is insignificant,—less than 1 per cent. of the gross area.

Section 4. LEVEL OF SUB-SOIL WATER TABLE.—Mr. Woods gives diagrams to show the sub-soil water levels in Sind, and suggests that the new canals will raise these levels.

On page 42 it is shown that the present canals of Sind block all natural drainage, and that this will be altered, when the new canals are made. All natural drains will then be kept clear, and new drainage channels cut, while great works (costing 109 lakhs) are to be constructed to improve the natural drainage. He goes on to compare the drainage conditions of Sind with those of Middle Egypt, to the detriment of the former, and states that much of the Egyptian irrigation is “lift”, and should be the same in Sind.

On page 43 it is shown that the natural drainage of Sind is better than that of Egypt, while the Egyptian Government is building barrages, and making new canals, to command all land by “flow.”

Section 5. PROPORTIONATE AREAS OF SUMMER AND WINTER IRRIGATION.—Mr. Woods says the Sukkur Project learns nothing from experience in Egypt, and gives figures to show the low intensity of perennial irrigation in Egypt, and the small proportion of winter irrigation.

On pages 43 to 45 it is shown that the object of the Egyptian Government, now being carried out, is to give perennial irrigation to 88 per cent. of the gross area of Egypt, while even at present 61 per cent. of the perennial irrigation is done in the winter.

He says the area irrigated in the winter in Madras is insignificant, and is always less than the summer irrigation.

On pages 45 and 46 it is pointed out that Madras Canals compare only with the rice canals of the Sukkur Project, and actual figures for Madras Canals are quoted, which show that the actual intensity there is 90.5 per cent. of culturable area, or exactly the same figure as adopted for the *final* intensity on the Rice Canals of the Sukkur Project.

He goes on to say that there is no justification, in or out of India, for the assumption in the Project that *final* winter cultivation will be double the summer cultivation, on the perennial canals.

Statistics of Punjab canals are quoted on page 46 to show that the winter cultivation, although limited by the supply available in the rivers and canals, is more than double the summer cultivation, and would be more still, if more water were available in the winter.

Mr. Woods refers to a letter of the Government of Bombay, dated 30th August 1918, in which they said that, in the estimates, only equal areas of rabi and kharif, (*viz.*, 27 per cent. of culturable for each), would be assumed. It is shown on page 47 that, in the 1920 estimates, the area of rabi irrigation estimated for, in the 10th year after completion, when the work had become productive, was only 26.5 per cent. of culturable, and of kharif only 25.5 per cent. of culturable. It is also stated that with the revised financial forecast, allowing for increased rate of interest on loans, (6 per cent.), and for sales of land, the work is still productive, (pays about 11.6 per cent.), in the 10th year after completion, with the same estimated areas of cultivation; so that the *final* anticipated increase of rabi cultivation is not necessary, but will almost certainly be attained in the 30 years estimated. The canals are designed to make this possible.

FORECAST OF AREA TO BE IRRIGATED EACH SEASON, ANNUALLY. Section 6.

—Mr. Woods works out an ingenious forecast of his own, in which he adopts what, he alleges, are some of the figures used in the 1920 Project; and purports to show the area of winter and summer irrigation in the project.

This forecast is examined on pages 47 to 49 of the Note, where it is shown that he has misrepresented, and misquoted, the Project figures.

Mr. Woods also makes many forecasts, based only on his own opinion. On pages 48 and 49 it is shown, by extracts from Punjab Reports, that Mr. Woods' forecasts were not infallible in connection with his own canals, and have long been surpassed on the Upper Chenab Canal, which is still developing.

1. THE PROJECT ESTIMATES OF COST.—Mr. Woods compares Appendix C. the cost of the Sukkur Project Canals with those of the Punjab Triple Canals, on the basis of their discharge at head, and neglects all other considerations.

On pages 50 and 51 of this Note, it is shown that they are in no way comparable.

But in order to adopt his method, a comparison is made, between his own Project for the Thal Canal, dated September 1919, and the Sukkur Project, dated July 1920. It is shown, on pages 51 to 53, that the cost of the Sukkur Project is Rs. 20.7 per acre of gross area commanded, while the Thal Project is only Rs. 18.4 per acre of gross

area ; and this in spite of the fact that the latter is to be an entirely new canal system, in a desert country, and requires heavy cross drainage works, and protection from river erosion ; all which conditions are far worse than in the case of the Rohri Canal.

Section 2. ESTIMATE RATES.—Mr. Woods refers to the addition of 255 lakhs, to the estimates for plant and ironwork, by the Government of India, and says they overlooked the necessity for revising the other rates.

It is explained on page 53 that the addition to cost of ironwork was anticipated in the Report on the Project, and that the other rates were carefully studied, and considered by the Government of India to be sufficient.

Mr. Woods goes on to criticise the Rates for works, provided in the Sukkur estimates, and gives a comparative table of a few items of Sukkur Barrage Rates in 1919, Sukkur Canals Project Rates 1920, and Punjab Rates 1920. (The latter are taken from his own Thal Project.)

This matter is investigated on pages 53 to 58. It is shown that in the items quoted by him, he has changed the nomenclature of some items to suit his purpose, and that such changed items do not exist in the Sukkur Estimates. A correct comparative statement for these items is shown on page 55 of the Note. It is explained on pages 55 and 56 that all building materials, for the Punjab works, have to be carried by public railways, distances varying from 491 to 328 miles in the case of the Sutlej Valley Project, and 100 to 150 miles in the case of the Thal Project; whereas for the Sukkur Project all building materials can be had, in unlimited quantities, within 3 miles of the Barrage, and can be carried, by a private works-railway, right on to work. Similarly, materials from Europe, or carried by sea, have to travel from Karachi, 300 miles to Sukkur, but 800 miles to the Thal Headworks.

A comparative statement of rates, for principal items of work, is given on page 56, from which it will be seen that, for most items, the Sukkur Project rates are far higher than Mr. Woods' rates in the Thal Project.

Page 57 shows that the Sukkur Project allows for an all-round increase of *at least* 30 per cent. over pre-war rates, whereas the New Delhi works are costing only 25 per cent. over pre-war rates.

It is shown on page 57, by quotations from Mr. Woods' report, that his rates in the Thal Project are from 20 per cent. to 30 per cent. over pre-war rates.

Section 3. HILL TORRENT WORKS, NORTH-WESTERN CANAL.—Mr. Woods states that the cost of works, designed to pass the floods of the Baluchistan hills across the North-Western Canal, has been omitted from the Project.

It is shown on pages 58 to 60 that this is incorrect, and Mr. Woods has misunderstood the proposals.

He further says the Paharpur Canal is similar to the proposed North-Western Canal, and has proved a financial failure, on account of the cost of its cross drainage works.

It is shown on pages 60 and 61 that there is no comparison between these two canals, and that the failure of the Paharpur Canal is due chiefly to its silting up, owing to the shifting nature of the river at its head. It is a very small inundation canal, which flows for 6 months only each year.

PROVISION FOR MAINTENANCE BEFORE COMPLETION.—Mr. Woods states that no provision has been made in the Sukkur Project for this item, and says that the actual cost of this item on the Punjab Triple Canal Project, under pre-war conditions, was Rs. 20,00,000.

Section 4.

On page 62, it is shown that both statements are incorrect. The correct amount for the Triple Project was Rs. 11,89,000 actually expended, against an estimate of Rs. 13,00,000.

The amount provided in the Sukkur Project is Rs. 11,63,000 and is shown to be ample for the conditions.

PROBABLE TOTAL COST.—Mr. Woods proceeds to make an estimate based on his previous incorrect statements.

Section 5.

As stated on page 63 these have all been disproved, and it is useless to discuss his conclusions therefrom.

CANAL DESIGNS. KUTTER'S COEFFICIENT.—Mr. Woods discusses the value of "N," adopted for the design of the Sukkur Canals, which he alleges is *too low*.

Appendix D,
Page 727,
Section 1.

This is fully discussed on pages 64 and 66 of the Note, which shows there is ample justification from experience and experiment in Sind for the value adopted. Some actual values obtained in Sind are given in the statement on page 65. These all show *lower values* than that adopted in the Project. The matter is also discussed on pages 21 and 22.

SILTING OF CANALS PROBABLE.—Mr. Woods' arguments in this Section are all based on his inaccurate assumption above, and are therefore vitiated by the disproof of that assumption.

Section 2.

He further suggests that the authors adopted this low value in order to keep down the cost of the works.

It is explained, on page 66, that works were first designed on scientific principles, and then estimated at reasonable rates. The cost of the Project was not even approximately known, until a fortnight before the completion of the three years' work involved, when all items could be totalled up, and the financial forecast prepared.

LOSS OF HEAD IN ENTRY.—Mr. Woods alleges that in the summer, when the mean velocity of the river is 6 or 7 feet per second, the loss of

Section 3.

head in entry will be 0·7 foot. This is not disputed but it is shown, on page 66 that it is immaterial at such times, as there is always ample head to spare. It is only in the winter season, when velocity is low, and loss of head in entry will not exceed 0·3 foot, that this low figure is needed.

Section 4. DURATION OF EXECUTION OF THE PROJECT.—Mr. Woods alleges that the works cannot be completed in the time allowed in the Project.

This is discussed on pages 67 and 68 where it is shown that the proposals are reasonable and possible.

Section 5. GROSS REVENUE RECEIPTS.—Mr. Woods discusses the estimated Revenue receipts, and attempts to show that these are unattainable.

The matter is answered on pages 69 and 70.

He goes on to discuss average water levels, and alleges that the Barrage gives no improvement to the levels in the summer season, and therefore cannot claim credit for increase of revenue.

It is shown, on pages 69 and 70, that the Barrage *does* very greatly improve the levels in Canals, even in the summer, and that the increased rates are properly credited to the Project.

Appendix G,
Page 729.

WORKING EXPENSES.—Mr. Woods discusses the provision for working expenses of canals and alleges that the figure adopted for the Sukkur Project is much too low, as compared with Punjab experience.

His examples are examined on pages 71 to 73 where it is shown that some are not comparable with the Sukkur Canals, and that others, though much more extravagant works, indicate that the rate adopted in the Project is sufficient.

It is admitted, however, that further investigation of this point, appears to indicate that somewhat higher rates should have been assumed during the years while cultivation will be extending. This is one of the few useful pieces of criticism, which has disclosed a slight error in the Project. The margin of profit is so wide, however, that the Project can easily bear an enhancement of 50 per cent., or more, to working expenses, during these years.

[This ends Mr. Woods' lecture, which may be described as an ingenious and industrious attempt to shake confidence in the Project, by methods of argument, which are either singularly misinformed, or of dubious honesty.]

Synopsis of Discussion and Correspondence on Mr. Woods' Paper and of the Replies thereto.

LORD LAMINGTON—Makes remarks which show he has been misled on the only point he refers to. This is explained on page 74 of the Note. Page 73C.

LORD SYDENHAM—Appears to have seen only the opponents' version of the Project. Discussed on page 74 of the Note.

SIR LIONEL JACOB—Admits his information is derived only from Dr. Summers and Mr. Woods. Discussed on page 74 of the Note. Page 731

MR. SYDNEY PRESTON—Declines to express an opinion on the Project. No comments. See page 74 of the Note.

DR. T. SUMMERS—Says he only asks for an examination of the Project in the hard light of facts.

It is hoped this Note will satisfy his wishes. Dr. Summers alleges Sir Sydney Crookshank was responsible for articles in *Pioneer*. This is believed to be untrue. Page 75 of the Note.

COLONEL SIR C. YATE, BT.—Says Mr. Woods has great experience of the Indus. On page 75 it is shown Mr. Woods has no experience of the Indus, or of local conditions, in *Sind*.

MAJOR GENERAL BERESFORD LOVETT—Refers to the vagaries of the Indus. This is discussed on page 75 of the Note.

SIR JAMES WILSON—Admits he is basing his remarks on information given by Dr. Summers and Mr. Woods. He deprecates the tendency to consider irrigation schemes piecemeal, which is exactly what Mr. Woods and Dr. Summers advocate.

He advances a suggestion for considering the best use that can be made of all water available. On pages 75 and 76 of the Note it is shown that this has been done, both in the Punjab and Sind.

He urges the desirability of greatly increasing water rates, which is the opposite of the Sukkur Project opponents' views, but is thoroughly agreed to by the authors of the Project.

He discusses the underground flow of seepage water to Sind. This is answered on pages 76 and 77 of the Note, where it is shown there is no net return of seepage water to the Indus at Sukkur.

He questions the safety of the Project, as regards the possibility of an avulsion. It is shown on page 78 of the Note, that the Barrage does nothing to increase such a possibility, which has always existed, but has never eventuated.

[This ends the discussion and correspondence on Mr. Woods' paper.]

**Synopsis of Sir John Benton's letter, dated the 23rd
August 1922, to the Secretary of State for India,
and reply thereto.**

- Paragraphs 1 to 5. Sir John Benton admits he bases his remarks on the addresses of Dr. Summers and Mr. Woods.
No comments on these paragraphs. See page 79 of the Note.
- Paragraph 6. Discusses the selection of new site for Barrage and says London Committee is not responsible.
Reply on page 79 shows that only Dr. Summers has alleged that this is suggested. The reasons for selection of the site are explained.
- Paragraph 7. Sir John Benton argues that the original upper site for the Barrage is safer than the present site.
This is discussed on pages 79 and 80 and it is shown that the lower site is safer than the upper one.
He further argues that the water at the new site will contain more silt than at the upper site.
This is discussed and disproved on pages 80 and 81 of the Note.
- Paragraph 8. Deals with the same matter, and is discussed on page 81 of the Note.
- Paragraph 9. Sir John Benton discusses the demonstration of the alleged economy of the change of site, and attempts to show that the demonstration fails. This is answered on pages 81 and 82 of the Note which shows that very great economy is effected by the changed site, quite apart from the increased height of the Barrage gates, on which, alone, Sir John Benton bases his argument.
- Paragraph 10. Sir John Benton alleges that the increase in height of gates will cause increased danger of an avulsion.
This is discussed and disproved on page 83 of the Note.
- Paragraphs 11 to 16. Need no comment.
[This ends Sir John Benton's letter.]

Reply to Mr. Woods' Lecture.

(Paragraphs and pages in margin refer to the "Journal of the Society of Arts," Nos. 3641 and 3642.)

Mr. Woods admits that two or more seasons of drought result in famine, and that one season of deficiency produces distress. In Sind, the seasons of deficiency on one or other canal, occur nearly every year, resulting in the distress Mr. Woods admits. Two or more successive seasons of acute shortage are not uncommon, and these occasionally (as in 1918-19) result in famine, or quasi famine, conditions, with the present system of irrigation. These conditions will be greatly aggravated and cultivation made still more hazardous, by the construction (now proceeding) of the four barrages for the Sutlej Project, which will have the effect of retarding the commencement of the inundation in Sind by at least 10 or 12 days, and will similarly shorten the duration of the inundation by an equal time at the end of the season. These are the two most critical periods for inundation cultivation; as the sowing of the crops cannot be delayed beyond a certain period, now only just attainable in normal years, while the last waterings now obtainable, just suffice to mature the principal crops grown.

Page 705,
Paragraph 1.

Mr. Woods' description of the evil effects of the Western Jumna Canal in its early days is not disputed, and they were due, as he himself shows, to the extreme bad alignment and design of the canal. As soon as these conditions were rectified, the state of the country improved, as might have been expected. No such evil conditions will be present in the properly aligned, and designed, canals of the Sukkur Project.

Page 706,
Paragraphs
5 to 7.

The present irrigation on this system (average of 10 years ending 1918-1919) was 669,000 acres or 25 per cent. of gross area of which 11½ per cent. was in the kharif season, and 13½ per cent. in the rabi season. An examination of the records shows that, contrary to Mr. Woods' suggestion, the rabi cultivation is increasing relatively to the kharif cultivation.

Paragraph 8.

The Lower Chenab was a complete failure until the weir was built, and was then an immediate success. The inference is obvious, and may be applied to the Sukkur Project.

Paragraph 9.

All available lessons of practical experience have been utilized and applied in the designs of the new Sind Canals. The rules for design are clearly stated in the project and are probably more careful and detailed than in any previous project.

Paragraph
10.

The Esna and Assiout Barrages in Zone III (Middle Egypt), and the projected one at Nag Hamadi, are not luxuries, but are necessities to give early water in February to cotton, and water to grow restorative crops on the cotton land in the winter.

Page 768,
Paragraphs
18 and 19.

Without water in February the cotton crop could not be grown, and the restorative crops in the winter save vast sums, which would otherwise be needed for artificial manure.

With regard to Madras and Behar, before the construction of the weirs at the heads of the deltas of the Cauvery, Krishna, and Godavari Rivers, and of the weir across the Sone River at Dehri-on-Sone, the areas now irrigated by the Canals now fed by them, suffered from chronic famine. It is therefore difficult to see how they can be classed as luxuries.

These three deltas of Madras are now densely populated by a prosperous peasantry.

Page 713,
Paragraph
27.

* List with
Mr. Gebbie.

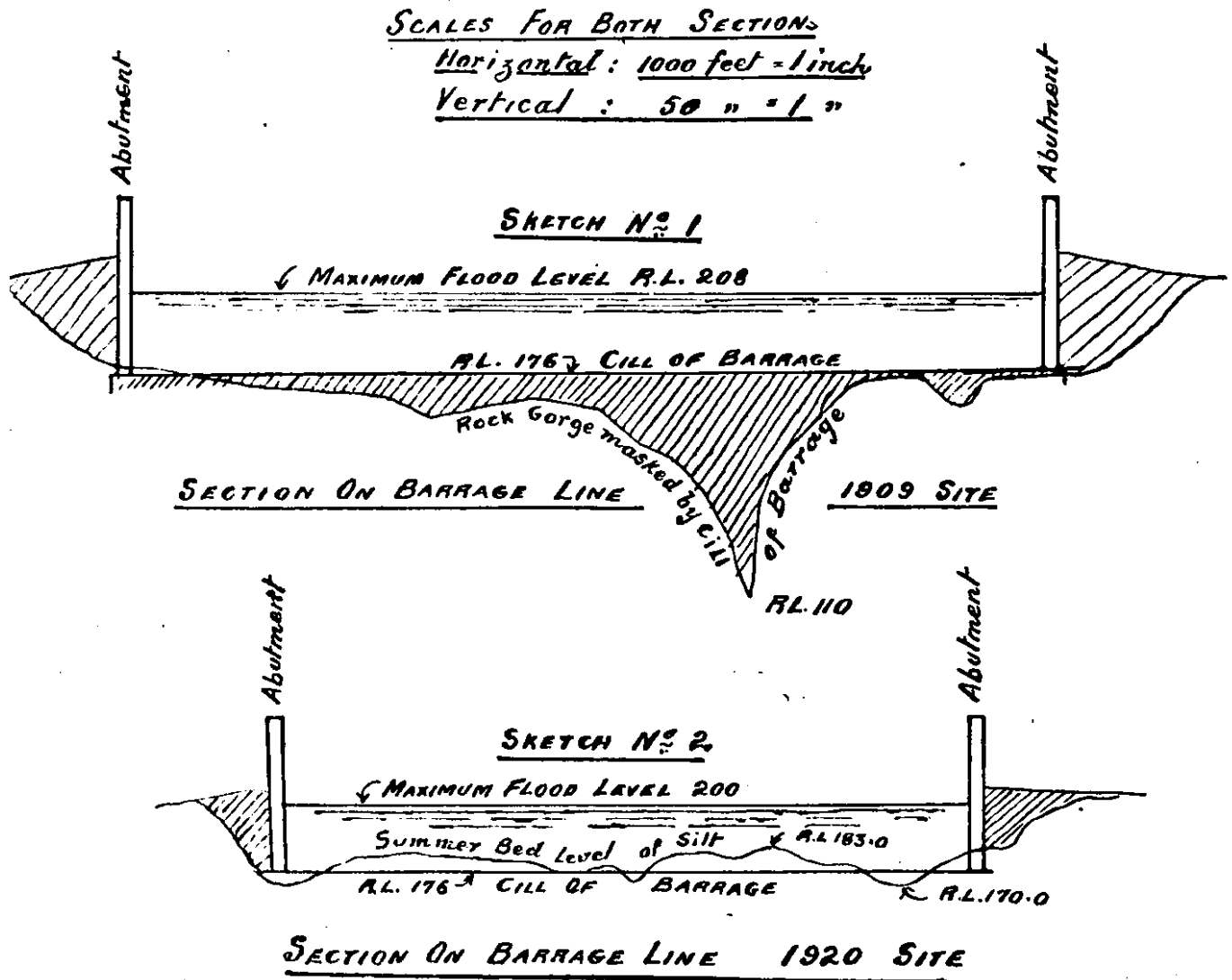
Mr. Woods says that scant attention has been paid to water-logging in the project. This problem is inseparably associated with *drainage* which is the preventative of water-logging. He says there is only one reference to subsoil water levels in the project, and he quotes *only half* of that reference. Actually there are 73 paragraphs in the Report dealing with the subject of drainage. He quotes *half of one paragraph*.* It has been clearly explained that every natural valley line has been left unobstructed, that land has been acquired along all such valleys, so that a strip can be kept clear of cultivation, jungle, etc., to allow free passage to all surface water; and further that directing channels will be cut along the bottom of all of them, which must lower the subsoil water level in the bottom of the valley at least to the bed of such channels, which will be roughly graded and have an average depth of 4' by 25' below ground for main drains, and 3' by 15' for branch drains. No obstructions of any kind will be allowed on such drains; all canal crossings being by aqueducts, and all roads by bridges or dropped causeways. All drains are provided with efficient outlets. The total amount provided in estimates for drainage works is Rs. 1,09,72,008.

Page 713,
Paragraph
28.

The level of the top of the gates in the 1910 project was *not* kept at R.L. 192 in order to minimise obstructions to river flow, as stated by Mr. Woods. The height of the gates has nothing to do with this, since all water is passed *below* the gates, whether they are regulating the river or leaving it entirely free. The height of the gates was fixed at R.L. 192 because that was the level required by Dr. Summers for the Rohri Canal, and was made the best of for the other canals. What affected the flow of the river in flood season was the level of the permanent masonry sill of the Barrage, which was kept at R.L. 176 in the 1910 project, and is the same in the 1920 project.

But at the 1910 site for Barrage, *i.e.*, just above the entrance of the gorges, the natural average bed level of the river was much lower than R.L. 176, (See Sketch No. 1), whereas at the 1920 site of Barrage the average bed level of the river is considerably above R.L. 176 (*viz.*, R.L. 179—See Sketch No. 2), so that the permanent sill can offer no obstruction to the flow of the river. On the contrary it will be possible to scour the natural bed to R.L. 176 if desired and thus give a greater waterway for the passage of floods. The 1909 permanent sill completely masked

the entrances to the gorge which at the Barrage site were 20 to 40 feet below the sill level.



Mr. Woods goes on to say that we claim that, the effect of the obstruction (*i.e.*, heading up to R.L. 194.5 the top of the gates) will not extend beyond the gorge, and that we appear to have been associating afflux with the maximum flood only. He is entirely wrong. We do not dispute that the effect of *heading up* the river to 194.5 will have a backwater effect for 16 miles above the gorge (in fact calculations were submitted to Government showing how far this ponding effect took place. See also Volume I, paragraph 51, page 21). But this back-water effect will never create a water level, at any point, which is as high as any natural floods; in fact it will never raise the level above the natural trough of the river; and therefore it does nothing to increase the danger of an avulsion. Mr. Woods says this backwater will cause shoaling above the gorge, and increase the risk of an avulsion. But we know that shoaling occurs there, naturally, at various times in the cold weather, and is often still there when a large flood comes down. And we further know that these silt deposits are at once scoured away, and carried through the gorge, and downstream, as soon as such a flood occurs. Hence, even if there is some shoaling above the

gorge, during times of regulation, with small discharges, (which will only be at times when the river is carrying a minimum quantity of silt), yet as soon as a large flood comes down, these will be swept away, and carried right down the river and under the Barrage gates, which will *always* be wholly or partially open at such times, leaving the Barrage floor (lower than the natural river bed) clear for the passage of the silt.

There are three separate problems to consider in connection with obstruction caused by the Barrage :—

- (a) The afflux created by the Barrage at times of highest flood, as this is the time of any possible danger to the River Bunds, or, of an avulsion.
- (b) The backwater effect of the Barrage on small discharges of the river, and the reservoir capacity thus created.
- (c) The possible deposit of silt in the river bed, upstream of the Barrage and the gorge, by the effect of (b), and the possible effect of such silting in increasing the height of great floods as per (a).

Mr. Woods has very cleverly omitted to define these three aspects of the case and has mixed them all up, so as to make it appear that the conditions to be created are dangerous and have been overlooked.

As the matter of fact if he applied the same system of reasoning to the 1909 site, which he appears to recommend as better than the 1920 site, he will find the conditions there, are *really* dangerous.

As regards (a), the afflux, in the very highest floods ever recorded, will be less than one foot at the Barrage and will disappear altogether at the gorges. It cannot therefore add any danger to the River Bunds above Sukkur, which they do not already sustain, and thus it cannot add to the possibility of an avulsion.

As regards (b) and (c) it is estimated that at times of lowest river discharges, the backwater effect will die out about 30 miles upstream of the Barrage, the raising of the natural water surface varying from *nil* at that point, to about 17 feet at the Barrage. But normally in the cold season, with ordinary low discharges, the backwater would not extend more than about 20 miles upstream. This ponding of the river will undoubtedly cause some deposit of silt, especially near the Barrage where the ponding is greatest. But after such conditions have occurred, and when an increased discharge begins to come down the river, there will be such a great difference of water level, on the two sides of the Barrage, that very great scouring power is available, and by opening the Barrage gates, a powerful draw will be given to the silt above it, causing the silt to be scoured away and passed through the Barrage. Similarly, as soon as a moderate flood begins to come down the river, it will scour all the river bed for miles above the gorges, carrying the silt through the gorges, and thence onward through the Barrage. The river undergoes all these conditions at present, only perhaps to a lesser degree. It is probable however that the deposit of silt above the gorges, caused by the ponding of water in the cold season, may raise the level of *early* floods until they have had time to scour the bed to its normal level. In other words there will be *more* silt to scour from the bed, and through the gorges, at the beginning of the flood season than there is at present normally, and

such extra silt may give the early floods a higher level, above the gorges, than they would naturally have. But such raising of the level would be only temporary, during the first comparatively small floods, and would disappear long before the full summer floods appear. Such raising of the early flood level would do no harm to the river banks, as it would be still much below full flood level. On the contrary it would benefit the inundation canals above the gorges, *i.e.*, the Begari and Desert Canals, etc., which require high water as soon as possible in the season. In fact the whole tendency of the effect of the Barrage on the floods will be, slightly, to prolong the period of high water at the beginning of the early floods, and to prolong it at the end of great floods. This is touched on in paragraph 26, Appendix E, Volume II.

Mr. Woods says the Barrage will "interfere with and obstruct" the flow of the river throughout the flood season, except in the month of August. This is a gross exaggeration and misrepresentation. When Bukkur gauge reads 12 feet, the full level at the Barrage, 194·5, required for all canals, will be obtained, without any regulation of the river, and no regulation would be done at such levels, except perhaps for a day at a time, at intervals, to create scouring head, if this is found necessary, to clear the approach channels.

The following table shows in how many years the average monthly gauge reading has been above 12' in the past 72 years:—

Month.	Average monthly gauge reading over 12' during past 72 years.	Gauge reading over 12' during part of month in remaining years.	Total out of 72 years.
June	5 years.	28 years.	33 years.
July	37 "	25 "	62 "
August	51 "	14 "	65 "
September	5 "	28 "	33 "

In the months when Bakkur reads less than 12', partial regulation will be done at the Barrage, as many gates as necessary being closed to head up the river to the required level.

The actual average monthly gauge readings during the past 35 years ending 1920 are shown below for the months of May to September inclusive:—

May	7·1
June	10·0
July	12·1
August	13·4
September	9·8

A gauge reading of 7' on Bukkur gives about R. L. 191 at the Barrage, and a gauge reading of 10' about R. L. 193 at the Barrage.

The required full supply level at Barrage is 194.5 so that in May it would be necessary to head up 3.5' at Barrage and in June and September only 1.5 feet, while in July and August no heading up would be necessary for full canal supply.

Paragraph
29.

We will now consider the worst case of silting ever recorded at the Barrage site.

Case I.

With Bukkur reading 6.9, on 21st September 1918, the actual water level at the Barrage was 190.01, the discharge 125,224 cusecs, the average bed level 184.04, mean velocity 3.93 feet per second, and mean depth 5.97. The mean width of the channel was 5,350 feet. But when the Barrage is constructed, the width of the river between regulator faces, at Barrage site, will be reduced to 4,680 feet so that if water level was 190.30 (there might be a slight afflux of say .3 foot, due to the constriction of the channel, and the obstruction caused by Barrage piers) and the bed remained unscoured, at R. L. 184.04, the mean depth would have been say 6.3 feet, the width 4,680, the discharge 125,224 cusecs; so that the mean velocity would have been 4.25 feet per second at the upstream end of Barrage piers. This velocity would probably not be sufficient to scour the bed rapidly though the water at this season carries little silt, and has a higher scouring value. But the water level, unaffected by Barrage Regulation, would have been only R. L. 190.3, and we require 194.5 for the benefit of the canals. Hence we should have had to raise the level, by means of the gates, to R. L. 194.5 giving a difference in level on the two sides of the Barrage of 4.2 feet. The difference would actually be greater owing to the abstraction of 46,000 cusecs above the Barrage by the canals, which would reduce the natural level below the Barrage by at least .8 foot, so that the difference of level, or afflux, would be 5'. Neglecting velocity of approach this would give a velocity under the gates (raised just about 1 foot) of .19 feet per second, which would, of course, scour away all silt down to the masonry floor, and the "draw" of this velocity below the gates would undoubtedly scour the river bed for a long distance above the Barrage; almost certainly as far as the end of the approach channels.

Supposing that this "draw" of the gates is not confined to the lower films of water, there would still be scour of the bed above the gates as shown below. The attraction of the stream lines would be greatest along the shortest line of approach to the gates, which would



always be along the silted bed, so that velocity would be far higher here than in the longer stream lines drawn down from the upper films. The downstream edge of the silt bank would be scoured away on a slope as shown, and on this slope the action of gravity would assist the draw of the gates to bring down the heavier silt, and this, dragging over the sloping edge of the silt bank, will assist in cutting away the bank.

This action is continually proceeding, under *natural* conditions, in the river, but never with such a great change of velocity, or "draw," to assist it, as there will be at the Barrage.

An afflux of only 1 foot at the Barrage would give a velocity below the Barrage gates of 7.6 feet per second which is ample to ensure scour below the gates, and in their vicinity. Such an afflux could be created whenever necessary, even in high floods, without danger to the river bunds above Sukkur, since at flood times there is always a drop of 2 to 3 feet below the gorges, and one foot of afflux would die out when it reached the gorges.

Now consider the case when the Barrage gates just cease to be needed, *i.e.*, when the *natural* river level is at 194.5 at the Barrage.

Case II.

This will be obtained when Bukkur reads 12' about. For such a level, the average discharge in the river is about 320,000 cusecs. The natural width of the river at Barrage site is 5,500' and if we assume that a mean velocity of 5 feet per second is necessary to cause scour (actual observations show that with bed at R. L. 180 scour ceases with a velocity somewhere between 4.35 and 5.75 feet per second) we find that the depth would be $\frac{320,000}{5 \times 5,500} = 11.6'$ or mean bed level would be 182.9. Actually such a high bed level has never been recorded with such a discharge, which indicates that the assumed velocity of 5' per second is too high, and that scour occurs with a lower velocity at this stage of the river.

However assuming these natural conditions let us see what will happen after construction of the Barrage.

The width between regulators being 4,680' and allowing for an afflux of .5' due to the constriction of the river width, and obstruction of piers, we have water level 195.0, velocity 5', discharge 320,000 cusecs. Then the depth must be $\frac{320,000}{5.80 \times 5} = 13.7'$ and bed level 181.3. But with water level 195 in the river, the rising cills of the regulators would be at R. L. 188.4, or 7.1 feet above the level of the *silted bed* of the river.

Moreover the afflux of .5' assumed at Barrage, would give a velocity through the Barrage piers of 7.2 feet per second, which would certainly scour the Barrage floor right down to the masonry at 176.0 and tend by its "draw" to scour the silted bed above, as already explained.

Suppose, however, that scour does not occur under these conditions and it is desired to reduce the bed level below 181.3. We can easily raise an afflux of say 2' at the Barrage, *i.e.*, from 194.5 downstream to 196.5 upstream. This will give a velocity below the gates of 17 feet per second, which would certainly cause scour of the bed upstream. And with water level raised to 196.5 above the Barrage the top of the regulator rising cills would be at about R. L. 190.5 or nearly 9' above the *un-scoured* bed. The above cases are all on *unfavourable* assumptions to suit Mr. Wood's arguments.

Let us now consider actual conditions.

Mr. Woods shows the river bed silted up to R. L. 184 with water level 194.4 at Barrage. No such conditions have ever occurred and never could do so.

Taking his silted bed 184 we find that the highest bed level ever recorded in the hot weather (1st May to 30th September) and was 184.04, on 21st September 1918, and the water level on that date was 190.01. This case has already been considered in Case I above.

Case III.

Now consider conditions with the *water* level he assumes, viz., R. L. 194.4 at Barrage site under *natural* conditions.

On the 21st July 1918 the actual water level at the Barrage site was 193.90 and mean bed level was 179.60, with discharge 405,000 cusecs.

The width of the river was 5,550, the mean depth 14.30 and mean velocity $\frac{405,000}{5,550 \times 14.30} = 5.1$ feet per second. The bed was actually scouring on this day.

Had the Barrage been built there would have been an afflux of about .5 foot, giving water level, above Barrage, of 194.4. The width between regulator faces would be 4,680', so that with the same velocity (scouring), the depth would have been $\frac{405,000}{5.1 \times 4,680} = 17$ feet, and bed level 177.4. Between the piers of the Barrage the clear width is only 3,960' so that if scour occurred to floor level (176) and water level between piers were as high as 193.5 (the actual natural river level on that day was 193.9 whereas there would actually be a fall of level between piers, and recovery downstream, and the downstream level would be reduced by the withdrawals of the canals), the depth between piers would be not more than 17.5 feet, and the velocity not less than $\frac{4,05,000}{17.5 \times 3,960} = 5.85$ feet per second, which is ample to ensure scouring.

Moreover on this day, with natural water level 193.90 plus afflux .5 foot or 194.4 the top of the rising sills of the regulators would have been at R. L. 187.0, or 11.0 feet above the bed in the approach channels. It is evident, therefore, that there would have been no necessity to create any afflux with the gates in order to ensure scouring of the approach channels. Actually some regulation might have been done with the under-sluice gates to reduce the *mean* velocity in the approach channels; and such regulation would create an afflux and give a higher velocity *under the gates*, and induce extra scour *along the floor*.

Case IV.

Now taking Mr. Woods' own figures (see sketch on page 717 figures 4 and 5) he takes water level 194.4 and bed level 184. According to his own table of discharges on the previous page, the discharge for this level (194.4) would be 385,000 cusecs. This is higher than actual average, and the correct discharge is probably about 320,000 cusecs. Even with this smaller discharge the mean velocity through the approach channels, width between regulators 4,680', would be $\frac{320,000}{4,680 \times 10.4} = 6.57$ feet per second, which is sufficient to ensure scour of the silted bed.

Taking the discharge 385,000 cusecs, as calculated from his table, the mean velocity would be $\frac{385,000}{4,030 \times 10^{-4}} = 7.92$ feet per second, which is an impossible condition for the retention of the silted bed shown in his sketch.

The velocities through the Barrage openings under above conditions would be $\frac{320,000}{8,960 \times 10^{-4}} = 7.78$ feet per second, and $\frac{385,000}{3,960 \times 10^{-4}} = 9.32$ feet per second, respectively, both of which would certainly scour to floor level.

Mr. Woods says the rising cills of the regulators cannot come into operation until the river level rises appreciably above R. L. 194.0. He has evidently not checked this statement by calculation, and he has not seen the calculations submitted to Government, which are not printed in the Report.

Actually, under normal working conditions, with R. L. 194.5 above Barrage, all rising cills will be in operation, and for such conditions the permanent masonry cills might have been built 5 feet higher than designed. They are actually designed, so that the canals can take full supply, with a level in the river of 193.5, or a margin of safety of 1 foot in regulation. The following table shows the level of the top of the gates, (or rising cills), of the Rohri Canal, for different levels in the river. The other canals give similar results. The table shows that, under normal working conditions, the top of the rising cills will be 11.15 feet above the floor of the Barrage :—

Bukkur.	Barrage Water Level.	Top of Gates.	Depth on under-sluiques.	Depth over gates.	Height of top of gates over under-sluique floor.	Maximum Velocity through Regulator.	Remarks.
10.5	193.5	182.30	17.5	11.2	6.3	3.98 feet per sec.	Minimum level for Full Supply.
11.2	194.0	185.43	18	8.57	9.43	5.31	
12	194.5	187.15	18.5	7.35	11.15	6.37	Normal working conditions.
13	195	188.4	19	6.6	12.4	7.28	
15	196	190.08	20	5.9	14.1	8.8	
16.7	197	191.36	21	5.61	15.39	10.1	
17.9	198	192.52	22	5.48	16.52	11.3	

Mr. Woods states that the value of "N" should be 0.025, or higher, but Sir John Benton, when Inspector-General of Irrigation in 1907, ordered that it should be taken as 0.020 for main canal and branches (page 208, paragraph 62, Volume VI, 1909 Project). This was based on practical

experience of existing channels in Sind, of which Mr. Woods has no knowledge. It seems unnecessary to discuss this figure which has been accepted as suitable by Sind engineers. This matter is again dealt with in the reply to Appendix D pages 64 to 65. Similarly the critical velocity was taken as .75 of that usually accepted in the Punjab (*vide* paragraph 21 of Mr. Benton's note, page 214, Volume VI, 1909). Both were adopted by Dr. Summers in his 1909 Project. Mr. Woods himself uses "N" = 0.0225 for the Thal Canal, which will carry a coarser silt, and, therefore, produce a rougher surface.

Page 717.
Last para-
graph.

As already shown it will *not* be necessary to raise the water surface from a natural level of 194.5 to 199.5 for the purpose of scouring the river bed. One to two feet of afflux is the most that will ever be needed, at or above this level, and this will not drown-out the fall between the gorges and Barrage.

Page 718
top.

The statement that the average surface slope in the river is 1 in 10,000, and in the canals as little as 1 in 15,600, and that, therefore, silting is bound to occur in the canals, is not a correct presentment of the facts. In the case of the river, there is nothing to regulate the quantity of silt carried, and most of it is in the bottom layers of the deep river. In the canals, only top water of the river will be admitted, and there will be steady flow in the canals, at velocity higher than the critical non-silting velocity for its depth. The canals are less deep than the river, and the less the depth, the flatter may be the slope, and the lower the velocity for non-silting.

Page 718
Paragraph
34.

Mr. Woods proposes to lower the Full Supply Level of the canals in order to provide a margin from the water level of the river, so that if silting occurs in the canals, the Full Supply Level may be raised, to force the required supply into them. He admits this lowering will not decrease their tendency to silt, so what would happen if, and when, they *had* silted, and Full Supply Level had been raised to project figures? Silting would be no less liable to occur at this stage, and there would, therefore, be no gain over the present proposal.

Paragraph
35.

The conditions of summer and winter irrigation in Sind will be almost identical to those in the Punjab, in spite of Mr. Woods elaborate attempt to show the country is physically different. In the Punjab a ratio of 3 of rabi, to 1 of kharif, is frequently obtained, and our ratio of 2 to 1 is perfectly feasible. In many parts of the Right Bank tract, in Sind, there is already far more rabi than kharif, simply because the water supply is available in the rabi season and not in the kharif. In other parts, where very little rabi water is available, it is always fully utilized.

Paragraph
36.

The Canals provide for a great increase, (about 50 per cent.) of rice and other kharif on the Right Bank: a small increase on the Rohri (50,000 acres): and a great increase on the Eastern Nara—about 75 per cent.: the total increase of kharif cultivation being nearly 600,000 acres per annum. No further economical extension of kharif is possible, as further

extension would have to be in rice, which would make extravagant and unworkable canals, and increase any tendency to water-log the country.

The areas of Sind not affected by the project are (a) those to the north, which could utilize a rabi supply, if available by another barrage, and which have an equal, or prior, claim to further water, as compared with the Punjab.

(b) Those to the south, which are not so suitable for a rabi supply, but could be supplied by another weir lower down.

It is questionable whether the Thal (Punjab) has any *vested* rights whatever in the water of the Indus, though it may have some moral claim.

The whole of Mr. Woods' argument, nullifying the value of Mr. Lawrence's note, is knocked out by the fact that he has misread and misquoted the note.

Volume 3642,
Page 719.

The area of the crops in 1918-19, which Mr. Lawrence valued at only £3,500,000 was an *estimated* area of only 1,200,000 acres, (12 lakhs), in *part* of the Barrage Zone, (Mr. Lawrence omitted the Eastern Nara area and took only approximate figures for Left and Right Bank Canals), out of his total estimated area in Sind, for that year, of 36 minus 8 lakhs=2,800,000 acres. The *actual* figure of cultivation that year in all Sind was still lower than Mr. Lawrence's estimate, *viz.*, 2,630,000 acres, as quoted by Mr. Woods himself, while the actual value of the crops on this area, as shown by Mr. Woods, was only Rs. 32 per acre. Mr. Lawrence based his argument on an estimated liberal valuation of Rs. 45 (£3) per acre.

As a matter of fact the argument is far stronger than Mr. Lawrence placed it. Thus:—

The actual area cultivated in the whole Barrage Zone, in 1918-19, was 1,720,000 acres, which, at the average actual value given by Mr. Woods, *viz.*, Rs. 32 per acre, (abnormally high for *bad* crops owing to general shortage), comes to Rs. 5,50,00,000, or say £ 3,670,000.

Had the Barrage and Canals been in existence, and fully developed, the estimated area of cultivation would have been 5,300,000, as per the Project forecast, but taking Mr. Woods' own estimate of only 3,700,000 acres, and assuming the value of such secured crops at an average of 55 per acre (£ 3.66) the value would have been £ 13,600,000, or an increased value of £ 10,000,000. If the Project estimate of final cultivation is taken, the value would have been £ 19,400,000 and the saving to the country £ 15,700,000. Thus even on Mr. Woods' estimate of cost of works (£ 17,000,000) and with his figures for final cultivation, more than the cost of the whole scheme would be saved in 2 such years of shortage. This excludes all advantage to the Khairpur State which similarly suffers in a bad year, and would similarly greatly benefit by the Barrage. The annual cultivation, in *good* years, in the State, is about 183,000 acres. Assuming it was only 160,000 in 1918-19, and the value at Rs. 32

per acre, total value was Rs. 51,20,000, or £ 341,000, whereas if the Barrage had been working, their cultivation would have been 498,000 acres at Rs. 50=Rs. 2,49,00,000 or £ 1,660,000, or a gain of £ 1,219,000 solely due to the Barrage. Total potential gain in 1918-19=£ 11,219,000 on Mr. Woods' estimate of cultivation, or £ 16,919,000 as per Barrage Forecast.

The unfairness of Mr. Woods' comments can be seen at a glance. Thus, he accepts Mr. Lawrence's comparison between the cultivation of the year 1918-19 with that of the *preceding* year, in the case of Sind, but he himself compares the cultivation in the Punjab of the year 1918-19 with that of the *following* year. Had he drawn a similar comparison of Punjab figures of 1918-19 with those for the *preceding* year, as Mr. Lawrence did, the results would have entirely confirmed Mr. Lawrence's arguments. All conditions were radically different in the following year, and did not in any way refute, but when the different conditions are honestly explained, actually strengthen, Mr. Lawrence's arguments.

Page 720,
Paragraph
38.

Mr. Woods gives no explanation whatever of the great variation in the area irrigated in the Punjab in the years 1917-18 to 1919-20. There must be some explanation, why does he not give it?

The explanation is given in the Administration Reports of the Irrigation Department of the Punjab for years 1918-19 and 1919-20. These Reports were written by Mr. Woods himself, and he cannot therefore pretend ignorance of the explanations given therein.

On page 6 of the 1919-20 Report he states that "The area irrigated (in that year) was the largest on record, conditions having been favourable in regard to both river supplies and rainfall, while the development of irrigation on the Triple Canals System was satisfactory. As compared with the year 1918-19 the area irrigated showed increases of 887,754 and 587,567 acres during Kharif and Rabi respectively. It is gratifying to note that the area irrigated in the Kharif season shows a tendency to increase relatively to the area irrigated during the Rabi season. The recent great increase in the value of agricultural produce having stimulated the zemindars to take advantage of the more abundant water supplies of the Kharif season."

NOTE.—On the Punjab Perennial Canals the difficulty is to get the Kharif water supply utilized, while in the Rabi season the difficulty is to meet the demand for water.

Lower down on the same page, Mr. Woods explains that more fodder crops were grown to secure protection against fodder famine and that the great increase in cotton was due to the very high prices being obtained.

On pages 1 and 2 of the 1918-19 Report Mr. Woods explains the great falling off in the area irrigated.

"KHARIF, 1918.—Conditions were unfavourable at first, as the preceding *rabi* season had been exceptionally dry, and less moisture than usual remained in the soil. Rainfall in March assisted the preliminary

sowings, particularly of cotton and cane, but the conditions of April and May were again unfavourable, and the crops received little or no assistance from rain. The monsoon began in June, but the current was extremely weak, and breaks in the rains occurred more often than usual. Rainfall improved during the latter half of August, but failed thereafter; and the total rainfall from June to September was very much below the normal. The sowings were restricted, and standing crops suffered through the insufficiency of the monsoon rains, and from attacks by grasshoppers and other insects."

"The scanty monsoon resulted in *low river levels*, and the Inundation Canals drew less water than usual. The demand for canal water was very keen; and on the perennial canals it was, on the whole, satisfactorily met; as the river supplies, though lower than usual, *were under complete control*."

"RABI, 1918-19.—*The river supplies fell very early in the season*, owing to the very poor monsoon rainfall, and much of the available water was utilized by the cultivators for the maturing of their *khariif* crops. Rabi sowings were further interfered with by the influenza epidemic of October and November 1918. There was some rainfall in the second week of December, advantage of which was taken for *rabi* sowings. A period of dry weather then ensued and lasted till end of January, when there was a substantial fall of rain throughout the Province, doing immense good to the crops. Thereafter the weather was generally dry till the end of March, when light, but fairly general, rain fell, which further benefited the standing crops."

"Generally speaking, the climatic conditions were unfavourable for the sowing and maturing of the *khariif* crops, and for the sowing of the *rabi* crops."

* * * * *

"Of the area irrigated under the heads Imperial and Provincial, the Productive Major Works accounted for 7,748,983 acres and the Minor Works for 666,490 acres, as compared with 7,531,316 acres and 1,068,842 acres, respectively, in 1917-18, and 7,632,536 acres and 1,013,959 acres, respectively, the averages for the triennium ending 1917-18. The figures for the Minor Works, and the Inundation Canals under Major Works, were adversely affected by the low river supplies, and climatic conditions, *whilst those for the perennial canals showed improved results*, except on the Western Jumna and Upper Bari Doab Canals, where the cotton and *jowar* crops suffered considerably, owing to the failure of the monsoon. The decrease on these canals was partly counterbalanced by an increase on the Lower Chenab and Triple Canals. On the former the demand for canal water was unusually keen, and the figures for the *khariif* season constitute a record. On the latter the increase was due to development of irrigation."

* * * * *

"The estimated value of crops raised on all canals including those of Native States, during the year under review, was Rs. 55,08,14,095 as

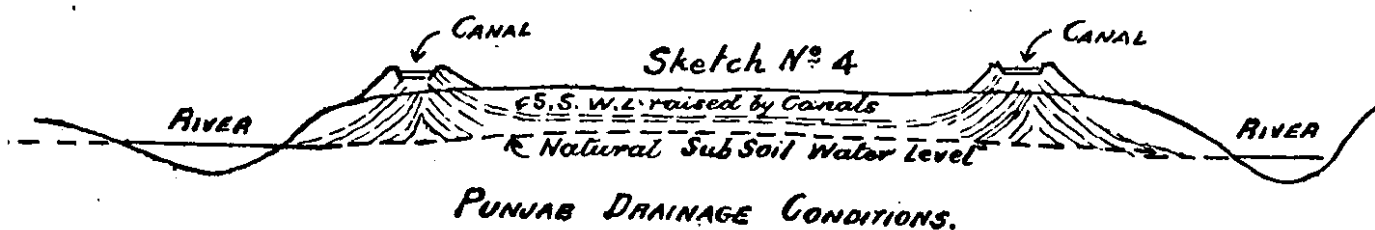
compared with Rs. 33,36,99,916 during the previous year. These figures represent Rs. 64 and Rs. 40, respectively, per acre matured ; the increase reflecting the rise in value of agricultural produce."

Thus it will be seen that the great differences of area, so in 1918-19 and 1919-20, was due to two principal causes :—

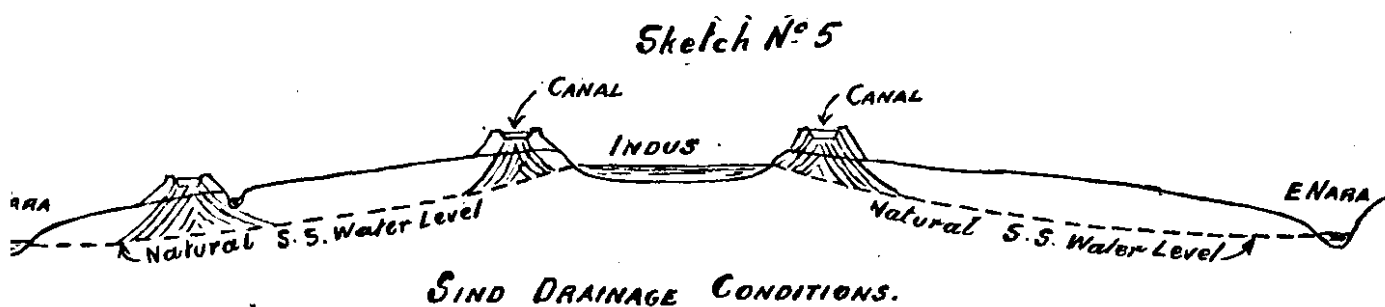
- (a) Climatic Conditions. The Punjab cultivation, even on the Perennial Canals, is considerably affected by rainfall, whereas in Sind the rainfall is almost negligible, and the new canals are designed for lower duties, *i.e.*, greater water supply per area of crop, than the Punjab canals, purposely to allow for this, and to make cultivation entirely independent of rainfall. If rains occur, the canal discharge will be reduced during such times, but no cultivator will depend on rain either for sowing or maturing his crop.
- (b) The development of the Triple Canal Project on which the cultivation was *greater* (217,667 acres), even in 1918-19, than in the preceding year, and was much greater still in the following year (1919-20).

Page 720,
Para. 40.

Mr. Woods says the water-logging of the soil will prevent any expansion of cultivation beyond 3,700,000 acres (finally). We deny that there will be any water-logging. All Mr. Woods' arguments for water-logging are based on the inaccurate assumption that proper measures are not to be taken to prevent it, and on figures and statistics of existing canals working under different conditions, and often with admittedly defective drainage arrangements. In the Sukkur project, large sums are provided to ensure thorough drainage, all natural drainage is kept unobstructed and assisted, and extravagant waterings are not given. The water-supply allowed should be ample to give an excellent supply to the growing crops, but will *not* be excessive. In fact Dr. Summers says it is insufficient. It is *excess* water, which cannot be utilized by the crops, which tends very greatly to raise the sub-soil water level. No rabi water supply at all is given in the rice areas ; and in the perennial areas, the kharif area is moderate and the crops require only moderate waterings, while the rabi crops also require only light waterings at long intervals. In the Punjab the natural drainage lines of the country are the rivers from which the winter supplies are taken. The canals are made at a high level between the rivers and their commanded areas, and roughly parallel to the rivers. Unavoidable percolation below canals therefore cuts off the commanded areas from their natural drainage lines, and tends to raise the sub-soil water level, besides which the water level in the river is raised at intervals to feed the canals. Thus—



The conditions in Sind are the reverse of this, for the natural drainage is *away* from the River, to the deep depressions—Eastern and Western Naras, on either bank. Thus—



Nowhere, in the Barrage Zone, will canals be allowed to block the natural drainage, and the many existing inundation canals, cut deeply into natural drainage lines, (more or less defined valleys), which will now be abandoned, will assist in acting as deep drains for the surrounding country.

Where a canal lies on the slope between another canal and its drainage line, a drain will be cut along the upper side of the canal, to prevent its percolation cone extending in that direction, and thus raising the subsoil water level.

Mr. Woods' Alternative to the Sukkur Project.

Page 721.
Paragraph
41.

Mr. Woods' "alternative" is not an alternative to the *Sukkur Project*, which comprises:—

- (1) The Barrage ;
- (2) The Rohri Canal ;
- (3) The Eastern Nara Canal System ;
- (4) The Right Bank Canal System ;
- (5) The Khairpur State Canal Systems ;

but is an alternative for *only one* canal system. He neglects entirely the other great canal systems, for which he could not provide any alternative without the Barrage. Moreover he neglects entirely the fact, that if his alternative for the Rohri Canal alone were made, it would immediately cause ruinous deficiency in the existing canals, on both banks, at and below Sukkur and Rohri, including the great Eastern Nara which already calls imperatively for *improved* water levels in the river. But let us consider his alternative for the Rohri Canal.

He commences by saying he "would have *no Barrage at all*, since it seems to be a needless and heavy item of expense."

It is stated above that the other proposed canal systems cannot possibly be designed to work without the Barrage, and this is amply proved in the Project Report. For the moment, we will assume that his alternative for the Rohri canal could work without the Barrage. He adduces several examples of existing works, in proof that perennial canals can work satisfactorily without a Barrage. We will examine these examples one by one. The first example he gives is the Lower Swat River Canal, with head at Abazai in the North West Frontier Province. He says this is fed from its parent river without the help of a Barrage, or Weir, across the latter. But this is *not* correct. There is a Barrage at Abazai which controls the river level for the benefit of the Lower Swat Canal. This example, therefore, fails to prove his case, in fact supports the case for the Sukkur Barrage.

His second example is the Upper Jhelum Canal with its head at Mangla in Kashmir. Either he does not understand the conditions at Mangla, and the régime of the Upper Jhelum Canal, or he is deliberately misrepresenting them.

In the first place, the Upper Jhelum Canal has dual functions. It is not only an irrigation Canal, but it is primarily a feeder channel, or bye pass, from the Jhelum river at Mangla, to the Chenab river at Khanki, where it is headed up by a weir. It is this latter function which makes all its working conditions fundamentally different to those of the Rohri Canal, which is purely and solely an irrigation canal, ending in a tail distributary, and thence on the fields. At every point throughout its length the Rohri Canal must give its supply at full designed level, or cause disaster to the cultivation depending on it.

Returning to the Upper Jhelum Canal with its head at Mangla, it should be stated that the lowest river level ever recorded there, is 866.0 (with whole river discharge passing into canal), as against Full Supply Level in the canal of 857.4, *i.e.*, the minimum river level is 8.6 *higher* than the required Full Supply Level in canal; whereas it has been shown below that the level of the Indus, at Rohri, is often 4 to 5 feet *lower*, *for months together*, than the Full Supply Level of Mr. Woods' alternative for the Rohri Canal.

The full designed discharge of the Upper Jhelum Canal is 8,500 cusecs. Of this quantity only 2,400 cusecs are required for irrigation on the canal, and the balance 6,100 cusecs, when available or required, is emptied into the Chenab River above the Khanki weir.

It is immaterial at what *level* this water enters the Chenab, as it can be headed up by the Khanki weir to the level required for the Upper Chenab Canal; while all silt deposits scoured out of the Upper Jhelum Canal can be passed down the natural river.

During the Kharif season, the full discharge into the Chenab is seldom required, and during the Rabi season, the supply in the Jhelum River, which is often deficient, has to be divided between the Upper and the Lower Jhelum Canals. Thus the conditions at Mangla, where the required *level* can always be obtained, are fundamentally different to those at Rohri, where the required level cannot be obtained from the natural river.

Hence the Barrage is required to guarantee the required level, and a supply in the Rabi season sufficient to irrigate an economic area.

But even at Mangla the conditions are changing, owing to the accumulation of shingle in front of the regulator; and some engineers now consider that a weir may be necessary in the course of time.

Mr. Woods' third example is the Trebeni Canal in Bihar, which he states is a perennial canal fed from a river without the help of a weir.

The Trebeni *is not and never has been a perennial Canal* there being no rabi supply. It is principally a rice canal, and always has been so. But even the rice crops, requiring water only from the beginning of June to the end of October, cannot be satisfactorily supplied at present; and a project is now being considered for building a boulder weir, across the river, to ensure the supply for the rice crop in October, and to give a rabi supply.

Thus Mr. Woods' three, so called, examples of Perennial Canals working without weirs, all fail to prove that a weir is not required for the Rohri Canal, and on the contrary, they prove by inference and analogy that a Barrage is essential.

Let us now consider the details of Mr. Woods' alternative design for the Rohri Canal.

Mr. Woods requires a cold season level of 186.5 for the supply of his alternative design of the Rohri Canal without a barrage. The natural river is R. L. 186.5 at this site, when the level at Bukkur is 187.5 and the gauge reads 3.0. The following table shows the number of years in which the average level of the river has been below the required level in the 71 years ending 1918, throughout the months shown :—

Month.	Number of years in which the average level of the river was below the required level 3.0 throughout the month.	Lowest average level throughout the month.		
		Bukkur Gauge.	Year.	Deficiency. Feet.
November	51 years.	0.4	1908	2.6
December	68 years.	—1.2	1908	4.2
January	69 years.	—1.6	1909	4.6
February	63 years.	—2.1	1909	5.1
March	58 years.	—1.7	1909	4.7
April	17 years.	0.4	1917	3.4

Thus in nearly every year, out of the past 70 years, there would have been a deficiency in his canal, throughout the three critical months of December, January and February. And moreover, the required Full Supply Level in the Canal, to command the land, would not have been available, this level falling by as much as 4 to 5 feet, in some years, for three months at a time.

With water level in River, at Canal Head, only 182.5, *i.e.*, 4' below level required by Mr. Woods, the discharge of the canal would be only 6,220 cusecs, and depth 7' and with river level 181.5; *i.e.*, 5' lower than required by Mr. Woods, the discharge would drop to 4,836 cusecs, and depth 6'; as against the designed full supply in Kharif season, of 13,636 cusecs, and depth 11', *which depth is required at any season to command the land.*

Actually Mr. Woods provides a *Full Supply Level* of only 151.7 at the head of the Nasrat Branch, (the first large branch), as against 156.45 provided by Dr. Summers, *i.e.*, 4.75' lower, so, that Mr. Woods must *certainly* get Fully Supply Level to command his land, whereas he will get a 4' to 5' lower level for months at a time, or 10' lower than Dr. Summers found necessary to command the land.

Mr. Woods says he has taken the lower Barrage site, for the head of his alternative Rohri Canal, as it is immaterial which site he adopts, and this is the *least favourable*. He omits to mention that by adopting the lower site, he avoids taking his canal through 5 or 6 miles of very heavy rock cutting, and the construction of an immense bridge for carrying the goods yard of the North-Western Railway over the canal. Further it avoids comparison, of the conditions of the river at its head, with the existing deplorable conditions at the head of the Eastern Nara Supply Channel, alongside which it would have to be made. So that Mr. Woods selection of "the least favourable site" is not so generous as at first sight appears. Actually he has realized, and utilized, the immense advantage of this lower site, for Barrage and Canal Heads, as compared with the original upper site; which advantage he has strenuously denied. In the cold weather season, when *levels* are more important, there is *no* loss of head by the change of site, as the saving in length of canal, and, therefore, saving of loss of head in the canal, exactly compensates for the loss of head in the river; while it saves completely a length of 3 miles of canal, and substitutes for the five miles of deep rock cutting, two miles of shallow cutting in soil. And it avoids altogether the crossing of the North-Western Railway goods yard.

Now, coming to Mr. Woods' cross section of his regulator for the Rohri Canal, (page 722), the first point that strikes one, is that in the upper view, representing the conditions at the regulator in the Kharif or flood season, he shows the river bed silted up to R. L. 184.0, as compared with R. L. 175 for his canal bed. This is in the season when velocity in the river is highest, and, therefore, best able to prevent silting, or to scour the bed. In the lower view he purports to show the conditions in the cold season, when the river has its lowest velocity and discharge. But the inconvenient deposit of silt, up to R. L. 184, has disappeared entirely, without explanation by Mr. Woods, and the river bed is now shown clear down to canal bed level R. L. 175, *i.e.*, 9 feet of silt has been scoured from the river bed by lower velocities in the river, than previously deposited it! How this wonderful and convenient phenomenon has occurred Mr. Woods does not explain. He provides no barrage or other means of scouring the river bed, in fact, leaves the natural river channel entirely unaltered. Let us see what the actual conditions are in the river bed, at this site, in the two seasons. These conditions have been accurately observed and recorded bi-weekly, or weekly, for the past 6 years.

From these records it is found that the *highest* average bed level, ever recorded at this site in the hot weather, (1st May to 30th September), is R. L. 184.4, while it is sometimes 5 to 6 feet lower. And in the cold season, (1st October to 30th April), the *lowest* average bed level recorded is R. L. 178.46, with water level 182.86; and is sometimes as high as R. L. 182.18, with water level 187.35.

Taking the *lowest* average bed level of 178.46, the level of the silt in the river would be 3.46 feet *above* the bed of his canal, while the

water level in the river (182·86) is 3·14 feet *below* the required Full Supply Level of the Canal.

If the higher conditions are considered, the water level in the river 187·35, is sufficient to give Full Supply Level in the canal ; but the silted bed of the river is at an average level of 182·18, or 7·18 feet above the bed of the canal, and he provides no means whatever of scouring it, or excluding it from his canal.

The whole design is quite impractical and would be certain to fail, as Mr. Woods must have realized if he studied it at all. Apparently it was only put forward to hoodwink those unable to check it.

Mr. Woods says the Sukkur Project provides for a Barrage and five canals, three on the Right Bank and two on the Left Bank. He omits entirely the two canals for the Khairpur State. These two canals provide a guaranteed water supply, for increasing the cultivation of the State, from its present figure of about 180,000 acres, to 478,000 acres; to the vast benefit of the State. His Highness the Mir of Khairpur is keenly desirous to have the Barrage and new canals, and has offered to pay whatever the British Government considers his fair share of the cost of the Barrage.

Appendix A,
Page 722.

Mr. Woods says that the claim of the project, that 87 per cent. of the gross area commanded by the Barrage Canals is culturable, *prima facie* errs on the side of optimism: and that, because, in the Punjab, the culturable area is only 82 per cent. of the gross area, and in Madras only 70 per cent. is culturable, it would be more reasonable to assume that only 80 per cent. of the gross area of Sind is culturable. Where is the reason in such an assumption? Adopting his own method of reasoning, his figures for the Punjab must be wrong because they show a much higher percentage than for Madras! But the figures for Sind, used in the Project, are the result of a more accurate and detailed survey of the soil, than has ever previously been made in Sind; and which was specially done by a senior and experienced Revenue officer, with a large staff, for the purpose of the Project. But Mr. Woods would scrap all this work, and adopt, instead, a figure which he arrives at by an utterly valueless and illogical assumption.

Mr. Woods states that a *soil survey* was carried out in 1910 (in connection with Dr. Summers project for the Rohri Canal).

No special soil survey was made in 1910, *i.e.*, no detailed survey of every unoccupied field. Mr. W. H. Lucas, then Commissioner in Sind, spent less than a month, in personally inspecting various areas spread over the 5 northern talukas of the Hyderabad District; but no attempt was made to make a systematic detailed survey, such as was made in 1918-19, by a large staff of specially trained men.

Mr. Lucas' estimate of the culturable area was purely an *estimate*, based on his general knowledge of the country, and on available records, which have since been proved to be totally unreliable in connection with other projects actually carried out. Messrs. Baker and Lane's figure, of culturable area in the Rohri Canal and Right Bank tracts, is not an *estimate* at all, but is an *actual summary of recorded detailed surveys*. There is, therefore, no question of a difference of estimation by equally expert observers, as Mr. Woods suggests. With regard to the Eastern Nara tract, Mr. Baker did not carry out a detailed survey, but based his estimate on a knowledge of the tract, as intimate as that of Mr. Lucas, and on the additional information secured in the 10 years since Mr. Lucas made his forecast.

Mr. Woods has given an accurate description of the Thar Country, but as he does not know this tract or the limits of this country, he is not

aware that there is no proposal to carry any irrigation into the Thar area. This tract of country, covered with sand-hills, everywhere forms the boundary of the area proposed to be irrigated, and every acre of land under the project is in areas which have been surveyed and classified for many years.

The existing Thar Canal, which is to be enlarged and remodelled, merely carries the name of the adjacent country and does not now, and will not in the future, penetrate into the region of sand-hills, or cultivate any land among them. The additional supply to be given to this canal will merely be used to increase the intensity of rice cultivation in present occupied lands, and to provide a rice supply for the unoccupied culturable lands within the present surveyed area, for which no supply is now available. This tract has a high sub-soil water level and is only suitable for rice cultivation. No rabi supply will be given to the canal, so that the country will have an opportunity to drain, and dry off, during the 7 months, October to April. Nowhere in the Eastern Nara Project does the commanded area penetrate, or include, any part of the Thar area, but merely extends up to it. In this respect the proposals are entirely dissimilar to those of Mr. Woods for the Thal Project in the Punjab, in which he proposes to irrigate the numerous small valleys, or bottomlands, scattered among the sand-hills.

Intensity of Irrigation.

Mr. Woods gives a table showing the percentages of gross areas actually irrigated at present, on various Punjab Perennial Canals, and shows that the highest percentage (on the Lower Chenab) is 70 per cent.* or 1 per cent. lower than is proposed for the *final* intensity on the Sukkur Canals. Later on in this Appendix he states that the designs for the Triple Canal Project allowed for an annual irrigated area of only 63 per cent. of gross (it was actually designed for equal areas of kharif and rabi), so that in the Punjab, contrary to the general impression given by Mr. Woods, that they are limiting irrigation, they have actually extended it much beyond the projected areas, and are still extending. Presumably the project design was based on what was believed to be the maximum attainable, and this has been found in practice to be surpassable. Speaking of the Lower Chenab, he says that owing to the rise of sub-soil water level, the cultivators in parts have already ceased to take canal water in the rabi season. This statement is hardly borne out by the following quotations from page 22 of the Administration Report of the Irrigation Department of the Punjab for the year 1920-21.

Appendix B.
Page 723.

“ NATURE OF SEASONS AND STATE OF DEMAND—KHARIF, 1920 ; RABI, 1920-21.—The year was an abnormal one. The Kharif season was unusually dry. The rainfall was scanty and the demand keen. Undeterred by the defective monsoon rains, the farmers tried to put in a large area under *rabi* ; unfortunately the usual Christmas rain also failed and the *rabi* crops were below the average. Later in the season a number of later sown fields with weak plants were sacrificed, as the water that would ordinarily have been poured on them, passed on to other more promising fields. As a consequence the area on which water rates were remitted was higher than in normal times.

“ The failure of the Christmas rains and *the keen demand* did not allow of closing the canal for annual repairs and inspections. It was closed for three days only for excluding silt laden waters from the canal.

* * * * *

“ IRRIGATION—KHARIF, 1920 ; RABI, 1920-21.—The following table compares the areas irrigated during the year with the averages of two previous triennia and with the figures for 1920-21 :—

Seasons.	Average of the three years ending		During	
	1916-17	1919-20	1919-20	1920-21.
	Acres.	Acres.	Acres.	Acres.
Kharif	693,474	791,329	851,161	834,149
Rabi	1,600,866	1,565,854	1,604,064	1,561,827
Total	2,294,340	2,357,183	2,455,225	2,395,976

* This statement is incorrect. See pages 40 and 41.

“The area irrigated (2,395,976 acres) was less by 59,249 acres only than the record figures of 1919-1920. This slight decrease was due to the very dry year and the low supply in the river. The *Kharif* produce was better than the average of either of the previous two triennia, but the *rabi* outturn was somewhat below the averages.”

Similarly his statement that *rabi* irrigation has been stopped, over a considerable proportion of the commanded area of the Upper Chenab Canal, is not supported by the following extract from pages 19 and 20 of the Administration Report, 1920-21, which shows a rapid increase of both *rabi* and *kharif* crops :—

“The *Rabi* season like the *Kharif* one was also marked by an almost entire absence of rain—not only was there no rain during the sowing period of the crop, but the so-called “Christmas rains,” which usually fall at the end of December and beginning of January, also entirely failed, so that the crop got no help from rain either in the sowing or in the developing period. Owing to the extraordinarily low state of both the Jhelum and Chenab rivers the rotational programme of the Quintuple Canal system had to be enforced from the 28th September, instead of the 1st October as usual, and the supplies in both the rivers continued to be extraordinarily low throughout the *rabi* season. The area irrigated, however, was 291,206 acres against a previous maximum of 238,811 acres. This was due to the *intense demand* for canal water owing to the complete failure of the rains and the general development of irrigation on this canal. Out of this irrigated area of 291,206 acres, 278,609 acres were successfully matured. In the Gujranwala District, the central district of the irrigated tract, the total rainfall recorded during *kharif* was 10·20 inches against 19·34 inches and in *rabi* 2·39 inches against 4·59 inches in the previous year; and as compared with average, of 20·49 inches and 3·79 inches during the three previous years. The demand for canal water was *extraordinarily keen throughout the year*. The canal was in flow for 180 days during *kharif* and 129 days during *rabi*. As stated above, rotational working of the linked canals was enforced from 29th September.

“The following table compares the areas irrigated during the year with preceding years and with the Project Forecast :—

Year.	Kharif.	Rabi.	Total.	Project forecast.
	Acres.	Acres.	Acres.	Acres.
1916-17 ..	285,917	151,560	437,477	648,367
1917-18 ..	245,110	137,825	382,935	648,367
1918-19. ..	204,694	222,170	426,864	648,367
1919-20 ..	303,845	238,811	542,656	648,367
1920-21 ..	310,141	291,209	601,347	648,367

“ The total area irrigated included 559,371 acres in old proprietary villages and 41,976 acres in new colony villages. It will be seen that the Project Forecast is now within a very short distance of attainment, whilst Mr. Woods' forecast of 530,000 acres in the Completion Report has long been surpassed; and, indeed, it is not too much to hope that Mr. Purves' forecast of 725,000 acres (*vide* Completion Report of Upper Chenab Canal) will also be attained when the water-course system of the canal is fully developed, and the remodelling required for the enhanced supplies entailed by the final orders on the zonal question fully completed.”

Again, his statements about the Upper Bari Doab Canal are hardly borne out by the following extract from pages 13 and 14 of the Administration Report, 1920-21, which states that the low rabi area was due to defective rainfall, and shortage of water in the canals, and *does not mention any cessation, or decrease, of demand:—*

‘AREA IRRIGATED—KHARIF, 1920 ; RABI, 1920-21.—The following table compares the area irrigated during the year with the averages of the two previous triennia and the figures of the previous year :—

Crop.	Average of three years ending		Area irrigated during	
	1916-17.	1919-20.	1919-20.	1920-21.
Kharif	529,596	573,226	639,019	606,176
Rabi	650,911	580,825	613,564	570,752
Total ..	1,180,507	1,154,051	1,252,583	1,176,922.

“ The total area irrigated during the year was less by about 75,000 acres as compared with the previous year's figures, the highest on record. The area irrigated during *kharif*, though better than the average of either of the two preceding triennia, was less by 32,849 acres than the figures of the previous year while that during *rabi*, although low, approaches the average of the triennium ending 1919-20. *The shortage in the area irrigated during rabi was due to very poor monsoon and total failures of winter rains. There was no barani area in the rabi to be subsequently matured by canal irrigation on this canal.* The total area, however, was equal to the average of the previous six years and, taking in account the unfavourable seasons, it is quite satisfactory.”

* * * * *

“ The monsoon of 1920-21 broke in July and the fall from June to September at Madhopur head-works amounted to 22·2 inches against 30·19 inches during the corresponding period of the previous year and 46·52 inches of 1917. It was, on the whole, a very poor monsoon.

“ Demand was very keen, but supply in the river insufficient. Tatiling of outlets and minors had to be resorted to and branches were run by rotation as usual.

“ Heavy rain fell in the first week of August and this was the only good fall that occurred in a few days in Amritsar and Lahore Districts. The year was practically rainless from October 1920 to March 1921 and this absence of rain had the effect of reducing rabi irrigation.

“ There was only one moderate flood on 23rd July 1920 which attained a height of 22 feet on Mukesar guage. The maximum flood on record is 30 feet.”

Similarly for the Lower Jhelum Canal, which he quotes, the following extract from pages 26 and 27 of the Punjab Administration Report for the year 1920-21, shows a steady and rapid increase of rabi irrigation ; and there is no sign that the Punjab authorities agree with Mr. Woods that it is necessary to restrict it.

“ The rainfall during the year was scanty, even less than in the preceding driest year 1918-19. The absence of rain during the winter months has, perhaps, no parallel within living memory. The *kharif* season although comparatively dry was, on the whole, not so bad as the rabi season when owing to the absence of winter rains, the maturing of the crops was a matter of great anxiety and the prospects of outturn not as good as it would have been if helped by rain. *Kharif* supplies were sufficient but rotational turns had to be resorted to during the rabi season to meet intense demand. Local Canal Officers distributed available supplies efficiently and judiciously.”

“ No calamity occurred during the year, the cotton crop being more fortunate than it usually is.”

* * * * *

AREA IRRIGATED—KHARIF, 1921 ; RABI, 1920-21.—“ The areas irrigated during the year compare as follows with the corresponding figures of the averages of the preceding two triennia and the figures of the year 1919-20” :—

Seasons.	Average of the three years ending		Area irrigated during	
	1916-17	1919-20	1919-20	1920-21
Kharif	Acres. 232,414	Acres. 255,848	Acres. 284,070	Acres. 273,000
Rabi	587,728	531,441	534,830	550,021
Total ..	820,142	787,289	818,900	823,021

“The area irrigated during *kharif*, though less by 11,070 acres than that in 1919-20 was larger than the average of either of the two previous triennia. The *rabi* area though less by 37,707 acres than the average of the triennium ending 1916-17, was better than in 1919-20, and the average of the triennial period ending 1919-20.

“The increase in the area irrigated is due to (a) absence of rain at time of sowing, and (b) new areas having been brought under irrigation.”

It should be noted that in all these canal areas the average rainfall is from 4 to 6 times that in Sind, and as many of the natural drainage lines are blocked by canals (this is now being improved), this rainfall probably has a far greater effect, than the canal irrigation, in water-logging the country, and raising the subsoil water level.

Mr. Woods says it is the *winter* irrigation, mainly, that water-logs and impoverishes the soil, and throws it out of cultivation in consequence; and that cultivation on the Sukkur Scheme should be limited to 50 per cent. of gross area.

This is not borne out by the latest practice in the Punjab, as shown by the following extract from the Administration Report, 1920-21, of the Upper Chenab Canal :

“This complicated ‘zonal question,’ which has hitherto retarded greatly the full development of the Upper Chenab Canal, has at last been satisfactorily settled and a simple workable system adopted instead of the complicated system of the original Project. Zones A and B have been amalgamated and a flat percentage of annual permissible irrigation (60 per cent.) laid down for this entire area. Similarly Zone C (*kharif* channels) has also obtained a flat percentage of 25 for the Raya Branch and Main Line channels and 20 per cent. for the Nokhar Branch. *Well irrigated areas, hitherto barred from canal irrigation in Zones B and C have now been included in the irrigation scheme, thus rendering water-course construction on scientific lines possible.* It is hoped that water-course construction all over the canal, which has been hanging fire for years pending the final settlement of this much discussed question, will now be pushed on and the canal rapidly brought to its full development as an irrigation machine.”

It will be noticed that in the perennial zones, permissible irrigation is to be 60 per cent. of gross areas, while in the Kharif zone it is limited to 25 per cent. or 20 per cent. of gross. It will also be noticed that areas irrigated by wells are now to be included in the canal irrigation scheme.

Mr. Woods probably thinks this is all wrong procedure, but nevertheless it is the latest Punjab practice, evolved from that practical experience which he claims should be followed in the design of the Sukkur Project.

Mr. Woods does not give the year, or average of years, on which he bases his table of intensity of cultivation, shown on page 723. His figures cannot be located from any of the statistics of recent years, published by the Irrigation Department of the Punjab. He states moreover that the *final* intensity of cultivation, 71 % of gross area, estimated for the Sukkur Canals, has been *approached* only in the case of the Lower Chenab Canal, for which he gives the intensity as 70% of gross. It will be seen from the following figures, that the Sukkur Canals estimated *final* intensity, of 71% of gross area, has been *exceeded* in the last two years for which records are available, on both the Upper Bari Doab, and the Lower Chenab Canals.

In 1919-20 which was a fairly favourable year, the intensity on the Upper Bari Doab Canal reached 76·5% of gross area, and on the Lower Chenab Canal 72·5% of gross. Even in 1920-21, when both rainfall, and supply available in the canals, was short, the intensities were 71·8 % and 70·7 % respectively.

The Sind cultivation must be independent of rainfall, and the canals will always have sufficient supply, unless the Punjab withdrawals greatly reduce the discharge of the river.

The following statistics, taken from the Administration Reports of the Punjab, illustrate the growth of cultivation on certain Punjab canals, and show the actual percentage of gross area cultivated :—

—	Triennium ending 1919-20.	In 1919-20.	In 1920-21.	Remarks.
<i>Western Jumna.</i>				
1. Gross area commanded .	2,729,000	2,729,000	2,707,000	1920-21 was an abnormally bad year as regards short rainfall; while canal supply was limited.
2. Irrigated area	767,000	855,000	819,000	
3. Percentage of gross area cultivated	28·1%	31·6%	30·2%	
<i>Upper Bari Doab.</i>				
1. Gross area commanded ..	1,687,000	1,639,000	1,639,000	In 1920-21 rainfall was deficient and supply available in river was insufficient to meet the demand of the canal.
2. Irrigated area	1,154,000	1,253,000	1,177,000	
3. Percentage of gross area irrigated	68·5%	76·5%	71·8%	
<i>Lower Jhelum Canal.</i>				
1. Gross area commanded .	1,359,000	1,342,000	1,342,000	In 1920-21 the rainfall was the lowest on record. The <i>rabi</i> supply available in the canal was barely sufficient. New areas were brought under cultivation.
2. Irrigated area	787,000	819,000	823,000	
3. Percentage of gross area irrigated	58%	61%	61·2%	

	Triennium ending 1919-20.	In 1919-20.	In 1920-21.	Remarks.
<i>Sirhind Canal.</i>				
1. Gross area commanded ..	4,527,000	4,527,000	4,541,000	In 1920-21 rainfall was deficient, but canal supply excellent, and demand keen.
2. Irrigated area	1,302,000	1,549,000	1,705,000	
3. Percentage of gross area irrigated	28·8%	34·2%	37·6%	
<i>Lower Chenab Canal.</i>				
1. Gross area commanded..	3,388,000	3,384,000	3,384,000	In 1920-21 rainfall was deficient and the supply available in the river was insufficient to meet the demand of the canal.
2. Irrigated area	2,357,000	2,455,000	2,396,000	
3. Percentage of gross area irrigated	69·5%	72·5%	70·7%	

2. WATER-LOGGING.—The above quotations from latest Punjab Reports disprove Mr. Woods' assertion that it is the winter irrigation, principally, which causes water-logging. In the Punjab they are now allowing 60 % intensity in perennial areas, and only 20 to 25% in areas having only a *kharif* supply. His assertion that, in the Punjab, perennial canal irrigation is not introduced into areas where the subsoil water level is less than 25' below the surface, is correct. But as shown before, the rainfall in these tracts is from 4 to 6 times the rainfall in Sind, and this is certainly largely instrumental in the raising of the subsoil water level, especially as many of the Punjab canals interfere with, and block, the natural drainage lines for carrying off the rainfall. In the Sind Project Canals all drainage lines are left unobstructed, and are assisted by artificial channels along their bottoms. Moreover if Mr. Woods' proposal, to limit perennial irrigation to areas in which the subsoil water level is more than 25' below the surface, were generally applied, it would be necessary to stop all the double cropping of rice in the Madras delta canals, where it is now everywhere adopted, and where the subsoil water level is much nearer the surface than 25'. In many parts of the Krishna, Godaveri and Cauveri deltas the subsoil water level is almost, or quite, at the surface, and yet two crops of rice are irrigated every year. The importance attached by the Bombay Government to the prevention of water-logging is shown by the provision of 110 lakhs of rupees, for drainage works, in the estimates of the project.

It may be remarked that at Mitho Machi, at M 52 of the Jamrao, the subsoil water level was at least 40' below the surface. There was no sign of salt on the surface before irrigation started. After 2 or 3 years, very bad salt efflorescence occurred in isolated patches. When this occurred subsoil water level was still about 40' below the surface.

At Jhando Mari, the subsoil water level was less than 30' below surface. After 10 years of perennial irrigation, there was not the slightest sign of salt on the land. This would seem to indicate that efflorescence

only appears when salt is in excess in the soil, and is independent of the subsoil water level. This may be contrary to theory, but is based on actual experience.

3. THE PRESERVATION OF WELL IRRIGATION.—Mr. Woods states that in the Punjab it is a well established principle that perennial canal irrigation shall not be introduced into a tract which is already irrigated to great extent by wells. The preceding extract (page 39 *ante*) from the Administration Report of the Upper Chenab Canal for 1919-20, shows that the Punjab Government has now abandoned this principle, and is now permitting perennial canal irrigation in the well-irrigated areas. But even if Mr. Woods' proposals were carried out in the Sind Project, and all well-irrigated lands were excluded, it would make only an infinitesimal difference to the project. The following statement shows the actual areas irrigated by wells in the whole Barrage Zone during the past 10 years. It will be seen that the average area thus irrigated was only 16,230 acres, and the maximum 24,083 acres, out of a total gross area of 7,500,000 acres; or a maximum of 0·32 % of the gross area. Even assuming that the intensity of irrigation on these well-lands is only 33 % (it is probably nearly 100 %) the gross area affected would be only 1 % of the total gross area on the project. In any case, the effect of these wells, on the subsoil water level, is absolutely negligible, since the inflow to the wells is extremely slow through the fine soil of Sind, and with any considerable increase of head, *i.e.*, lowering of water level in the well, the soil at bottom of well immediately "blows" and puts it out of action.

Statement of area irrigated from wells in Barrage Zone of Sind for the last ten years (1912-13 to 1921-22):—

Years.	Acres.
1912-1913	17,960
1913-1914	18,253
1914-1915	9,645
1915-1916	22,452
1916-1917	16,282
1917-1918	9,215
1918-1919	16,306
1919-1920	14,174
1920-1921	24,083
1921-1922	13,926
	<hr/>
	162,296
	<hr/>
	16,230 average.

4. LEVEL OF SUBSOIL WATER TABLE.—Mr. Woods' diagrams of Subsoil Water Level, Plate II, Figs (a) and (b), page 711, show correctly the present conditions in Sind; but the existing canals in Sind block almost every natural drainage line, especially on the Right Bank; while the heavy flooding caused by the unregulated canals, at times of high floods, and the filling of the Munchar Lake, which is the natural collect-

ing basin of all the drainage, by the Aral Canal, all tend to keep the subsoil water level at a high level. In the Barrage Project, provision is made for abandoning, and cutting through, all such canals as block the drainage; for preventing all flooding by canals; and for draining the Munchar Lake to a very low level, shutting out all Indus water from it, and draining off all accumulation of drainage water therein, at a very rapid rate. It is expected that these improvements will affect a considerable lowering of the present subsoil water level, and should more than balance the extra irrigation water to be given after final development.

Mr. Woods says that the conditions in Sind (after development) will be much worse than in Middle Egypt because—

- (a) The area irrigated in Middle Egypt, in the winter, is much less than in the summer, whereas in the Sind Project it will be twice as great.

But the Egyptian records divide Egypt into Upper Egypt (Asswan to Cairo) and Lower Egypt (the Delta—from Cairo to the sea). We cannot check Mr. Woods' definition of Middle Egypt, but will later deal with Upper and Lower Egypt.

- (b) He says the Bahr Yusuf is at a relatively low level, and acts as a drain to the subsoil water level, but there is no corresponding provision in the Sukkur Project.

In the first place the Bahr Yusuf is a channel leading to Lake Qurun, which is an inland lake having no outlet, but at a very low level. The Bahr Yusuf only traverses half of Upper Egypt. In Sind we have great natural drains on either bank. That on the Left Bank is the Eastern Nara Channel, which has a steep fall, and runs out to the sea, and is at a considerably lower level than the Indus, or than the lands to be irrigated, which drain towards it. That on the Right Bank is the Western Nara Valley. This is also much below the level of the Indus, and all lands to be irrigated, drain into it. It empties into the Munchar Lake, a great natural depression at the extreme south of the irrigated area. The Munchar Lake can, and will, be drained, almost empty (to a much lower level than it ever reaches at present) by the great drainage channel to be cut from it to the river.

- (c) He states that much of the perennial irrigation in Egypt is "lift" irrigation, whereas that on the Sukkur Project is to be entirely "flow." Both statements are correct, but many of the existing Egyptian perennial canals were merely old natural channels, utilized as canals, in much the same way as many of the existing Sind inundation canals were evolved. The Egyptian authorities are now building barrages, and cutting new canals, so as to command all land by flow, and the old canals will be abandoned, and used as drains, exactly as we now propose to do in Sind.

5. PROPORTIONATE AREAS OF SUMMER AND WINTER IRRIGATION.

—Mr. Woods says the Sukkur Project draws no useful lessons from irrigation experience in Egypt, and says that in Upper Egypt only 43 per cent. of the culturable area is allotted to perennial irrigation.

	Feddans.
The area perennially cultivated is	1,005,000
„ „ of basin irrigation is	995,842
„ „ of flood irrigated land in berms and islands.	290,793
	2,291,635

i.e., 44 per cent. of the total cultivation (which is the whole culturable area) is perennial irrigation. There is no question of *allotting* this area to perennial irrigation, it is merely limited by the total perennial water supply available.

From "Nile
Control"
p. 10.

"Eventually the whole of Upper Egypt will be perennially cultivated, except some inconsiderable patches which are not reclaimable, and low-lying Nile islands and berms. The great part of the present basins will be given free flow irrigation from the existing Assyut and Esna Barrages and a new barrage to be built at Nag Hamadi." The Egyptian definition of perennial land is that which produces two crops annually. The figures given in "Nile Control" quoted from the *Annuaire Statistique* are as follows:—

Year.	Cultivated Area.	Perennial Area.	Area cultivated twice.	Percentage of Perennial Area cultivated twice.
	Feddans.	Feddans.	Feddans.	
1913-1914	5,020,000	3,820,000	2,550,000	67
1914-1915	5,310,000	4,110,000	2,520,000	61
1915-1916	5,230,000	4,030,000	2,300,000	57
1916-1917	5,320,000	4,120,000	2,370,000	58
			Mean ..	61

which show that from the years 1913 to 1917 the percentage of area cultivated twice was 61 per cent. of perennial irrigation.

The aim of Egypt, as stated in the above quotation, is to convert the whole country to perennial irrigation, as will be seen from

the following figures which are hoped to be attained when the salt lakes in the north are fully reclaimed :

	Feddans.
Cultivable perennially	7,191,000
Berms and islands cultivable after flood	101,635
Fisheries	200,000
Uncultivable	650,165
Total ..	8,142,800

i.e., the aim is to give perennial irrigation 88·4 per cent. of the gross area of Egypt. In no place in the Delta of the Nile is the subsoil water level as low as 25 feet below the surface ; in fact, in many places it is well within 10 feet of the surface.

Mr. Woods says that the area irrigated in the winter season in Madras, excluding the Godavari, is insignificant. Insignificant is a relative term. The following table shows actuals for some of the other canals.

These areas really compare only with the Rice Canals of the Sukkur Project, in which the final intensity is calculated as 90·5 per cent. of culturable, which is exactly the figure for these Madras Canals as shown below :—

Canal.	Triennium ending 1919-20.		During 1919-20.		During 1920-21.	
	1st crop.	2nd crop.	1st crop.	2nd crop.	1st crop.	2nd crop.
1. Kurnool-Cudd a p a h Canal	64,960	13,570	66,724	14,721	92,968	13,321
2. Penner River Canals.	153,350	41,722	154,132	46,148	154,923	15,962
3. Barur Tank	3,428	1,529	3,730	2,226	3,327	576
4. Poiney Anicut System	20,393	6,038	22,522	9,031	21,408	5,923
5. Cheyyar Anicut System	20,409	10,706	20,976	15,040	21,504	14,808
6. Cauvery Delta System	876,456	92,879	896,433	109,911	897,487	100,625
7. Periyar System	128,683	46,709	128,767	50,821	129,712	49,694
8. Srivai Kuntam Anicut.	25,068	20,180	25,032	20,065	25,278	18,255
Totals- ..	1,292,747	233,333	1,318,316	266,963	1,346,607	219,164
Percentage of 2nd crop to 1st crop .. ..	..	18%	..	20·2%	..	16·3%

Canal.	Culturable area commanded.	Area at present estimated as annually irrigable by canal.	Actual cultivation 1919-20 and percentage of irrigable.	Actual cultivation 1920-21 and percentage of irrigable.
1. Kurnool-Cuddapah Canal.	357,470	122,899	81,445 77%	106,289 87%
2. Penner River Canals ..	190,000	147,274	200,280 136%	170,885 116%
3. Barur Tank	6,887	6,887	5,956 87%	3,903 57%
4. Poiney Anicut System ..	23,824	22,462	31,553 140%	27,331 122%
5. Cheyyar ,, ,, ..	29,461	22,463	36,016 160%	36,312 162%
6. Cauvery Delta ,, ..	909,034	900,926	1,005,344 112%	998,112 111%
7. Periyar System	not known	143,000	179,588 125%	179,406 125%
8. Srivai Kuntam Anicut ..	33,500	23,014	45,098 196%	43,536 189%
Totals ..	1,550,176	1,388,925	1,585,280	1,565,771
Percentage of estimated annually irrigable, actually irrigated .. ..	.....	.....	114%	113%
Percentage of culturable, actually irrigated, omitting (7) because not known ..	.....	.....	90.5%	89.4%

These figures seem to indicate that the winter cultivation, which is almost wholly rice, is only limited by the supply available, and by the fact that such a very high proportion of the area is sown (with rice) in kharif season, leaving little area for 2nd crops, unless grown on the same land. Mr. Woods says there is no justification in past irrigation experience, either in, or out of, India, for the assumption that the winter irrigation in the Sind project will be double the summer irrigation.

The following statistics for some of the Punjab Perennial Canals are given in support of the Sind estimate :—

	3 years ending 1916-17.	3 years ending 1919-20.	During 1919-20.	During 1920-21.
<i>Lower Chenab.</i>				
Kharif	693,474	791,329	851,161	834,149
Rabi	1,600,866	1,565,854	1,604,064	1,561,827
Percentage of Rabi to Kharif	230%	198%	188%	188%
<i>Lower Jhelum.</i>				
Kharif	232,414	255,848	284,070	273,000
Rabi	587,728	531,441	534,830	550,021
Percentage of Rabi to Kharif	253%	208%	188%	202%

It has already been explained from the Administration Reports, that in both 1919-20 and 1920-21, the amount of rabi irrigation was limited only by the climatic conditions, and the water supply available ; and that the demand for canal irrigation was very keen. Had the rainfall been heavier, and more water available in the canals, still more rabi would have been grown.

Mr. Woods refers to the Bombay Government letter in which it was stated that " in the final estimates only 27% of the culturable area would probably be estimated as rabi area " but " provision was to be made for it " (*i.e.*, for a possible area of 54% of culturable). Actually in the estimates the full final area of 54% of culturable has been worked out, to show the possible eventual results, but a productive project was shown 10 years after completion of the canals, and at this date the area of rabi estimated is 1,579,900 acres only, out of a culturable area on the *perennial canals only* of 5,994,485 acres, or 26.5% of the culturable, while kharif area is 1,529,705 acres or 25.5% of culturable. With the revised rate of interest, 6% on capital outlay, and crediting the project with the sale value of lands, the return on outlay in this 10th year after completion, is now estimated to be 11.6% on capital outlay, so that if no further expansion of rabi cultivation took place, the project would still pay handsomely. But there is not the slightest reason to suppose that rabi cultivation will stop at 27% of culturable, and it is extremely likely that it will reach the full estimated area, of 54% of culturable.

The Bombay Government never considered it prudent, as stated by Mr. Woods, to design the canals to carry a supply for only 27% of culturable. They specifically stated in the letter he quotes, that provision should be made in the designs for supplying 54% of the culturable area in the rabi season. They merely stated that the financial productivity of the project would probably be calculated on a 27% rabi area, and this has actually been done.

FORECAST OF AREA TO BE IRRIGATED EACH SEASON ANNUALLY.—
Mr. Woods states that in the Sukkur Project the estimated area of irrigation in the 21st year, *i.e.*, 10 years after completion is 3,741,000 acres. This is correct. He goes on to say that the existing cultivation on the Right Bank is 894,000 acres annually (this is correct) out of which 575,000 acres are under rice, and will not be fit hereafter for anything but summer irrigation. This is not correct. He further says "Deducting these 575,000 acres from 3,741,000, we have left 3,166,000 acres, which, under the Project design, are to be irrigated 1,055,000 acres in the summer, and 2,110,000 in the winter."

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Actually on the Right Bank, out of 894,000 acres of present cultivation, only 364,081 are rice. He further omits all present rice cultivation on the Left Bank (Rohri Canal and Eastern Nara System) which amounts to 157,449 acres annually, or a total present area of rice

cultivation of 521,530 acres. He proceeds to deduct *present* rice cultivation from future *total* cultivation to obtain an estimate of future perennial cultivation in the project, and he omits altogether to take any notice of the great expansion of rice cultivation allowed for. Why he should have gone to the trouble of working out a fictitious estimate of the perennial cropping in the project, when actual estimated figures are given on the same page as the present rice area, is not apparent, unless he deliberately wished to mislead.

The Sukkur Project provides for extending the present rice cultivation, in tracts only suitable for it, from the present area of 521,530 acres of rice, to 812,867 acres of rice with 47,500 acres of other kharif, totalling 860,000 acres summer cultivation in rice areas (and no winter irrigation). This leaves $3,741,000 - 860,000 = 2,881,000$ acres of annual irrigation in the perennial tracts, of which 1,579,900 acres are rabi, and 1,301,000 acres are kharif (excluding rice), *i.e.*, in the 21st year the proportions of kharif and rabi are 45% and 55% of the total cultivation in the *perennially irrigated* tracts, while in the rice tracts there is no rabi.

The area of culturable land in the rice tracts is 952,000 acres, and the total culturable area under the Project is 6,530,000 acres, so that the total culturable area under perennial irrigation is 5,578,000 acres, of which the estimated rabi in the 21st year, *viz.*, 1,579,900 acres as above, is 28.3 % only. Thus the actual area of winter irrigation allowed for in the project in the 21st year, while much less than the figure Mr. Woods calculates it to be, (2,110,000), is only 2,900 acres more than he himself estimates as reasonable (1,577,000). Again he repeats all the above misleading and incorrect statements in connection with the Project final estimate of cultivation in the 41st year. Here again the final rice cultivation estimated for is 812,867 acres, with 47,500 acres of other kharif, in the rice tracts, totalling 860,000 acres of summer cultivation, on the 952,000 acres of culturable land in the rice tracts. (There is no further expansion after the 21st year.) Deducting this area from the final total cultivation of 5,308,000 acres, leaves 4,448,000 acres of annual irrigation in the perennially irrigated tracts, of which 3,091,000 is rabi and 1,357,000 is kharif, (excluding rice), or 69.5 % and 30.5 % respectively of the eventual cultivation, or a ratio of 2.28 of rabi to 1 of kharif. In 1915-16 on the Lower Chenab Canal, which is a perennial system remodelled from an inundation system, the ratio of rabi to kharif (excluding rice) was 2.63 to 1.

This section of Mr. Woods' paper is based throughout on his own opinion and judgment. Thus he says "my opinion is that this forecast will probably not materialize, and that the winter area will not be greater than the summer area". "My opinion is that no greater area can ever be expected". "I reckon that the project will not commence irrigation till the 11th year," etc.

Mr. Woods may be an expert in these matters for the districts he knows in the Punjab but even there "his opinion" and his forecasts

are by no means infallible, as is shown in the following extract from the Administration Report of the Punjab Irrigation for 1920-21, page 20, which shows that the actual results on the Upper Chenab Canal (still developing) already far surpass his estimate of cultivation, made by him in modification of other officers' estimates, which are now almost attained.

“ The total area irrigated included 559,371 acres in old proprietary villages and 41,976 acres in new colony villages. It will be seen that the Project Forecast is now within a very short distance of attainment, *whilst Mr. Woods' forecast of 530,000 acres in the Completion Report has long been surpassed*; and, indeed, it is not too much to hope that Mr. Purves' forecast of 725,000 acres (*vide* Completion Report of Upper Chenab Canal) will also be attained, when the water-course system of the Canal is fully developed and the remodelling required for the enhanced supplies entailed by the final orders on the zonal question fully completed.”

Mr. Woods says that he reckons the Project will not commence irrigation till the 11th year. He seems to overlook the fact that many of the great branch canals are already complete, such as the Dad and Nasrat and Jamrao Canals, and only require linking up to the main head canal; while many others such as the Mithrao, Thar, etc., only need slight remodelling, and enlarging, similarly to benefit, directly the short new supply channel is cut. Mr. Woods surely does not suggest that it will take 11 years to cut one head canal 8 miles long, and another 65 miles long. The project allows 6 years for this work, which should be ample, with the rapid mechanical excavators proposed to be used, and which have so amply proved their capacity in Siam, the Sudan and elsewhere.

The Project Estimates of Cost.

Mr. Woods says that a simple check on the sufficiency of the estimates of the Sukkur Project, may be found in a comparison with the figures of the Triple Canal Project, completed in 1912-15.

He takes the Upper Chenab and the Lower Bari Doab Canals; combined, with a designed discharge at head of 11,694 cusecs, for comparison with the Rohri Canal having a designed discharge at head of 10,992 cusecs.

But he omits to point out that these systems are in no way comparable on the ground of cost.

In the first place the Upper Chenab Canal utilizes only 4,944 cusecs, throughout the 113 miles of its length, on the irrigation of its commanded area. It has to carry the balance, 6,750 cusecs, throughout its 113 miles, for the use of the Lower Bari Doab Canal, whose first outlet—the Montgomery Branch—is at mile 41, where the discharge is 6,233. Thus the combined canals have to carry 6,233 cusecs for 154 miles. The discharge of the Rohri Canal is 10,992 at the head, and its first large branches, the Nasrat and Sehra, are at mile 61, where the discharge in the main canal is 9,555 cusecs. At 81 miles from the head, the discharge in the main line is reduced to 6,263 cusecs, or almost exactly the same discharge as that of the Lower Bari Doab 154 miles from the head of the Upper Chenab Canal. For the first 23 miles of its length the Upper Chenab Canal carries 11,700 cusecs, reducing at this point to 9,434 cusecs, or approximately the same as the Rohri Canal at mile 61.

Thus the comparison between the two systems is as follows:—

Upper Chenab Canal and Lower Bari Doab Canal.			Rohri Canal.		
	Length (Miles)	Discharge.		Length	Discharge.
(a) Head of Upper Chenab Canal to mile 23.	23·7	11694 11489	(a) Head to mile 61 ..	61	10992 9555
(b) Mile 25 to mile 119·4	89·3	9434 6546	(b) Mile 61 to 81 ..	20	9555 6263
(c) Head of Lower Bari Doab Canal to mile 41.	41	6546 6233			
		Mile cusecs.			Mile cusecs.
Mile cusecs	(a) 23·7×11,592	=274,500	(a) 61×10,273	=626,500	
	(b) 89·3× 7,995	=714,000	(b) 20×7909	=158,200	
	(c) 41×6,390	=262,000			
		1,250,500			784,700

The mile cusecs of Upper Chenab Canal plus Lower Bari Doab Canal is 60 per cent. greater than Rohri Canal up to the point where discharge in both is about the same, viz., 6,233, and 6,263 respectively.

Secondly, these Punjab Canals cross the main drainage of the country where the average rainfall is about 25 inches per annum, and in the first 24 miles have 12 cross drainage works, while on the Raya Branch there are 17 cross drainage works in the first 30 miles, costing together over Rs. 18,00,000, while the Rohri Canal passes through a tract in which the average rainfall is less than 7 inches per annum, and there is only one cross drainage work required, costing Rs. 62,000.

Thirdly, these two Punjab Canals and their distributing systems were entirely new works, every bit of which had to be done *de novo*.

The two largest branches of the Rohri Canal are already in existence, were remodelled in 1903, and need very slight remodelling now, consisting mainly of raising banks in places; while many other of the new branches will utilize, in whole or part, existing canals. Similarly with the Eastern Nara System, and the Right Bank Canal System, many of the largest branches are already in existence and only need slight alterations; and many other of the new branches utilize great lengths of existing channels, for which the remodelling work will cost far less than original excavation. It is therefore impossible to compare usefully the cost of the Upper Chenab and Lower Bari Doab Canals with the cost of any of the Sind Canals, and all Mr. Wood estimates of the cost of the Sukkur Project, and the return thereon, are therefore vitiated.

However since Mr. Woods compares Punjab Canals with Sind Canals, it will be interesting to see how the cost of the Sukkur Project, submitted to the Government of India in July 1920, compares with Mr. Woods' own project for the Thal Canal, submitted to the Government of India in September 1919, when conditions for estimating costs were practically identical. Taking his own method, in the Thal Project, of estimating per acre of gross area, the cost of the Sukkur Project, including all direct charges for works, establishment, and tools and plant, works out to Rs. $\frac{15,46,25,352}{\text{Acres } 7,494,077} = 20.7$ rupees per acre of gross area.

While for the Thal Canal the figures are—Rs. $\frac{9,08,50,000}{\text{Acres } 4,937,000} = 18.4$ rupees per acre of gross area. These figures are even more in favour of the Sukkur Project than they appear at first sight, since the Thal Project is all *de novo*, and includes very heavy drainage works, *viz.*:—

- (1) The Jaba Superpassage which has to provide for 20,400 cusecs.
- (2) The Wahi Syphon which has to pass 26,800 cusecs. The cost of the cross drainage works in Mr. Woods' estimate aggregate Rs. 33,50,000, as against only Rs. 62,000 for those on the Rohri Canal.

Moreover there will be considerable expense and difficulty in protecting the first 9 miles of the Thal Canal from attacks of River Indus as explained in the following extract of Mr. Woods' report :—

“ The first 14 miles of this alignment, from the proposed head, down to the vicinity of the village of Moch, will lie within the riverin ;

and it is calculated that it will be necessary to protect it from attack by river floods in the first 9 miles, or so, of its length."

Secondly, as already explained, many of the Sukkur Branch Canals are already in existence.

Thirdly, the areas to be served, and in which the new works have to be carried out are entirely different. All the Sind Canals (with the exception of the Eastern Nara River, on which only banks have to be made) pass through country already cultivated and inhabited, where food and water supplies are always available, whereas the Thal Project Canals are made among a desolate desert of sand-hills, sparsely populated, and where water and food supplies will be much more difficult to obtain locally, than they are in Sind.

The following descriptions of the Thal area are taken from Mr. Woods' own report on the Project :—

" *The sand-dunes of the Thal.*—The most striking feature of the uplands of the Thal is the wilderness of sand-hills, or sand-dunes, or drift, sand which extends over so much of its area. Similar sand-dunes may be seen in every Punjab Doab, in particular localities ; but nowhere, except in the *Thal*, do they extend over quite so vast an area, or over so large a fraction of the gross area of the Doab. These sand-drifts are scattered over the expanse of the *Thal*, and have been estimated to cover about one-quarter of the whole area. In the Bhakkar and Leiah Thasils, which extend across the Doab as a central belt, the area covered by sand has been estimated to amount to 800,000 acres, or 1,250 square miles, out of a gross area of 3,000,000 acres, or 4,700 square miles. The sand-dunes prevail with greatest intensity in the eastern parts of the Doab, bordering on the rivers Jhelum and Chenab ; but they present a forbidding aspect also in the north towards Mianwali and Khushab, and in the south towards Muzaffargarh."

" It should, however, be distinctly understood that the colonization on the canal will bear little or no resemblance to the existing Canal Colonies of the Punjab. The irrigable areas will be of very irregular shape and much dispersed, communications will be inadequate, the soil will, much of it, be difficult of cultivation, and irrigation may for a time be subject to interruptions from the difficulties of maintaining the water-courses. The crown land will probably be found unsuitable for anything on a large scale in the shape of reward grants to soldiers, or of grants to colonists from distant areas, and it will have to be colonised on a system of its own, which will possibly include a large proportion of capitalist areas, and the

adoption of an inferior class of peasant colonists, recruited mainly from the *Thal* itself and other areas in the Western Punjab."

"The existence of the sand-dunes, both in proprietary and in Government land, will be a serious obstacle, and the Lieutenant-Governor does not anticipate any very substantial disappearance of the sandy areas such as has taken place on other canals. The experience of cultivation on the inundation canals in Muzaffargarh Thal gives grounds, however, for expecting that the cultivation may increase to some extent beyond the amount assumed in the project by the gradual levelling and irrigating of land now occupied by sand hills."

With regard to Mr. Woods' reference to the increase of 255 lakhs of rupees, made by the Government of India to the estimates for Ironwork and Plant in the Sukkur Project, the Report on that Project definitely stated that some such addition might be necessary in the light of later information possessed by the Government of India; and a special table was given in the report to facilitate the addition of such items if the Government of India found it necessary. The original estimates for these items were stated in the Report to have been prepared in 1918, on most unsatisfactory and indefinite information, at a time when no one could foresee prices two years ahead. Paragraph 2.

Mr. Woods' says the Government of India overlooked the necessity of revising the rates for other classes of work. These were not overlooked, and were carefully studied and reviewed by the Government of India, who considered that the rates provided were sufficient.

We now come to Mr. Woods' comparative table of rates at the bottom of page 726. The first point to notice is Mr. Woods' deliberate change of nomenclature of items, in order to enable him to make fictitious comparisons between items not really comparable. Thus the first item shown is :—

"Concrete of Brick Ballast and Kankar Lime." The word kankar is never once used in the Report or Estimates of the Sukkur Project, for the simple reason that there is no kankar in Sind, and no one ever proposed to use it. Mr. Woods has altered this item to kankar lime from hydraulic lime, probably not knowing that hydraulic lime is a local product made artificially from the local limestone.

CONCRETE OF BRICK BALLAST AND KANKAR LIME, SUKKUR CANALS
PROJECT, 1920, Rs. 32.

Item I.

No *kankar* lime is provided anywhere in the project. The item quoted should be concrete with *hydraulic* lime—locally prepared by burning white lime with clay—and brick ballast at Rs. 17 per 100 c. ft., *vide* page I, Volume XIV,

Item II.

CONCRETE OF BRICK BALLAST AND WHITE LIME.

Barrage Estimate, 1919.	Canals Project, 1920.
Rs.	Rs.
17-8.	26

In the Barrage estimate, *no* concrete of Brick Ballast is provided. This concrete, in the Barrage estimate, is of *stone* metal and *hydraulic* lime. Metal is available at the Barrage for Rs. 3 per 100 c.ft., and hydraulic lime has been taken at 35 per 100 c.ft. The rate of Rs. 26 per 100 c.ft. for Brick Ballast and white lime concrete on canals is with brick ballast at 17 per 100 c.ft.; and white lime probably about Rs. 20 per 100 c.ft. None is actually used in the works. Only the rate is shown.

Item III.

CONCRETE OF STONE BALLAST AND KANKAR LIME IN CANALS
PROJECT, 1920, AT RS. 25.

This should be with *hydraulic* lime, as shown in estimates, page I, Volume XIV. This concrete is only provided for canal works near Rohri and Sukkur. The rate is higher than at the Barrage (Rs. 17-8) because materials will have to be *carted* to work, and not railed as for Barrage. Also the works will be comparatively small.

Item IV.

CONCRETE OF STONE METAL IN CEMENT MORTAR.

Barrage Estimate, 1919.	Canals Project, 1920.
Rs.	Rs.
45	80

The cement concrete at Barrage is made of stone metal at Rs. 3 per 100 c. ft. The mixture is 1 : 3 : 6 and there will be enormous quantities made in a well laid out yard, served by railways, transporters and cranes. The cement concrete in the Canals Projects is a very small item and is used solely for the soling of roadways over bridges. It will be made of Brick Ballast aggregate at Rs. 17 per 100 c.ft. and the mixture estimated for is 1 : 2 : 4. Cement will have a long lead by cart.

Item V.

RANDOM RUBBLE MASONRY.

Barrage Estimate, 1919.	Canal Projects, 1920.
Rs.	Rs.
27	30

At the Barrage there will be enormous quantities of this masonry in the floor of Barrage. All materials will be carried by rail right on to work from the quarries three miles distant. For the Canal works this masonry is only provided on a few works near Rohri and Sukkur, and the extra cost is due to materials being carried by cart instead of by rail.

Item VI

COURSED RUBBLE MASONRY.—Barrage Estimate, 1919, Rs. 40.

This masonry is used only in the Barrage and canal head works. There will be an enormous quantity of it, and materials will have a lead of only 3 or 4 miles by rail right on to work.

Most of this masonry will be in piers and spandrils of Barrage. Only the outer faces of the 10' thick piers will be coursed masonry, the interior being uncoursed rubble masonry. The rate is a combined one for this composite masonry (*vide* paragraph 137 (a), page 48, Volume I). An extra rate is provided for Cut and Easewater Facings.

No such masonry is provided on the canals as the designs are more suitable for brickwork.

The list as corrected will read as follows :—

Item No.	Class of Work.	Rates of cost (Rupees).		
		Barrage Estimate, 1919.	Sukkur Canal Projects, 1920.	Punjab Rates, 1920.
1	Concrete of Brick Ballast and hydraulic lime	<i>Nil.</i>	32	35
2	Concrete of Brick Ballast and white lime (None provided in estimates. Rates only shown) .. .. .	....	26	35
3	Concrete of Stone Ballast and hydraulic lime	17-8	....	} 35
	Do. near Sukkur and Rohri only	....	25	
4	Concrete of Stone Ballast and Cement Mortar 1 : 3 : 6	45	<i>Nil.</i>	} 75 to 80
5	Concrete of Brick Ballast and Cement mortar 1 : 2 : 4 small quantities only	<i>Nil.</i>	80	
6	Random Rubble Masonry in hydraulic lime mortar	27	....	} 45
	Do. near Sukkur and Rohri only.	....	30	
7	Coursed Rubble Masonry in hydraulic lime mortar	40	<i>Nil.</i>	50

With regard to the rates given by Mr. Woods as "Punjab rates, 1920" kankar has almost invariably to be collected and railed long distances, and when burnt has to be passed through a disintegrator, as this kankar will not slake like the ordinary quick lime obtained from Sukkur stone. The kankar now being used on the Sutlej Project is being carried some 60 to 70 miles by rail from the Bikanir State to the kilns at works. With regard to white lime, all the lime-stone at present used on the Sutlej Valley Project is being railed from the quarries at Baganwala to the kilns at Bahawalnagar—a distance of 400 miles, at a cost of Rs. 10-11 per 100 c.ft. for railway freight alone. This is equivalent to an extra rate for freight of about Rs. 6 per 100 c.ft. of white lime. Arrangements are also being made at present to take lime-stone from *Rohri*, i.e., *three miles* from the *Sukkur* Barrage to the Sutlej Valley Project, a lead of

about 328 miles. All building stone for the Sutlej Project is being carried by rail from Baganwala or Taraki distances of 400 and 491 miles average lead respectively. Even for Mr. Woods' Thal Project all lime stone for lime burning has to be carried from Baganwala to Kalabagh by rail, a distance of 150 miles. And all building stone has to be carried from Baganwala or Hasan Abdal, to Kalabagh by rail, distances of 150 and 100 miles, respectively, as against 3 miles for all stone at Sukkur.

The following table shows some of the principal items of work in the Sukkur Project, the rates at which these are estimated therein, together with Mr. Woods' own estimate for similar items in the Thal Project. It should be remembered throughout that all stone and lime at Sukkur can be had within a lead of 3 to 4 miles, whereas at the Thal head works* the lead for these materials is from 100 to 150 miles; and the lead for all ironwork from Europe, from the coast port Karachi, is only 303 miles to Sukkur, and 796 miles to Kalabagh:—

* Kalabagh

Item.	Position.	Rate Sukkur.	Rate Thal.	Remarks.
Earthwork.	Headworks Embankment. . .	Rs. 14 and 11 per 1,000 c.ft. according to lead.	Rs. 10 throughout.	
Do.	Do. Excavation—sand wet	Rs. a. 15 0	10	
Do.	Do. „ sand dry .	6 0	5	
	<i>Main Line Canal.</i>			
	Excavation 0' to 5' ..	12 2	6	Mean lead to spoil, 2 chains with 10' lift.
	5' to 10' ..	13 3	9	
	10' to 15' ..	14 4	12	
Masonry work.	Concrete Cement	1:2:4 80 0	70	
	Lime Concrete White ..	1:2:4 26 0	mixture not given. 35	
	Brickwork, bridges, etc. ..	42 0	mixture not given. 38	
	„ Archwork	50 0	45	
	Dry pitching	25 0	20	
	„ brick ballast	18 0	9	
	<i>Stonework.</i>			
	Ashlar masonry	100 0	175	
	Rubble stone masonry with coursed rubble facing ..	40 0	....
	Rubble stone masonry ..	..	40	
	Pitching stone	8 0	12	
Miscellaneous	<i>Ironwork.</i>			
	Sheet Steel Piling	10 11 per sq. ft.	5 per sq. ft.	
	Rolled Steel beams	33 6 per cwt.	40 per cwt.	
	Barrage Gates in under- sluices	139 0 per sq. ft.	40 per sq. ft.	Local stone.

A strong Committee consisting of officials, and non-official business men, was recently appointed to consider, amongst other things, the increase in cost of work on New Delhi, due to the War. After a very careful and full investigation this Committee has reported to the Government of India that the all-over increase of cost of work is 25 per cent. above pre-war rates. New Delhi may be considered a typical work as it includes almost every class of work, such as earthwork, stone masonry, brickwork, steelwork, railways, reinforced concrete construction, etc., and large quantities of up-to-date machinery and plant, and the most modern methods of work, are being employed. The plant includes electric cranes, stone dressing and cutting machinery, and concrete handling plant.

The Sukkur Project Rates allow for an all-round increase of at least 30 per cent. over pre-war-rates, while Mr. Woods, in the Thal project, allows for an increase of 20 per cent. to 30 per cent. over pre-war rates, as may be seen from the following extracts from his report on the Thal Project :—

“ESTIMATE OF COST OF HEAD WORKS AND MAIN CANAL.—The following works have been designed, and their cost estimated, in full details :—

- (a) The Weir and its Sluices.
- (b) The Canal Head Regulator.
- (c) The River Training Works.
- (d) The Jaba Superpassage, R. D. 15,000, Main Line.
- (e) The District Road Bridge, R. D. 75,416, Main Line.
- (f) The Earthwork of the Main Line Upper, down to the first bifurcation at R. D. 170,400.

The cost of the Whai and other Drainage Syphons has been inferred from the statistics of the actual cost of similar works on the Upper Jhelum Canal; the same being expressed in terms of rates per square foot of water-way of barrel, length of barrel, etc.

Similarly the cost of bridges has been deduced from the detailed estimate of the District Road Bridge at R. D. 75,416, and the cost of Regulators, Foot Bridges, Inlets, etc., has been deduced from the statistics of cost of similar works on the Triple Canal System.

SCHEDULE OF RATES OF WORKS.—The rates of cost assumed for the different classes of work involved in the detailed estimates (a), (b), (c), (d), (e) of the preceding paragraph are set forth in the Schedule of Rates appended (Appendix S). These rates are generally from 25 to 30 per cent. in excess of the rates actually paid for the construction of the Triple Canal System; or about 20 per cent. in excess of the rates paid for the Gujrat Branch, the most recently constructed portion of the Triple Canal System.

The rates for Earthwork in channel excavation and embankment are about 20 per cent. higher than those paid on the Triple Canal System.”

It is true, as Mr. Woods says on page 727, that the rates he has selected and misrepresented may "tend to shake confidence in the sufficiency of the Sukkur Project estimates," but had he more fairly given *all* the rates, and shown actual pre-war rates, and his own rates for the Thal Project for comparison, they would have had a very different effect.

3. HILL TORRENT WORKS, NORTH-WESTERN CANAL.—Mr. Woods states that "no provision has been made in the estimates of the Sukkur Project for the cost of works designed to pass the floods of the hill torrents of the Baluchistan border across the North-Western Canal. The proposal is to debit the cost of such works to a separate Provincial Fund, instead of to the Project Estimate."

This is entirely incorrect.

The flood protective works to which he refers, and which have been excluded from the Project, do not effect the North-Western Canal at all. They affect the South-Eastern Perennial Canal, and as parts of the Protective Works have been omitted, no extension of irrigation, over existing cultivation, has been calculated for on areas not protected, as will be explained later. There is only one place at which floods from the Baluchistan border affect the North Western Canal, and these are satisfactorily provided for in the project, as described in the following extract from Appendix H, Volume VI of the Barrage Project Report :—

"To the west of the tract runs a range of hills,—the Khirthar Hills—which run with a few breaks North to South starting from the Quetta hills, and extending right down to the sea coast near Karachi. The attached small tracing No. 112 of 1919, scale 32 miles to the inch, shews the general configuration of the country. The area commanded by the Right Bank Canal is coloured red, and the possible extension into Nasirabad Tahsil, etc., is shown in a lighter shade of red.

"It will be seen that there are a number of rivers or torrents flowing southward, across the open country to the north of the commanded area. Of these the most important appear to be the Bolan and Mulla rivers which meet at the extreme north-west corner of the commanded area and flow through the valley line shown in plan 107 T along the north-west boundary of the commanded area. There is also a branch of the Bolan River, and a branch of the Chaker River, which debouch over the country to the east of the main streams already described, *i.e.*, to the north of the Sir wah.

"During years of ordinary rainfall of short duration it is probable that there is very little run-off through these torrents, most of the rainfall being absorbed and evaporated in its long journey across this arid tract.

"When, however, rain is of long duration, or great intensity, as happens at long intervals, there is a heavy run-off, and these torrents carry a large discharge. In the case of the westerly torrents (Bolan

and Mulla rivers) these have an unimpeded course through the north-western valley line described, and thence through the main Western Nara valley (much interrupted with canals) into the Manchar Lake. In the case of the two easterly torrents these discharge over the country to the north of the Sir wah, the banks of which, if unbreached, serve to divert the flood water westward, where it joins the tail of the Bolan river and flows with it into the North-Western Valley, and thence to Manchar. If the Sir wah banks breach, as, being weak, they generally do, with a high flood, the water finds its way more directly into the main valley through the North-Eastern Valley line shown on plan 107 T.

“ This North-Eastern Valley is only at all well defined southward from a point close to the proposed Khirthar Branch; and above this point the contours show no defined valley, but a steady fall to the south and west.

“ As the Khirthar Branch, to the west of this point, runs parallel to the contours for 2 or 3 miles, and thereafter runs down-hill, it is not considered necessary to provide an opening through the canal for the floods, as the proposed strong canal bank will divert the floods to the south-westward for 2 or 3 miles, after which they can fall with the contours, to the south and west, outside the canal banks, and enter the main North-Western Main Valley.

“ The present weak banks of Sir wah, which hold up and divert smaller floods, cross the North-Eastern Valley where it is well defined, and has concentrated a large flow of water, but the new Khirthar Branch passes beyond the defined valley, and with its strong banks should have no difficulty in holding up, and diverting, the distributed flood water above it.

“ The North-Western Valley and the main Western Nara Valley with its collecting basin, the Manchar Lake, is and always must be the natural and only course for these floods to take.

The hill floods entering the commanded area of the South-Eastern Perennial Canal, are much more difficult to deal with, and a great project has been prepared to protect the country from these, and to utilize them elsewhere, outside the protected area. This complete project will be found in Volume XIII of the Barrage Project Report.

All the flood-excluding banks, therein provided, have been omitted from the Barrage Project, but the drainage works, necessary to deal with floods, have been retained, and the large sum of Rs. 76,43,121 is provided for these works.

The procedure resulting from these omissions is fully explained in the following extract from Part I, Section I, Volume V of the Sukkur Project Reports :—

“MUNCHAR DRAINAGE.—Although a complete Project for the protection of all irrigated lands, from the hill floods, has been prepared

and is submitted in Volume XIII of this Project, it has been considered desirable to exclude these works from this irrigation Project, as the Protective Works form an agricultural work and should be paid for by a special protective cess, independent of the irrigation rates.

“ It has therefore been decided to include in this Project only such works as are necessary to ensure the satisfactory drainage of the irrigated areas. These works consist of the great high-level and low-level drains from the Munchar Lake to the River, with the Combined Head Regulator for same. The cost of these works is estimated at Rs. 76,43,121 and is debited to the Right Bank Canal System, no special revenue being credited to the Project on their account.

“ These arrangements provide for draining off accumulated floods at a fairly rapid rate, as the river falls, but do not alter any of the present flooding conditions at the time floods are entering the lake. The entering floods will still damage kharif crops, as at present, and the whole country up to the highest level (R. L. 124·0) to which the floods accumulate, will be covered with water for some months in a bad year.

“ It is therefore decided, in the latter area, to allow for no increase of cultivation, and to provide for present cultivated area at the enhanced rates taken by Messrs. Baker and Lane, since the supply will be improved by the new canals ; but to deduct from the total revenue thus obtained, remissions, equivalent to 30% of revenue obtained from kharif cultivation, but no remissions from rabi, as it is assumed that the new drain will free all present rabi areas, in time for cultivation.

“ For the remaining area which was flooded in 1917, *i.e.*, between contour 124·0 and the northern limit of flooding, full rabi development is allowed for, as this area can be rapidly drained, and the kharif is assumed to increase from the present area half-way to the anticipated area (as calculated for protected lands in the rest of the Project).

“ All the Flood Diversion, Valley and Lake—containing Banks are omitted from this project, but the complete Protective Scheme is sent up with this Project in Volume XIII and the remaining works may be considered later if desired, as an Agricultural Work.”

Mr. Woods says the Paharpur Canal is somewhat similar to the North-Western Canal of the Sukkur Project.

There is no similarity at all.

In the first place the North-Western Canal is a large perennial canal supplied from a protected head at the Sukkur Barrage, and having a discharge of 4,313 cusecs. It does not cross the catchment of a country with heavy rainfall.

The Paharpur Canal is a purely inundation canal with an average discharge of only 200 cusecs for 6 months in the year, and bone dry for the remaining six months. It is fed from the Bilot creek of the River Indus, with no means of ensuring its supply, or excluding silt from it.

It is crossed by many hill torrents which continually breach it, and which in fact supply the water for the greater part of the irrigation. The following extract from pages 2 and 3 of the Administration Report of the North-West Frontier Province, 1920-21, gives a description of the canal which shows that no one could reasonably compare it with the large perennial North-Western Canal of the Sukkur Project :—

“ IRRIGATED AREA.—A comparison of the area irrigated during the year with the previous years is given below :—

Irrigated
area.

Year.	Kharif.	Rabi.	Total.
1917-18	8,392	16,574	24,966
1918-19	3,714	3,070	6,784
1919-20	7,522	13,148	20,670
1920-21	8,428	5,501	13,929.

“ The irrigation is entirely dependent on the rise and fall of the River Indus and the intensity of the hill torrents during the irrigating period. Water-rates were remitted on 6,254 acres of crops that failed to mature ; this gives a very high percentage of 46 on the area irrigated and was due to insufficient supply, bad germination and bad soil.

“ FINANCIAL RESULTS.—The gross revenue, direct and indirect, was Rs. 27,272 and the working expenses Rs. 63,359. The result of the year's working is thus a loss of Rs. 36,087. The capital outlay on the canal is Rs. 9,20,749.

“ GENERAL REMARKS.—It is now realised that this canal is a hopeless concern. An expenditure of at least Rs. 1,00,000 would be necessary to thoroughly silt clear it, but the feeding creek and the course of the River Indus are more unstable than in the past, and this heavy expenditure might be fruitless. A still larger expenditure on cross drainage works would be necessary to prevent the numerous hill torrents from breaching the canal and interrupting the supply from the river, but the country is being gradually raised by silt deposits brought down by these torrents and the effectiveness of such works would not therefore be permanent ; moreover the bulk of the irrigation is effected by these torrents. The conversion of the canal into a perennial channel and extending it is not a commercial proposition by any means. The question of handing it over to the civil authorities to be worked on the lines of district canals is now being considered. The estimated value of the crops matured by this canal is Rs. 2,78,196.”

Mr. Woods says that “the authors of the Sukkur Project take credit for the revenue accruing from the extension of the (North-Western) Canal to command an area of 400,000 acres of new land along the Baluch border, but they shirk debiting the full cost of that extension to their Project. This is not right. The cost, which may, perhaps, amount to half a crore of rupees (£300,000) should be added to the Project estimates.” This statement is entirely incorrect as shown above. No necessary works have been omitted from this canal project, and the full cost of all estimated works is debited to it.

4. PROVISION FOR MAINTENANCE BEFORE COMPLETION.—Mr. Woods states that no provision has been made in the Sukkur Project for maintenance of canal works, between the date of their completion and the date of commencement of irrigation. This is entirely wrong, and Mr. Woods has either not taken the trouble to look at the estimates, or is deliberately misleading his readers.

The actual provision made in the Sukkur Project, for maintenance of canals during construction, is Rs. 11,63,133.

He further says that in the case of the Triple Canal Project the actual cost of this maintenance was, under pre-war conditions, Rs. 20,00,000, equivalent under post-war conditions to Rs. 26,00,000. This figure is also incorrect. The actual total expenditure for maintenance during construction of the Triple Canal Project, as given in the Completion Report, edited by Mr. Woods himself, was Rs. 11,88,923, against the project estimate of Rs. 13,00,657.

As this was a pre-war expenditure we may add 30 per cent. to it to give an equivalent post-war expenditure or Rs. 11,88,923+30 per cent., say Rs. 15,50,000.

But the Triple Canal Project is entirely within a tract having an average rainfall of 7 to 32 inches per annum, while the average rainfall in the Sukkur Project tract is only 4½ to 7 inches per annum, or less than one-quarter of that in the Punjab, while the cross drainages in the Punjab are extremely numerous and heavy; and in Sind are few and light. It is this rainfall which damages canal works, as is clearly shown by an inspection of the actual expenditure for maintenance on the three canals of the Triple Project. (See table below):—

Canal.	Main Canal Miles.	Branch Canals Miles.	Total Miles.	Average Rainfall.	Total expenditure on maintenance, excluding Headworks.	Maintenance per mile.
					Rs.	Rs.
Upper Jhelum . .	88	37	125	15 to 32 ins.	4,28,452	3,410
Upper Chenab . .	119	53	172	8 to 25 ins.	3,26,566	1,904
Lower Bari Doab	134	62	196	7 to 11 ins.	3,03,866	1,550

The length of the Sukkur Project, Main Canals and Branches, is 1,571 miles, so that the provision made amounts to Rs. 740 per mile, in an area of far lighter rainfall. But it has been estimated in detail, from the actual length of each canal, and the number of years it will have to be maintained, at rates which experience of maintaining canals in Sind shows to be ample.

5. PROBABLE TOTAL COST.—Mr. Woods says there are “ other numerous instances of omission, or of under-estimation, which need not be described in detail.” It is of course impossible to answer a vague assertion of this nature, but it may be assumed that Mr. Woods has selected what he considers the worst of such omissions, and under-estimations, in his preceding arguments, and as his specific accusations have been shown to be incorrect statements, exaggerations, or misrepresentations, there is no need to discuss his general assertion.

Kutter's Coefficient.

Appendix D.

Mr. Woods says "the value of Kutter's Coefficient is not likely, in practice, to be so low as 0.02. In the Punjab, the practice has been, for 20 or 30 years past, to design main canals on the assumption that 'N' = 0.0225." And he proceeds to quote the average value of "N", found by experiment in three of the Punjab Canals. Again he says "The soil of Sind is said to be lighter and more friable than that of the Punjab, but even if it be not, it is quite on the cards that the canals of the Sukkur Project may exhibit a rugosity implying 'N' = 0.027." And again "In any case it is impossible for any expert to deny that the Sukkur Canals may have a coefficient of rugosity as high as 0.25 or even 0.27 in their head reaches." Now, in Sind, elaborate and careful experiments have been made for several years past, in every district, to determine the actual value of "N" on numerous canals.

Mr. Woods might have enquired for these figures had he really wished for accurate information. Why then does he not quote actual figures for existing Sind Canals, instead of quoting Punjab figures, and making assumptions and assertions of his own, to get figures for the Sukkur Project? The reason is obvious. The actual figures do not suit his argument. Let us examine some actual figures for Sind. It should be noted in passing that every engineer, with any knowledge of Sind and the Punjab, knows that the soil of Sind is much finer than that of the Punjab, as is also the silt carried in suspension in the river and canals. The heavier silts and sands are deposited in the upper reaches of a river and the finer silts carried onward, so that as we progress towards the mouth of a river, the silt in suspension, and the soil formed by its deposition, becomes finer and finer. The finer the soil, the smoother is the exposed surface of a canal cut in it, and therefore the lower the coefficient of rugosity.

It may further be noticed that the existing Sind Canals are seldom designed on modern methods, or have the most satisfactory alignments and cross-sections, all which affect the value of "N." Nor are many of them maintained in that excellent order which is assumed to be a *sine qua non* of the working of the proposed new canals. Hence, results which have actually been obtained in existing Sind canals, will certainly be attained, or exceeded, in the new canals. The following table gives a few actual results obtained in Sind. All the experiments quoted have been carried out by selected, trained officers, with specially designed arrangements to ensure accuracy. It will be seen that, contrary to Mr. Woods' assertion that in practice, the value of "N" is not likely to be so low as 0.02, it is found very often, *in practice, to be much lower* than 0.02. The results quoted below provide ample proof that it is perfectly safe and reasonable to assume a value of 0.02 for large channels in Sind, maintained in good order, and designed to correct hydraulic sections. For the smaller channels—everything carrying less than 200 cusecs—the value of "N" has been assumed in the Project as 0.0225 whereas actuals in Sind show that, even in these small channels, the value is often as low as 0.017, in fact, even lower values are obtained.

Some selected results of observations for values of "N" in Sind Canals in the 3 years 1916-1918 are given below. These canals have fairly good sections.

Canal and place of observation.	Date,	Mean Velocity.	Discharge.	"N"
Discharges over 2000 cusecs.				
Western Nara New Akil Mouth Mile 0/1	24-6-1917	3·62	3946	·015
Do. do.	16-7-1917	2·72	2568	·016
Do. do.	30-8-1916	3·73	5505	·021
Sukkur Canal Mile 18	15-7-1916	3·58	2764	·016
Dad Wah Mile 11/3	27-7-1916	3·58	3601	·015
	14-8-1916	3·66	3514	·013
	27-7-1917	3·30	3315	·016
Discharges between 1000 and 2000 cusecs.				
Colonel Fife's Channel	18-7-1918	3·06	1750	·019
Do. do.	27-8-1918	3·22	1864	·019
Pritchard Canal	31-8-1917	2·69	1297	·019
Do. do.	10-8-1916	3·40	1853	·019
Desert Canal	14-8-1917	3·53	1698	·018
Dad Wah Mile 50	8-8-1917	3·14	1333	·015
Do. do.	9-10-1917	2·64	1066	·016
Unhar Wah Mile 5	1-8-1916	3·30	1782	·017
Mithrao Canal Mile 27	15-7-1916	2·58	1112	·019
Do. do.	11-8-1916	3·25	1420	·017
Nasrat Canal	22-8-1916	2·75	1321	·015
Do. do.	3-9-1916	2·87	1313	·019
Discharges between 100 and 1000 cusecs.				
Fuleli Escape at 1100'	3-2-1917	1·85	426	·017
Do. do.	7-3-1917	1·59	441	·021
Jamrao Canal Mile 85	31-5-1916	2·08	501	·020
Do. do.	15-7-1917	2·20	548	·019
Amarji Branch Mile 12	31-8-1917	1·92	114	·018
Do. do.	7-8-1918	1·63	87	·019
Jamrao West Branch Mile 3/4	27-3-1918	1·47	378	·022
Dad Wah Mile 52	12-9-1917	2·48	998	·019
Shadi Wah taki 12	30-7-1918	1·69	192	·018
Do. do.	26-9-1918	1·65	156	·016
Mithrao Mile 45	3-2-1919	1·24	160	·021
Rajwah ex Western Nara 0/4	23-7-1918	2·09	345	·020
Do. do.	23-8-1918	1·73	225	·019
Mahi Wah Mile 16	17-6-1918	2·16	471	·018
Do. do.	15-8-1918	2·10	321	·016
Channel No. 1 ex Sind Canal	19-7-1918	2·09	164	·019
Do. do.	28-8-1918	2·29	186	·018

2. SILTING OF CANALS PROBABLE.—Mr. Woods' arguments in this section depend on the accuracy of his assumptions in the preceding section. As these have been shown to be inaccurate, there is no need to discuss the hypothetical case he is arguing.

It may be noticed however that he says "In assuming that Kutter's 'N' for their canals will be so low as 0·020, the authors of the Project have been guided probably, mainly by a desire to keep down the cost of the canals on paper. They rest this figure on an Inspector General of Irrigation's order, dated January 1907, which, however, was superseded by a subsequent order issued in the Punjab by the same authority."

The order of the Inspector General of Irrigation (Sir John Benton) fixing the value of "N" as 0.020 for the Sukkur Project applied solely to Sind, and was based on information he had collected of actual conditions in Sind. It was never superseded in the case of Sind by any other order. The change of orders for the *Punjab canals* is quite another matter, of which we have no knowledge, but if 0.02 is the suitable value for Sind, it is pretty obvious that a higher value is required for the Punjab with its coarser soils and silts.

As regards the desire of the authors of the Project, to keep down the cost on paper, we do not know Mr. Woods' methods of preparing a project, but the methods adopted for the Sukkur Project are clearly explained in Volume V. These were, to design the canal on scientific principles first carefully decided on, and to find its cost *afterwards* by estimating at rates, similarly decided on, before the cost of the scheme was known. Possibly Mr. Woods reverses these methods.

3. LOSS OF "HEAD" IN ENTRY.—Mr. Woods states that "in the summer the river will be flowing past the canal head, at right angles to the direction of the canal, with a mean velocity of 6 or 7 feet per second. In order to enter the canal the current will have to swing round through a quadrant; it will strike the piers of the canal head obliquely, and the disturbance set up will be such that the loss of head in entry cannot safely be put at less than, say, 0.7 foot."

The mean velocity of the river over the Barrage floor will only be 6 or 7 feet per second, when Bukkur reads more than 12 feet, and when the natural level, plus afflux, at the Barrage will be 195.0 or more. Under these conditions the difference between Full Supply Level in the Canals and the level in the river will be as shown in the table below, from which it will be seen that the minimum drop into any canal is 0.8' at the Eastern Nara Head, and in the other canals varies from 1.0' to 2', so that it is immaterial whether the loss of head in entry is 0.3' or 0.7'.

Canal.	R. L. of river at Barrage.	Full Supply Level of Canal.	Difference of level.
			Feet.
Rohri Canal	195.0	193.0	2.0
Eastern Nara Canals System ..	"	194.2	0.8
Khairpur Canals	"	193.5	1.5
North Western Perennial Canal ..	"	193.5	1.5
South Eastern Perennial Canal ..	"	193.5	1.5
Central Rice Canal	"	194.0	1.0

At all times when there is no head to spare, the Barrage gates will be regulating the level of the river, and the velocity in the approach channels can be kept as low as desired, usually about 3 feet per second. Under these conditions the loss of head in entry will not exceed 0.3' as designed.

DURATION OF EXECUTION OF THE PROJECT.—Mr. Woods says it seems clear that it will take much longer than 12 years to complete all the Sukkur Project Canals, whose aggregate head discharges amount to 42,600 cusecs, when it took 12 years to construct the Lower Chenab Canal, and 12 years to complete the combined Upper Chenab and Lower Bari Doab Canals which have a head discharge of 11,700 cusecs. He omits to mention that in the latter case, the Upper Jhelum Canal, having a head discharge of 8,500 cusecs, was being simultaneously constructed, *i.e.*, the whole Triple Canal Project. The following extract from pages 60 and 61, Volume V of the Sukkur Project Report, explains the grounds on which the estimated expenditure was calculated :—

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Page 726.

“ The programme of construction of all works has been limited to give a total expenditure not exceeding 171 lakhs per annum, for works only, or 209 lakhs including establishment and tools and plant.

“ On the Triple Canals Projects in the Punjab the maximum expenditure was 144 lakhs per annum. Considering that all rates are now about 33 per cent. higher than they were at the time these projects were carried out, the present equivalent expenditure would be about 192 lakhs per annum.

“ As the Barrage Canals will be spread over a much greater area than the Triple Canals, (about 72 lakhs of acres against 40 lakhs of latter), and much of our work will be in partly developed country, where food and water and other amenities are readily available for imported labour, it is assumed that such progress is possible.”

It must be further noted that it is proposed to use mechanical excavators for all the large channels, and probably on many of the smaller ones. These machines have completely proved their reliability and suitability for such work in Siam and the Sudan, when operated by native labour. Apart from the fact that they compete very definitely in cost of excavation, they have the very great advantage, that they require very little manual labour to serve them, so that one machine will replace hundreds of coolies. Similarly stone-cutting and dressing machinery will be extensively used at the head-works, and will replace the greater proportion of the skilled and unskilled labour required for ordinary hand-dressed stone-work, and enable great quantities of stone to be handled in far less time than it could be done by the largest practicable collection of manual labour.

On the Triple Canal Project the only mechanical excavators used were steam shovels in the Mangla Cut of the Upper Jhelum Canal. The conditions at this place were extremely severe—a cutting 1,500' long with a maximum depth of 110' through indurated clay and shingle. On the Sukkur Project all excavation will be in agricultural soil, and in no place exceeds 18' in depth, only a short length being of such depth. On the Lower Bari Doab and Upper Chenab Canals, Lubecker Conveyor Excavators were tried, but proved to be quite useless and had to be scrapped. This is not a suitable type of machine for canal excavation

in India. The drag line excavators, since used in Siam and the Sudan, have proved thoroughly satisfactory, while they are universally employed in the United States of America. It is with the aid of such machinery of the very latest pattern, and thoroughly proved capacity, that the programme of construction has been worked out for the Sukkur Project. As is shown in the preceding extract, the maximum annual expenditure will be only 209 lakhs per annum, or less than 10 per cent. more than the maximum annual expenditure actually made in the Punjab.

The additional cost of plant, as added by the Government of India, though increasing this annual expenditure, makes no increase in the amount of work to be done, or the labour required. The simultaneous construction of other great works in other parts of India, will add no difficulty in obtaining the necessary machinery, and, on the contrary, will simplify the obtaining of spare parts, and expert advice, from the makers, since with the opening of all these works it will pay the makers to open branches in India. They are already arranging to do so.

Gross Revenue Receipts.

Mr. Woods' remarks, in the first paragraph of this appendix, Appendix F are based on the inaccurate assumptions in his previous sections, which have already been disapproved. It is true that no deductions from Revenue have been made on account of Kharaba remissions, but this is not usually done in Project estimates. It was not done in the case of the Punjab Triple Canal Project, nor in the Dr. Summers' 1919 Project for the Rohri Canal, and there are no orders to this effect in the Public Works Department Code instructions for the preparation of financial forecasts. As to remissions under Tenancy Rules, no such rules exist in Sind, and the assessment is a consolidated one for land and water.

Mr. Woods goes on to work out ingenious calculations to show the present average rate of assessment in Sind, and the future average rate after the Barrage Project comes into operation. But why all this ingenuity, when actual present and proposed rates are already clearly known? The present average rate of assessment is considerably higher than the Rs. 3 per acre calculated by Mr. Woods, but owing to the very heavy remissions, now necessary, on account of the fluctuating and uncertain water supply, the gross revenue actually received from crops is reduced to this low figure. With the new canals, having a guaranteed supply, there should be no remission on account of deficiency, or excess, of water.

Mr. Woods says it will not be practicable to increase the rate of assessment on the existing irrigation so suddenly.

Why not? If the water supply is suddenly improved and guaranteed, surely the cultivator can afford to pay the increased value of this supply as soon as his improved crops have been reaped.

In any case these new proposed rates of assessment, and increased areas of crops, have not been decided by the engineers designing the scheme, and preparing the financial forecast, but are the proposals of expert Revenue officers with long experience of Sind and of its crops and people.

Mr. Woods goes on to state the *average* water surface levels of the Indus at Sukkur, and attempts to show that the new canals will give lower levels than these present *averages*, and therefore that they confer no benefits on the existing rice lands.

Now to start with, the principal Rice Canals in the Barrage Zone are the Ghar, and the Western Nara, on the Right Bank, and the Thar and Mithrao ex. the Eastern Nara, on the Left Bank. The two canals on the Right Bank take off the river 60 miles below Bukkur, and the average river levels he gives for Bukkur do not therefore apply to them. But these levels do apply to the Eastern Nara System, and Mr. Woods says the Barrage will affect no improvement in this. Yet we know that in spite of these average levels, relied on by Mr. Woods, the Eastern Nara System

suffers badly in almost every alternate year. This canal actually gets full supply when Bukkur reads about 12 ft., or with water level at Bukkur 196.5. By means of the Barrage and the new head to the System, we are able to give a corresponding level all through the year. It will be seen from Mr. Woods' own figures, that in June the average level is 2 ft. below that required, in July $\frac{1}{2}$ foot, in August is 1 foot higher than required (and this excess level is useless, and is shut out of the canal), and in September is 2.1 feet lower than required. These *average* levels would not serve to give a good supply, even if they were constant throughout the months, and were not *averages*. Any excess above the average will be useful in the months June, July and September, but the average is made up of excesses and deficiencies, and these deficiencies will most adversely affect the canal and its cultivation. What is needed for a canal is not a good *average* river level, however high, but a *constant* level at sufficient height to give full supply to the canal. This is what the Barrage will ensure, with the resulting certainty of irrigation.

Mr. Woods says that if the rice crop can afford to pay the proposed rates, it can afford to do so now, whether the Barrage be built or not. But the present rates of assessment take into account the present uncertain and fluctuating water supply, and the consequent poverty of the crops. The proposed rates similarly take into account the future certainty and regularity of supply and the consequent good crops to be relied on.

Mr. Woods says the amount of the increased assessment cannot fairly be credited to the Barrage Project, as an asset that can be created only by means of the Barrage. But constancy of level, and regularity of supply, even in June to September are assets that can only be created by the Barrage; and hence the increased assessments are properly credited to the Barrage Project.

Working Expenses.

Mr. Woods quotes the figures of working expenses of various Punjab Canals to show that the estimate in the Sukkur Project, *viz.* Rs. 1.25 per acre irrigated is insufficient. Actually three of the canals he quotes give a *lower* rate for working expenses than that estimated for in the Sukkur Project. Mr. Woods gives no reasons for disregarding these figures of actual cost per acre irrigated, but adopts instead a method of his own, which better suits his purpose, and which is illogical, and has never previously been adopted by Government. He estimates his rate on the basis of capacity of canal at head, irrespective of the length of the canal, the cost of its head works and cross drainage works, the intensity of irrigation supplied by it, and the length of its distributing system.

Appendix G.
Page 729.

It is obvious that all these points must be taken into consideration in estimating the cost of maintenance. Now examining the figures given by Mr. Woods in his table on page 729, the first canal shown is the Western Jumna. This is not a suitable canal with which to compare the working expenses of a modern perennial system, as is shown by the following extract from Mr. Woods own report on it, taken from his report on the Thal Project.

“THE SIRSA BRANCH CANAL.—The alignment of the Sirsa Branch of the Western Jumna Canal is a case in point, illustrative of this tendency. Mr. Higham, in his note on the Completion Report of the Sirsa Branch, wrote as follows :—

“The first scheme for a Branch of the Western Jumna canal to Sirsa was prepared in 1870 by Mr. J. C. Hammer. The idea of this extension was abandoned for the time, until the more important and urgent work of remodelling the Western Jumna Canal had been completed. In 1884 the matter was revived, and orders were issued for the necessary detailed surveys and estimates which were submitted by Colonel Palmer in 1887. This estimate was sanctioned by the Secretary of State in 1888. The project alignment closely followed that proposed by Mr. Hammer in 1870, and has been itself very closely followed in execution. It may, indeed, be noted with satisfaction, that on all points, alignment, capacity, area commanded, date of completion and capital cost, there has been a close agreement between the final results and the proposals of the sanctioned estimates.”

“It is easy for us to see now, on inspection of contoured maps, that the alignment of the Sirsa Branch is for the greater part very faulty. Its offtake from the Western Jumna Canal should have been located at least 10 miles further upstream than the site at which it was offtaken in practice ; and its alignment, along the most marked water-shed of the country, should have crossed the present alignment in order to connect with the lower half of the Hansi Branch ; the Upper part of the latter being scrapped.

“ The close agreement of the design and cost of the completed canal with the corresponding provisions in the project forecast was only achieved by a mechanical adherence to a faulty and ill-digested design, based on hasty reconnaissance surveys carried out 17 years earlier, and a temporary administrative satisfaction was secured, at a cost of a real fiasco of engineering science.

“ The Sirsa Branch Project of 1887 should have involved the scrapping of the 30 mile reach of the Western Jumna Canal upstream of Indri, as well as of the Hansi Branch, both of which defective canals were legacies of the Dark Ages of Mughal rule in India ; and the engineers of 1887 might have realized this if they have not been tempted to follow the 1870 Project as a matter of immediate convenience.”

Next, the Sirhind Canal is crossed by extremely heavy floods, and has many very large cross drainage works. It irrigates a very low proportion of its commanded area, only 30 per cent., so that the distribution of water must be extremely expensive and uneconomical, owing to the length of channels required. It is fed by a large weir at Rupar, with expensive training works, the whole cost of which has to be borne by this one canal.

The Upper Bari Doab Canal is one of the older perennial canals. It is supplied by a weir at Madhopur on the Ravi, the whole cost of which has to be borne by this comparatively small canal, and much money has been spent in remodelling its regulator. As will be seen however the cost of maintenance is only Rs. 1·24 per acre assessed (or less per acre irrigated) and is slightly less than the Sukkur Project Estimate of 1·25 per acre.

The Lower Chenab Canal is a fairly modern system, but has to bear the whole cost of the weir and river training works at Khanki. These works are extremely expensive to maintain, and the weir and canal regulator have twice been remodelled. Nevertheless the cost of maintenance of the whole canal and headworks comes to only Rs. 1·0 per acre of assessed cultivation (and less per acre irrigated).

The Lower Jhelum is another fairly modern system but has to bear the whole cost of the weir and river training works at Rasul for a small canal of only 4,000 cusecs capacity. The cost of maintenance is Rs. 1·2 per acre assessed (and less per acre irrigated).

These last three canals give some comparison with the conditions for the Sukkur Canals, though the latter will be designed on more modern lines, and will each bear only a share of the cost of one Barrage, with very little training works, while cross drainage works are light, and intensity of irrigation high, leading to economy in length of channels.

The Upper Chenab and Lower Bari Doab Canals are the most modern works in the Punjab and are in some ways comparable to the Sukkur Canals. But these canals require each a separate weir, one at Marala and the other a Barrage at Balloki. The comparatively high

cost of maintenance per acre assessed is probably due to the undeveloped state of the irrigation on them, and should improve when cultivation extends. This would appear to indicate that in the Sukkur Project a higher rate for maintenance should have been taken during the years in which cultivation was extending. But the margin of profit and productivity is so wide, that it can easily bear an increase of 50 per cent. or more, without affecting the final results of the whole scheme.

Mr. Woods' method of estimating the cost of working expenses bears no relation to the actual facts of the proposed canals and cannot be checked in any way. Finally he says that "the Eastern Nara Channel with 135 miles length of Supply Channel in the conditions of a natural river will require enormous expenditure on maintenance and improvements, as part of a perennial canal system." This is not so. Apart from the maintenance of the new banks to be made along it, there will be practically no maintenance necessary. It has served as a perennial channel for the past 60 years, under much more difficult conditions than it will have after the Barrage construction, and nothing has been spent on it except in clearing the head reach which becomes silted, owing to the lack of a Barrage to provide means of scouring the river silt from its head. When this is provided as proposed, and the water level kept completely under control, the natural channel will give no trouble and need practically no maintenance.

Finally it may be pointed out that in Mr. Woods' own recent Project, for the Thal Canal, he has provided for working expenses at Rs. 1.5 per acre. This canal is provided with a weir for its sole benefit, will have to be protected from attacks of the river in the first nine miles of its length, flows through a country of blowing and drifting sand, from which it will be difficult to keep the channels free, and the channels must be lengthy and extravagant since they are to irrigate only 37 per cent. of the gross area, in which the culturable area lies in scattered patches.

**Replies to the Discussion and Correspondence on
Mr. Woods' papers.**

Page 730.

THE CHAIRMAN (LORD LAMINGTON)—The only point calling for mention is the concluding sentence.

Lord Lamington said it was impossible for him to understand why one of the biggest engineering projects (The Sukkur Barrage) ever placed before the world should be begun before the far less costly project (The Rohri Canal).

It is *not* proposed to build the Barrage before the Rohri Canal. This is the wrong impression which Dr. Summers has sedulously fostered.

Both works are to be commenced simultaneously, and as soon as the Barrage is completed, a large portion of the Rohri Canal (and of all the other canals) will be ready to make use of it, to improve and extend the present irrigation. It would be useless to have all canals completed by the time the Barrage was ready, as the people and the land would not be ready to fully utilize it. The progressive completion of the canals, after the completion of their first sections, (simultaneously with the Barrage completion) will give time to proceed with the disposal of new lands, and for the people to become accustomed to the improved water supply, and to improve their methods to suit it.

Page 730.

LORD SYDENHAM.—It would appear that Lord Sydenham has seen only the opponents' version of the project, and has no means of checking their statements. These are admittedly damaging, but are in many cases untrue, and in others are misrepresentations of the facts. When his Lordship has seen the answers to their criticisms, he will be in a better position to express an opinion, and will probably modify his present dislike to the Project.

SIR LIONEL JACOB—Admits that his opinions are based "on information given by Dr. Summers" and on the further statements made by Mr. Woods in his lecture. It is to be regretted that Sir Lionel did not have an opportunity of studying the actual proposals of the Project himself, and that he has been unable to discuss it with anyone knowing, and able to explain it, from the point of view of the designers. It can hardly be doubted that so distinguished an engineer will be glad to study the question from both sides, as he will now be able to do.

As all his remarks are based on their statements, which have now been answered in this note, there is no need to deal further with them.

MR. SIDNEY PRESTON.—There is nothing to comment on in these remarks, except that Mr. Preston very wisely admitted that he was not in a position to comment on a scheme which he had not seen. It is to be regretted that other eminent engineers, with reputations to lose, were not equally honest and careful.

He drew attention to the fact that there was no one present at the meeting to explain the case in favour of the Project.

DR. T. SUMMERS—It is hoped that “the examination” (of the Project) “in the hard light of facts”, which has been attempted in this note, and in that answering Dr. Summers’ own paper, will satisfy his desires as expressed.

It is perhaps worth recording that we have the best of reasons, for believing that Sir Sydney Crookshank was not responsible for the article in the “*Pioneer*,” which Dr. Summers attributes to him, and which was headed “From our own Correspondent.”

COLONEL SIR C. YATE, BT.—Stated that Mr. Woods “had worked on the Indus and its tributaries for the best part of his life.” This is correct, but requires to be amplified by adding that all this experience was in the Punjab. Mr. Woods has had no experience whatever of the Indus, or of the local conditions, *in Sind*, with which the Project he criticises is concerned.

MAJOR GENERAL BERESFORD LOVETT—Stated that the vagaries of the Indus existed wherever the banks were not solid rock. This is not strictly correct. If the records and surveys of the river in Sind are studied, it will be found that there are two places where the banks never alter. One is the stretch of 3 miles below the rocky gorges at Sukkur down to the proposed Barrage site. In the last two miles of this reach the banks are of clay.

The other place is at Kotri where the hills approach both sides, but the actual banks are of hard clay. The great railway bridge at Kotri, completed in 1900, has no training works whatever.

MR. WOODS—Said he would welcome any authoritative attempt to meet his criticisms.

It is hoped the attempt made to do so in this note will satisfy him.

SIR JAMES WILSON—Admits that he has not seen the project, and is basing his remarks on the information given by Dr. Summers and Mr. Woods. He then goes on to say that, in his time, there was a tendency to consider irrigation schemes piecemeal; and it may be pointed out that this is exactly the process adopted by Dr. Summers and Mr. Woods in their alternatives to the Sukkur Project.

He further suggests that a very large contoured map should be made, including not only the whole Punjab, but the whole Indus Valley down to the sea, and a great part of Rajputana; and that the limits of command, from the Indus and its tributaries, be marked on this map, irrespective of Provincial and State Boundaries. And that it should be considered what an engineer could best do with the water available, if he had a clean slate to work upon. The culturable commanded areas in the Punjab, Sind, and Bahawalpur are already known, and marked

on maps ; and projects have been, or are being, formulated to make the best possible use of the water available on these areas. With the exception of a few hundred thousand acres in the north of Bikanir, none of the rest of Rajputana can be commanded by any possible canal from the Indus or its distributaries. This was pointed out in reply to a similar suggestion made by Sir J. Wilson in May 1901. In forwarding the Project Estimate of the Triple Canal Project to the Government of India in August 1904 Sir John Benton wrote—

“ However it may be observed that the *untold millions of acres* of irrigable desert land are purely imaginary, being uncommanded, except for a narrow belt of ground, in foreign territory, lying alongside the Bahawalpur inundation canal tract, a great part of which is covered with sandhills.”

This part of Bahawalpur will be irrigated by the Sutlej Valley Project, as will also be a part of the commanded area in Bikanir. The balance of the commandable area in Bikanir will be irrigated by the Bakhra Dam Project, if this project ever eventuates. Sir J. Wilson appears to deprecate the encouraging of large numbers of people to migrate from their homes and settle in new villages.

It may be pointed out that colonization forms no part of the development of the Sukkur Barrage Project. We thoroughly agree with Sir J. Wilson's remarks with regard to water rates, and the desirability of increasing them. These remarks are diametrically opposed to the views expressed by Mr. Woods in his criticisms of the Sukkur Barrage Project.

Sir J. Wilson speaks of the great underground flow of seepage water, from the Punjab irrigated tracts, into the Indus at Sukkur. It is not clear how this flow (if it exists) can get to the Indus at Sukkur. To do so, it must first cross all the five tributaries of the Indus, which each forms the drainage lines of their surrounding country in the cold season. The Sutlej Scheme includes a Barrage on the Punjnad, *i.e.*, below the confluence of the five rivers, and this Barrage is designed to pick up all the seepage water of the five rivers. The only river which will be free to bring down to Sind any collection of seepage water is the Indus. The only irrigated tracts whose seepage is free to flow to the Indus in Sind are those to the south of the Sutlej. Any seepage from these has to pass under the Rajputana desert, and might possibly meet the Indus above Rohri, where the river, being deltaic, and its bed above the level of the sub-soil water table, it is evident that seepage cannot flow into it.

But Mr. Woods, in his report on the Thal Project, says that the levels of the surface of the sub-soil water table under the Thal are generally lower than the bed level of the Indus at points on the same parallel of latitude. It is therefore obvious that there can be no seepage into the Indus above its junction with the five rivers. Below this point there

is also no seepage into the Indus, even under present conditions. This is evident from discharge observations which have been taken during the cold weather for the last 8 years at Mithankot (just below the junction) and at Sukkur. These observations show that the discharge at Sukkur, in the cold weather, is never greater than that at Mithankot, and is generally less, as shown in the table below :—

Month and Year.	Mithankot.	Sukkur.	Difference.
	Average monthly Discharge Cusecs.	Average monthly Discharge Cusecs.	Loss between Mithankot and Sukkur.
1915 February ..	64,678	59,571	5,107
March ..	80,290	67,194	13,096
November ..	76,733	56,333	20,400
December ..	52,548	36,677	14,871
1916 January ..	48,870	28,710	20,160
February ..	48,759	28,310	20,449
March ..	42,742	27,000	15,742
April ..	57,567	41,700	15,867
November ..	51,100	51,000	Nil.
December ..	39,226	37,161	2,065
1917 January ..	31,419	27,097	4,322
February ..	27,786	25,429	2,357
March ..	22,806	19,871	2,935
April ..	29,967	22,733	7,234
November ..	Not recorded.		
December ..	57,000	50,000	7,000
1918 January ..	47,000	42,000	5,000
February ..	37,000	35,000	2,000
March ..	64,000	60,000	4,000
April ..	1,47,000	1,43,000	4,000
November ..	Not recorded.		
December ..	39,000	28,000	11,000
1919 January ..	35,000	25,000	10,000
February ..	57,000	29,000	28,000
March ..	80,000	30,000	50,000
April ..	1,40,000	76,000	64,000
November ..	Not recorded.		
December ..	Do.		
1920 January ..	45,000	36,000	9,000
February ..	40,000	35,000	5,000
March ..	52,000	44,000	8,000
April ..	75,000	56,000	19,000
November ..	Not recorded.		
December ..	35,000	33,000	2,000
1921 January ..	32,000	32,000	Nil.
February ..	30,000	29,000	1,000
March ..	35,000	26,000	9,000
April ..	74,000	48,000	26,000

In 1911 a Committee, including, amongst others, Sir John Benton and Dr. Summers, considered the question of a possible avulsion of the river to the west, in connection with the then-proposal to construct a Barrage above the Sukkur gorges. It was unanimously agreed that, while an avulsion to the west had always been a possible occurrence, in the portions of the river from 0 to 5 miles, and from 12 to 18 miles, north of Sukkur, if certain precautions in the matter of training works, in connection with the then-proposed Barrage at the upper site, were taken, the river could not desert the gorge and make a detour to the west.

It has been shown, in the reply to Mr. Woods' lecture, that the construction of the Barrage below the gorges will make no alteration in present conditions; and therefore the danger of an avulsion is not increased, and is no greater than it has always been in the past. The maintenance of the river in its present channel will depend in the future, as it has in the past, on the efficient upkeep of the river embankment to the north of Sukkur.

Reply to Sir John Benton's letter to the Secretary of State.

Sir John Benton, like many other critics, is basing his opinion on the presentation of the case by its opponents only.

He says "I have read both addresses (*i.e.*, Dr. Summers' and Mr. Woods') very carefully, and, as far as the supplied data go, I am of opinion that the above conclusions are substantially correct."

All his remarks in the first 5 paragraphs of his letter are concerned with their statements, which have already been answered, and need no further comment.

With reference to the new site proposed for the Barrage, Sir John Benton says that "the London Committee never approved, accepted, or recommended any such site, and they must be entirely exonerated from all responsibility for the faulty Project of 1920." No one responsible for the Project has ever suggested that the London Committee were responsible for the selection of the new site of the weir. Dr. Summers is entirely responsible for such a statement. Paragraph 6.

The reasons for the preparation of the new Project, and for the selection of the new Barrage site, are clearly stated on pages 12 to 15 and 17 to 19 of Volume I of the Project Report.

Sir John says that if the barrage were located at the original site *above* the gorges, the dangerous Western low bank from 3.5 to 7.5 miles (above the new barrage site) would be fully safeguarded by the Western stone guide bank, built in connection with the Barrage; while with the new site for the Barrage, this stone guide bank will be omitted, and heavy expenditure will be required, for which no provision has been made in the estimate. Paragraph 7.

In the first place it may be pointed out that in the 1910 design for a Barrage above the gorge, the length of the western stone guide bank was only 4,000 feet (and of the Eastern guide bank only 3,000') which brings its upstream end to a point only $3\frac{3}{4}$ miles above the present site for the Barrage. It is difficult to understand therefore how it could safeguard the low western bank of the river from 3.5 to 7.5 miles (above the new site). See page 62,
para
Note 8,
Vol. IV of
1910 Project.

But in any case these guide banks were not provided as a safeguard to the river banks, but were necessary, and intended for ensuring, that the river should approach the Barrage normally, and to prevent it approaching the Barrage openings obliquely, from one side or the other, as the natural stream usually does at present.

These guide banks would not have protected the low western bank of the river, from miles 3.5 to 7.5, against erosion. Had such protection been considered necessary it would have had to be provided, as an extra to the 1910 Project, and could be similarly provided as an extra to the 1920 Project, if required. But even with the afflux which it was admitted would be created in great floods by the 1910 Barrage above the

gorges, it was not considered necessary to provide such protection in the 1910 Project.

It appears that on the 21st-23rd February 1911, a Conference was held in Karachi, attended by Sir John Benton, Dr. Summers, Messrs. A. Hill, W. L. Strange, G. McHarrison and Beale, at which the question of an avulsion was discussed; and it was decided that a stone armoured training work about 4 miles in length, upstream, in continuation of the right hand guide bank, should be constructed, in order effectually to obviate the river ever forming loops, nearly down to the Sukkur Canal; but no estimate appears to have been prepared and it was certainly not included in the 1910 Project which was submitted to the Government of India on 5th December 1910.

With the 1920 Barrage there will be no measurable afflux above the gorges in high floods, and no interference with, or obstruction to, the gorges: in fact the 1920 Barrage will in no way alter the existing conditions in the high flood season, so that, as no protection is now considered necessary for the low Western bank of the Indus, except the ordinary river embankments, nothing further is required with the 1920 Barrage.

No artificial guide banks are required to lead the water directly on to the present site of the Barrage, as the *permanent* river channel above it, whose clay banks are to be protected with stone, serve this purpose completely.

The new site therefore has this great advantage (beside many others) over the original site above the gorges.

Paragraph 7.

Sir John Benton says "the canal off-takes will be fed with turbid water, projected down at great velocity from the gorge, and it will be found impossible to keep them clear of heavy silt deposits." Now after leaving the gorges, the river water, which is there undoubtedly churned up, and heavily charged with silt, even in the upper films, has to travel a full 2 miles in a steadily widening and regular natural channel, until it reaches the Barrage. During this two miles travel the velocity is steadily reduced, until, at the Barrage site, it has fallen to its normal velocity, or slightly less, and forms a natural bar at the Barrage site; after which it usually divides into two or more channels, which meander along from side to side, within the natural high bank limits.

Before the water reaches the *Outfall section* (6,100 feet above the Barrage site and about 1 mile below the gorges) it has lost nearly all sign of the turbulence with which it leaves the gorges, and has settled down to a fairly steady, though rapid, stream-line flow; and the heavier silts, thrown into the upper films by the disturbance in the gorges, has begun to settle again to the lower films, or to roll along the bed. By the time the water reaches the Barrage site, normal conditions of steady flow have been practically restored, and all heavier silts have settled down to the lowest films of the stream. The conditions of the channel at, and for

a mile and a half above, the Barrage site are more favourable to steady flow, than in most lengths of the river throughout Sind, owing to the regular section, and almost straight reach of the natural banks in this stretch of the river, and to the entire absence of scour in the banks.

The conditions here are far more favourable in this respect than they are immediately *above* the gorges, where the river swings in sharp curves, and is constantly eroding its banks on one side or the other; causing whirls and eddies, and interfering with steady flow, and with the settlement of the heavier silts to the lower layers of the stream.

The quantity of water approaching the Barrage is the same as that approaching the gorges, and contains the same quantity of silt in suspension. If therefore the conditions of the stream at, and above, the new Barrage site are more favourable to steady flow than they are above the gorges, there is no reason why the silt contents of the upper films should not be even less at the Barrage site than above the gorges. Even at the *Outfall* section, which is less than half way from the gorges to the Barrage site, the silt contents of the river are found by actual measurement to be very little different to those of the water above the gorges, and in a good many cases the silt content is actually less at the Outfall, as the following table shows.

Unfortunately, hitherto, no silt observations have been taken at the new Barrage site, but it is certain the silt contents must be less here than at the Outfall.

Thus the conditions assumed by Sir John Benton in this paragraph do not actually exist. There is no question of locating the canal heads within a couple of miles of the site of active erosion. On the contrary, there will never be any erosion whatever for at least three miles above the canal heads—a most unusually favourable position for a canal head in Sind, Paragraph 8.

No erosion occurs now, under natural conditions, in this three miles, and to ensure that it never shall, the natural permanent banks are to be pitched with stone throughout. Sir John Benton speaks of the high velocities which obtain at the new site. The velocity of the river at the Barrage site is lower than the normal velocity, in the main stream of the river, in most stretches between Sukkur and Kotri, and is much lower than that at Kotri.

Secondly Sir John Benton may be correct in stating that, the prevention of silting in the Sirhind Canal was effected by the construction of training works, to prevent the erosion of the river banks 4 miles above the canal head. But it is generally understood, that what finally effected the cure of this silting, was the remodelling of the Head Regulator and Head-works of the canal, and the provision of a high raised sill.

Paragraph 9.

Sir John Benton says, because the raising of canal levels by 2½ feet, was just as feasible at the upper site, as at the new lower site for the Barrage, that therefore the demonstration of the economy of the new site completely fails.

But this demonstration of economy did not depend only on the raising of canal levels as assumed by Sir John Benton. The alteration of the site produces the following economies:—

- (a) The construction of the Barrage itself is cheaper at the lower site than at the upper site, at similar rates for work.
- (b) The Rohri Canal, and all Right Bank Canals, are three miles shorter from the lower site, without any loss of command.
- (c) The three miles of Canals saved, omits entirely the enormously expensive Supply Channel for the Rohri Canal, which would have had to be cut through solid rock. The estimated cost of this channel in 1910, excluding head regulator, was Rs. 47,04,000 or, at present rates, allowing 30 per cent. increase, would be Rs. 61,00,000.
- (d) The new site also avoids the very expensive and troublesome widening of the existing Eastern Nara Supply Channel in its first 4 miles, where the bed and lower portions of the cutting are in rock, and would have necessitated closing the canal for one or more cold weather seasons, thus losing all rabi crops on the Mithrao, Jamrao, etc. The cost of the extra length of the new head to the Supply Channel is far more than covered by this avoidance of all rock cutting and loss of crops: the widening of the remaining 8 miles of the existing supply channel (which is common to both sites for the same conditions of supply) can be done by dredger, without closing the canal, as it is all in soil below this point.

- (e) The portions of the Right Bank Canals omitted by the new site of Barrage would all have been in deep cutting, through very expensive land along the outskirts of the town of Sukkur. They would have required many expensive bridges over them, unless they were to restrict communications, and the growth of the town: and any tendency to percolation from the canals would have been detrimental to the drainage and health of the town.

The above savings are due *solely to the change of site* of the Barrage, and amount in the aggregate to a very large sum of money, and are independent of the raising of the full supply levels of the canals. This raising of the full supply level accounts for a further great saving, but this latter saving could equally be made in connection with a Barrage at the upper site, as stated by Sir John Benton. It was not proposed in 1910 Project, because the Rohri Canal did not need it, and it was not realized at the time by those designing the Barrage, what a large saving could be effected by it.

Sir John Benton says the raising of the Full Supply Level of the Canals, by $2\frac{1}{2}$ feet at the Barrage, will cause an extra height of from 4 to 5 feet in the water level of the River, at the point where an avulsion is likely to occur,

Paragraph
10.

The point referred to is between miles 3.5 to 7.5 above the Barrage site.

It has been shown in the note replying to Mr. Woods' lecture, that it will not be necessary to regulate the river level after it reaches 194.5 at the Barrage *naturally, i.e.*, when Bukkur reads 12 feet, so that the Barrage will affect no change in natural river levels for any level above 12 feet on Bukkur gauge. As the natural river rises as high as 17.9 feet on Bukkur, the Barrage does not increase any possible existing danger to the low river banks between miles 3.5 to 7.5 above its site.

At the times when the Barrage will raise the natural level of the river, this natural level will always be lower than 12' on Bukkur; and the level to which the Barrage will raise the water at any point above the gorge, will always be less than that given by a natural river with 12' on Bukkur, so that it imposes no dangerous conditions on the low banks.

It cannot be understood how Sir John Benton estimates that raising the river level to R. L. 194.5 at the Barrage, (*i.e.*, equivalent to 12 feet at Bukkur), will cause an *extra* height of 4 to 5 feet, in the water level at a point 3.5 to 7 miles upstream, and thus add any danger to the low banks there. The raising of the water level at Barrage, to 194.5, could only raise the water level at this dangerous spot by 4 to 5 feet, at such times as the natural river was very low, about 3.5 feet, or lower, on Bukkur, and there can be no question of it being dangerous to raise the level by 5 feet at such a stage, since the natural river is often 14 feet higher.

The remainder of Sir John Benton's letter needs no comment.

**Dr. Summers' Articles in the "Pioneer" of
6th and 7th January 1922.**

ROHRIMEDE, COLINTON, EDINBURGH,

14th December 1921.

THE SUKKUR BARRAGE PROJECT.

SIR,

I hope that you will, from a sense of fairness, and of the public interest in the subject, afford me space in your columns to reply to certain articles which appeared in the "*Pioneer Mail*" of 19th August and 16th September last, supporting the views of the advocates of the Sukkur Barrage Project of 1920. These articles were obviously supplied to the '*Pioneer*' by Sir Sydney Crookshank, K.C.M.G., Secretary to the Government of India in the Public Works Department; but, since Sir Sydney is not an Irrigation Engineer, it is evident further that he has been merely the mouthpiece of propaganda in favour of the 1920 Barrage Project engineered by Mr. Gebbie, now Inspector-General of Irrigation in India, and formerly Chief Engineer for Irrigation, Bombay. I trust that your courtesy will now permit me to reply to the offensive personalities as well as to the gross inaccuracies and misrepresentations contained in the articles. I may add here that this reply has been delayed by my illness, an illness from which I have not yet fully recovered.

2. In articles appearing in the "*Pioneer Mail*" of the 19th August 1921, it was argued that experts in England ought to be discouraged from 'sitting upon' schemes "carefully framed by experts on the spot" (*i.e.*, India); that Home experts "are too often retired officers, who not only have lost touch with modern conditions in India but too often bring to bear on their enquiries cranks and prejudices which perhaps they were unable to air successfully in India itself."

It was further contended by the Simla propagandists, that criticisms of the Sukkur Barrage Project were inspired by the "natural desire of the retired official to breathe once more the eastern atmosphere in the leisurely chambers of the India Office.....accompanied with prejudicious relaxation in the neighbouring club or theatre."

I need not comment on the irrelevance and personal offensiveness of remarks such as these, exhibiting, as they do, on the part of the Simla officials who inspired them, a degree of personal rancour and official impropriety, which ought to shake the confidence of the Government of India, and of the Indian public, in the impartiality of their official judgment.

3. In the "*Pioneer Mail*" of the 16th September 1921, there appeared an elaborate and lengthy defence of the Sukkur Barrage Project of 1920. This composition bristles with inaccuracies and misrepresentations which I propose, with your kind permission, to deal with *seriatim*; but before doing so I have a few comments to make on a

leading article entitled : " A Mare's Nest at Sukkur," which appeared in the same issue of the "*Pioneer Mail*." In this article the Sukkur Barrage Project of 1920 was described misleadingly as a " canal scheme which has had the warm approval of the three Inspectors-General of Irrigation." The fact is that this Project was prepared by the Chief Engineer, Bombay, in collaboration with Mr. (now Sir) Thomas Ward, Inspector-General of Irrigation. After the project had been approved of by the Governments of Bombay and India, respectively, on the advice of these officers, Sir Thomas Ward retired from the service and Mr. Gebbie was appointed Inspector-General. In this way the project was safeguarded from adverse criticism by any Punjab Engineer who might have succeeded Sir T. Ward, and Mr. Gebbie was able to claim two Inspectors-General for the project ; but who is the third referred to ? Neither Sir John Benton nor Sir Michael Nethersole can be claimed as approvers of the Gebbie-Ward 1920 Project, but it is sufficient to cite the fact that the date of its preparation, 1919-20, shows that no expert advisers of the Government of India except Sir T. Ward and Mr. Gebbie have been given a chance of examining it professionally.

4. Turning now to the defence of this project, which appeared in the "*Pioneer Mail*" of 16th September it will be convenient, if I reproduce below, in italics, the various arguments, or assertions, one by one, together with my rejoinders thereto in ordinary print. It may be convenient for reference to distinguish these extracts by capital letters.

A.

" Sind, at present depends for its irrigation upon Canals from the Indus, the supply of which canals fluctuates daily with the rise and fall of the water level in the river, there being no means of regulating this level artificially as is done in the case of all the other great canals of India."

Sir Sydney Crookshank appears to be unaware that the *rabi* water supply of the great Punjab Triple Canal Project is obtained principally from the river Jhelum at *Mangla*, without the help of a weir or barrage across the River. The Upper Jhelum Canal, the main winter source of water supply of the Triple Canal Projects, is an inundation canal, in as far as it has no barrage, but it is also a perennial canal, and the conditions existing at Sukkur on the River Indus are more favourable than those at Mangla, on the River Jhelum, for the construction of a successful Left Bank Canal of this type.

B.

" The object of the Barrage Project is to afford the country irrigated an assured supply throughout the whole year.

" This is to be accomplished by constructing a barrage across the Indus below Sukkur, where the river passes through a deep gorge."

5. This object can be assured, as far as the tract to be irrigated by the Rohri Canal is concerned, without going to the enormous expense of building the barrage before it is required for the other canals which it is to serve. The Rohri Canal as stated in Appendix A of the 1920 Project Reports "*is the greatest irrigational want of the Province at present; it is the almost universal opinion that this canal should be started first.*"

Out of the three Inspectors-General of Irrigation who have dealt with the Sukkur Barrage Projects since 1906 Sir Thomas Ward (1916-20) is the only one who has advocated the building of the Barrage first, and its completion several years before the completion of any of the canal systems which it is to serve. Sir Michael Nethersole (1912-16) was decidedly against this procedure and even admitted the possibility of *completing the Rohri Canal before the weir* "*whereby the project may be relieved of inflated interest charges.*"

C.

ESTIMATED COST.

4. "*The total cost of the scheme is estimated at Rs. 18 $\frac{2}{3}$ crores of rupees, of which the barrage accounts for about 5 $\frac{2}{3}$ crores and the canals for Rs. 13 crores.*" "*The ultimate annual net revenue forecasted as obtainable from the projects after paying working expenses, is Rs. 194 lakhs, which represents a return of 10 $\frac{1}{2}$ per cent. on capital. This is the return from water rates alone, but a further large increase in general revenues may safely be reckoned upon from the area of 3 $\frac{1}{2}$ million acres of waste which will be brought under cultivation. There will be increases on this account under practically every head of revenue such as railways, customs, stamps, excise and the like, not to mention the addition to the country's wealth owing to the production of land at present barren of crops to the value of Rs. 25 crores per annum.*"

6. Here it is stated that the cost of the Barrage will be 566 lakhs of rupees. In Volume I of the Report on the Project, however, the cost of the Barrage is estimated at 342 lakhs only.

In reply to my enquiry, the India Office has informed me that the discrepancy is mainly due to an addition of 255 lakhs, made by the Government of India, to the estimates of the cost of steel work, etc. Other items which account for this great addition are iron-work and plant, as stated in Sir S. Crookshank's note. Here then we have a sample of the haphazard way in which the estimates have been prepared. The 342 lakhs estimate presumably prepared under the direction of Mr. Gebbie was recommended to the Government of India for sanction, but possibly owing to pressure of other work Mr. Gebbie may not have noticed the errors in the estimates. What confidence can the Govern-

ment of India place in estimates, to one of which, amounting to only 342 lakhs, a sum of 255 lakhs has to be added for errors in estimating ?

I will return to this question of the reliability of the Project Estimates of capital cost later on, but meanwhile pass to other considerations.

7. Sir S. Crookshank claims that the 1920 Project will yield a net revenue of 194 lakhs of rupees, which represents a return of 10½ per cent., but he omits to mention that, even according to Sir Thomas Wards' own calculations, this return will not be obtained till 29 years after completion of work, when according to the P. W. Code the period should be 10 years, the test by which all productive public works have been gauged. Let me proceed to show the unreliability of the financial calculations on which the forecasts for this project are based.

(a) RATE OF PROGRESS OF CONSTRUCTION.—In the Sukkur Barrage Project it is calculated that the construction of the Barrage will be completed in 6 years and that the entire project, including canals, will be completed in 12 years. This rate of progress is impracticable. Taking into account the sum of 255 lakhs added to the estimate of cost of the Barrage by the Government of India, it means that the expenditure during the first 6 years will amount to 1225 lakhs of rupees, or an average of 200 lakhs per annum.

On the Punjab Triple Canal Project the expenditure during the first 6 years amounted to only 376 lakhs, or an average of 63 lakhs per annum. Conditions were far more favourable, 15 years ago, to rapidity of engineering construction than they are now. The labour supply had not been affected at that time, as it has been since, by the Great War, by the terrible Malaria epidemic of 1917, by the equally terrible epidemic of influenza in 1918, or by the vastly increased demand for agricultural labour consequent upon the spread of irrigated cultivation under the Triple Canal Project. Moreover the Triple Canal Project had no rival in the engineering field, and was able to draw on the entire surplus labour forces of the Punjab, United Provinces, North-Western Frontier Province, and Afghanistan. The Sukkur Barrage Canals Project will have to compete, in its demand for labour, with the great Sutlej Valley Canals Project of the Punjab (estimated to cost about 1200 lakhs), and with irrigation projects of corresponding magnitude in progress in the United Provinces.

It is unreasonable to suppose, therefore, that the rate of progress on the Sukkur Project will be three times the rate obtained on the Triple Canal Project.

The Triple Canal Project commenced to irrigate, on a small scale for the first time, in the 9th year of construction ; and its construction was completed nominally at the end of the 13th year, but actually the capital expenditure in the 14th year was nearly the same as that in the 13th year, and there was appreciable expenditure even in the next two years.

The Triple Canal Project was estimated to cost less than 800 lakhs of rupees, whilst the Sukkur Project is estimated to cost 1800 lakhs. Bearing this in mind, together with what I have written above, I am confident that any Committee of Experts would agree with me that it is not reasonable to expect that the Sukkur Project can be completed in less than 16 years.

(b) RATE OF INTEREST CHARGES ON CAPITAL OUTLAY.—In the financial forecasts of the Project it has been assumed that the capital necessary for the work can be borrowed at 5 per cent. I need only mention the fact, and leave it to your readers to judge whether that is a reasonable anticipation. The rate should have been reckoned at not less than 6 per cent.

(c) GROSS REVENUE RECEIPTS.—Within the area that is covered by the scope of the Sukkur Project about 2 million acres are already irrigated annually by inundation canals, which bring in a gross revenue of about 55 lakhs of rupees per annum at an average rate of about rupees 2·8 per acre. In the Sukkur Project it is calculated that at the end of 6 years, not only will the Barrage be completed, but simultaneously the canals will be ready to irrigate on a small scale. It is calculated that 200,000 acres of new land will thus be irrigated in the 8th year; and that in consequence thereof the revenue will be suddenly increased from 55 lakhs of rupees per annum to 90 lakhs, the average rate per acre being raised from 2·8 to 4·0 not only on the new area (200,000 acres) irrigated from the new canals, but also on the area of 2 million acres that are receiving their irrigation from the existing inundation canals. Just think what this means. In the Project it is calculated that the increase of irrigation due to the new canal system will be 200,000 acres in the 8th year, 300,000 in the 9th year, 500,000 in the 10th, 700,000 in the 11th and about 1 million in the 12th.

It will not be till the 12th year that the existing canal system will be fully linked up to, or superseded by, the new canal system. During this period from the 8th to the 12th year, the existing canals will, to a greater or lesser extent, be receiving their supplies from the existing canal system. To that extent they will be receiving no benefit from the new canal system. Why then should they be assessed at the higher water rates of the new system? It is perfectly certain that in practice this will not be done; and that the revenue calculated upon in the project, as derivable from the 2 million acres of existing irrigation, will simply not be obtained. Even after the 12th year the revenue anticipated in the Project from these 2 millions acres will probably not be obtained. Of these 2 million acres about 1,300,000 acres are at present irrigated in the kharif season and about 700,000 acres in the rabi season. The new Barrage Canals will undoubtedly benefit the 700,000 acres of rabi irrigation, but it is not clear how they can be expected to very greatly benefit the kharif.

(d) REVENUE FROM NARA RIVER CANALS.—This tract is irrigated by the Jamrao and what are called the Eastern Nara Canals. In

the whole tract the area irrigated annually is taken at 484,679 acres, the average assessment per acre is rupees 2·79 and the gross revenue 13·54 lakhs. In the second year after completion of barrage, and four years before the completion of the proposed Nara improvement works, it is estimated that these figures will become 560,150, 4·89 and 27·39. This means that only two years after completion of the Barrage, the area irrigated will be increased by 75,471 acres or 16 per cent., while the assessment per acre is increased by 2·1 rupees or 75 per cent., and the gross revenue by 13·85 lakhs or 102 per cent. Of this increase in gross revenue 3·69 lakhs will be obtained from the 75,471 acres of new cultivation, at 4·89 rupees per acre, and 10·16 lakhs from an increase of 75 per cent. on the present rate of assessment of 2·79 rupees on existing cultivation.

It might be supposed that the cultivators would receive an increase supply of water for this great and sudden increase in assessment, but this is not the case.

8. At present the Full Supply Factor (F.S.F) of the Jamrao Canal for dry crop is 45. This means that this canal irrigates 45 acres to each cusec of its full supply, taken at 3,470 cusecs as actually observed. Its estimated full supply was 3,200 cusecs, on which it irrigates 50 acres per cusec.

Now in the 1920 Project it is assumed that the F.S.F. for dry crops will be 78 acres, compared with 45 on the Jamrao. This is equivalent to a duty of about 97 acres to each cusec of average supply.

For rice cultivation the F.S.F. is assumed as 39 which is more hopeless than 78 for dry crops. This is equivalent to a duty of about 50 acres at canal heads. Further comment on these figures is unnecessary. To anyone who has experience of Sind irrigation they are impracticable.

I agree with Mr. Gebbie's opinion that if less water is given to Sindi cultivators, they will not make it go further, but will simply cultivate a smaller area.

Sir T. Ward on the other hand assumes that "given the incentive of a supply restricted to that actually required, a good market, healthy surroundings, and a stimulating water rate, the Sindi will eventually rise to the occasion and improve his "duties".

In the 1920 Project, it is also assumed that the present net revenue of 8·89 lakhs from this tract will be increased to 46·72 lakhs, i.e., by 37·83 lakhs, or 425 per cent. in the 10th year after completion of the new canals. This 38 lakhs, which could not possibly be obtained from this tract is, however, part of the net revenue of 122·6 lakhs, which gives the return of 5·57 per cent. on the capital invested in the 10th year after completion.

This is more than double the revenue forecast made by Mr. Lucas in 1910 and by Messrs. Baker and Lane in 1919.

Ultimately, it is assumed that when 81 per cent. of this tract is irrigated the present net revenue of 8·89 lakhs will increase to 70·64 lakhs or by nearly 700 per cent.

To anyone who is acquainted with the Nara Valley, the proposed intensity of cultivation of 81 per cent. full supply factor of 78 for dry crops and 39 for rice at canal heads and increase ultimately in average all over assessment from 2·8 to 5·8 rupees per acre or 120 per cent. are all impossible of attainment, in this unhealthy, malarious, and sparsely populated tract with its high sub-soil water level.

It is claimed that the landowners are very desirous that the Barrage should be constructed, but I am perfectly certain that they do not realize what the Project proposals involve in the way of increased assessments.

The matter which is of vital importance to the Zamindar and to the tax-payer should be placed beyond doubt or dispute by a public proclamation explaining the proposed enhancement of assessment on existing irrigation; and written agreements should be taken from the landowners agreeing to the enhancement of assessments and reduction in water supply, before enormous capital expenditure is undertaken on the hypothesis that they will agree.

If this be not done, and if after the Barrage has been built the Zamindars agitate against the proposed enhancement, the Government of Bombay may be impaled on the horns of a dilemma, political and financial.

I notice in Indian papers, that Zamindars have been enquiring as to what assessments they will be charged to make this project pay, and that the majority are quite in the dark. In my opinion it is perfectly certain that the Zamindars will not pay the assessments forecasted in the 1920 Project.

(e) MAINTENANCE OF WORKING EXPENSES.—The existing system of inundation canals irrigates an area of about 2 million acres annually; and their working expenses amount to about 20 lakhs of rupees per annum; or about one rupee per acre per annum. Under the new Project, with all its more up to date machinery of design, construction, and administration it is calculated that the working expenses will be only very slightly increased, *viz.*, to 1·2 per acre annually irrigated. Sir Sydney Crookshank's adviser, presumably Mr. Gebbie, declares that this "rate is actually being worked to, at present, and under post-war conditions on the great modern canal systems of the Punjab". The fact is, however, that in the case of the most modern canal system of the Punjab, *viz.*, the Triple Canal system, the incidence of working expenses amounts to over rupees two per acre irrigated annually. Mr. Gebbie doubtless relies on the figures presented by the Lower Chemab and Lower Jhelum Canals, but there is no good reason why the Sukkur Barrage Canals, at any rate in their early stages, with which we are concerned at present, should work more cheaply than the Triple Canal System.

There are special reasons why the Working Expenses of the Lower Chenab and Lower Jhelum Canals should be relatively low, as they possess special features which do not appear in the Sukkur Project. On the Lower Chenab Canal about 75 per cent. of the commanded area is Colony land, where the canal system was designed on a tabular area. On the Lower Jhelum Canal half the commanded area is in Colony land, but in the Sukkur Project only about 20 per cent. of the commanded area is Government waste land.

Apart from the forgoing considerations, I may remark that the Working Expenses of the Sukkur Canals will be specially heavy during the transition period, when irrigation is commencing gradually, whilst the construction of the new canals and their linking up with the existing system is incomplete.

Moreover, no provision appears to have been made for the cost of maintenance and repairs of the new canals before they begin to irrigate. In the revised estimate (1910) of the Punjab Triple Canal Project, the allowance made for Working Expenses chargeable to capital account was about 20 lakhs of rupees. The corresponding cost for the Sukkur Canals fully double this amount, should be added to the capital account of the project.

9. To summarize then, my reply to the declaration in the *Pioneer*, which is quoted above (C), I beg leave to say that I am prepared to prove, to the satisfaction of any Committee of Experts, that the Sukkur Barrage Project Report enormously exaggerates the gross revenue and net revenue derivable from the Project, whilst it woefully underestimates the rate of interest charges, the probable working expenses, and the length of time that it will take to carry out the scheme.

Taking all this into account, together with the under-estimates of cost of works (which I will refer to further on) I reckon that the net revenue derivable from the 1920 Project, as designed to be carried out, in the 26th year, is not likely to exceed say three per cent.

D.

5. "The rival scheme, which is being advocated by the opposition in England, is for a canal on the left bank of the Indus, to be supplied in the first instance without a barrage, the barrage to be added at some future date. The main arguments adduced in its favour are that it would be cheaper in the first instance and that the accumulated arrears of interest during construction would be less."

"This scheme was, of course, considered carefully by Government before they committed themselves to the Barrage Project but was rejected unanimously by all their advisers. Inundation irrigation is at best precarious and, in the light of all modern experience, can only be considered as a most inefficient substitute for a perennial supply. The almost complete failure of the inundation in 1918 showed the extent

to which disaster may be caused by the absence of control over the river. The only method of obviating such catastrophes in future is by the construction of a barrage to afford control of the supplies in the Indus."

10. The whole of this argument is a misrepresentation of facts. The contention of the opposition to the 1920 Project is that as the water levels of the Indus are high enough to command the Rohri Canal at all seasons of the year, it is not necessary to build the barrage for the purpose of controlling the low water levels in this canal.

What Sir Sydney's adviser refers to as a "rival scheme" is not a scheme for an inundation (non-perennial) canal, but for a perennial canal of the type of the Upper Jhelum Canal, in the Punjab. The case for the immediate construction of a barrage is much weaker now than it was thought to be 10 or 15 years ago. At that time it was feared that the withdrawal of water from the Punjab rivers by the Triple Canal Project would at once seriously lower the water levels of the Indus at Sukkur, and damage the interests of the inundation canals offtaking from the river there. But this fear has since been proved to be groundless, the effect on the river water levels having been found to be inappreciable.

The working of the Upper Jhelum Canal, even during the abnormally bad year 1918 is a practical proof that a perennial supply can be ensured to a canal without the help of a barrage. Apart from this consideration there is the further one that even if a barrage be necessary to the complete fulfilment of an irrigation project, it is contrary to all established practice to start its construction as soon as construction is begun on the project generally. It has been established by experience that the longer earthwork of a Canal project takes much more time to complete than the headworks of the Canal, including the barrage or weir across the parent river.

The 1920 project aims at completing the barrage in the 6th year, so as to commence irrigation in the 8th. But it is calculated that the increase in the area irrigated in the 8th year will be only 200,000 acres, in the 9th year 300,000, in the 10th, 470,000 and in the 11th, 670,000. As a business proposition it is not worth while catering for the early small areas. It would be better to save interest charges by commencing the barrage 3 years later, and commencing irrigation with 670,000 acres instead of only 200,000.

E.

THE ALTERNATIVE SCHEME.

"There are other and almost equally weighty objections to the alternative scheme. Dr. Summers' proposals necessitate taking the canal off the river above the Sukkur gorge which means that the barrage, when constructed, would also have to be located above the gorge. This site has, however, been con-

demned by every expert who has examined it on account of the unfavourable geological formation of the river bed, which is such that no engineer would risk building a great work of this nature upon it. Moreover, the general design of an inundation canal differs in several important respects from that of a perennial canal, and if the main left bank canal were treated as proposed enormous extra outlay would be required, firstly in giving it the enhanced capacity necessary for an inundation canal and, secondly, in reducing this capacity again when the barrage was constructed."

11. These arguments are irrelevant. The original Lucas-Summers 1910 Project was for a perennial canal, not for an inundation canal. This idea that we propose to make a large inundation canal at first is not in accordance with facts.

If the Rohri Canal is made above the gorge, it does not follow that the barrage should be located above the gorge.

Sir John Ottley, in a Memo. in 1913, on the Barrage Project said with reference to the Nara River Supply Channel "there should be no insuperable difficulty in providing all the water required without the assistance of any weir or barrage in the river."

Sir Colin Scott Moncrieff, Sir Thomas Higham, Mr. W. B. Gordon held this opinion, so do Sir Lionel Jacob and Mr. W. L. Cameron (who with Sir John Ottley were on the 1913 Barrage Committee). Messrs. H. F. Beale, G. McC. Harrison-Wallace, W. L. Strange, F. Wright (who succeeded me as Chief Engineer in Sind), Mr. Gebbie, now Inspector-General of Irrigation, also held the same opinion while in Sind. In fact I do not know of a single engineer who agrees on this point with Mr. Gebbie or Sir T. Ward.

When he says that the upper site has been condemned by every expert Sir Sydney's adviser ignores Col. Fife, who first chose the Upper Site, Col. Rundall, a former Inspector-General of Irrigation, Mr. F. E. Robertson who examined the River bed in connection with the construction of the Landsdowne Bridge and who gave me his opinion as to how he would build the barrage at this site.

Mr. W. L. Strange, M.I.C.E., who was in immediate charge, as Chief Engineer in Sind of the Indus River Observations, in a recent article on the Barrage Project, wrote "The foundations, at the Upper Site are of crystalline limestone, which is practically insoluble and has withstood erosion for countless ages: the rock has accordingly been accepted by engineers for 60 years as suitable for carrying a weir."

"It is perhaps possible, because a submerged weir on rock foundations is unusual in Upper India, that objections have been raised to this type for the Barrage, but such objections are not supported by successful constructions elsewhere of the submerged type of weir."

The fact that Indian engineers do not understand the construction of weirs on rock has been brought forward as a reason for the lower site, at which the barrage will be founded on sand, but the obvious reply to this is to consult engineers who do understand rock foundations. The Sukkur rock is fissured, but so is the rock on which the Aswan Dam and other dams have been successfully founded.

The fact remains that the expert engineer advisers of the Government of India in the year 1912 advised that Government that it was quite safe to build a barrage at the site above the gorge. If those advisers were mistaken in their advice who shall say that the present advisers of the same Government are infallible.

F.

Dr. Summers has "denounced the barrage Project on a number of grounds, most of which are so entirely false that they cannot be allowed to pass unnoticed."

(2) *"It is against the opinion of every member of the Sukkur Barrage Committee. This is also incorrect. The Committee referred to sat in 1912 to consider a previous scheme for a barrage above the Sukkur Gorge, a proposal they rightly condemned."*

12. My friends and I have not condemned any possible project for a Barrage and Canals at Sukkur, but only the latest 1920 Project which originated in 1919, and which owing to the proposed expenditure of 480 lakhs (£4,800,000) in the first 3 years on the barrage alone, compared with only 25 lakhs (£250,000) on the Rohri Canal and 80 lakhs on the other 2 canal systems, makes the accumulation of interest charges so enormous, that the scheme cannot be a productive work under any circumstances however favourable.

It was a note which I sent to the Bombay Government in 1904, which first brought the barrage feature into the project. I have never been opposed to the idea of a Barrage, but have always urged that the Rohri Canal should be begun first. I have even been taken to task on several occasions for bringing the barrage into the project.

The views of Lord Curzon's Commission, which are strongly in favour of making the Rohri Canal first, are given in my pamphlet.

Sir Colin Scott Moncrieff said, "make the Rohri Canal first. This seems to me so evident that it is like flogging a dead horse."

Sir Thomas Higham recommended the *completion* of the canals before the barrage, and Mr. W. B. Gordon, the third engineer on this Commission, gave his opinion that the immediate construction of the Barrage, in the 1912 Project, was based "on groundless apprehensions as to the effect of future withdrawals of water in the Punjab." The data given in my pamphlet show that there is absolutely no risk in beginning with the Rohri Canal, which will make a certainty of the work being remunerative.

Sir John Ottley and Mr. Cameron, members of the 1913 Barrage Committee, have always been in favour of beginning with the Rohri Canal, on account of the great saving in interest charges by this programme. Their opinions are in my pamphlet, and so is that of Sir Lionel Jacob, the third member with Indian experience.

This Committee condemned the 1912 Project, mainly because they considered the barrage was underestimated and that the scheme with the Barrage first would not be a productive work, and not because the site for the barrage was above the gorge. Mr. Cameron's note in the discussion on my lecture makes this clear.

The Committee stated that if a site was chosen below the gorge it should be a *few miles* below the outfall gauge. At this gauge, as pointed out by Mr. Beale, Chief Engineer, "the heavy rush through the gorge seems to continue its scouring action."

The site chosen in the 1920 Project is only 6,000 feet below the outfall. With the barrage and canals as designed at this site the canals in my opinion and in the opinion of experts well qualified to judge are practically certain to have silt deposited in them. This will reduce their discharge and consequently their revenue. The largest canal is designed with its full supply level only 6 inches below the top of the barrage gates.

G.

"If the barrage is constructed as designed, there is a likelihood of the river leaving its present course, a calamity which can only be prevented by extensive training works for which no provision is made in the estimate. This is so serious a charge that it requires a little detailed comment.

13. Strong expert opinion is against Mr. Gebbie and Sir Thomas Ward on this point, but it would take up too much space to go into the question here.

I will only say that the majority of experts hold the opinion that if the flow through the gorge is interfered with in any way, as it would be by the barrage below it, the river is likely to be diverted from its present course, unless prevented from doing so by costly training works above the gorge, for which the 1920 estimate does not provide.

Sir Michael Nethersole, who dealt with this project from 1912 to 1916, was of opinion that the engineering questions in connection with the Sukkur barrage were so serious that they "would need to be solved by an exceptionally strong Committee of experts before work on it could be started."

Mr. H. F. Beale, while Chief Engineer, Bombay, in a well-considered note, pointed out that the lower site would necessitate ample training works above Sukkur to prevent the river changing its course, and that possible silting in the gorge "would cause further rise in flood levels, and cost for protective works."

When Mr. Beale wrote this note the barrage gates were designed to hold up water to a level of 192 so that they would not be used in the inundation months, June to September, but with the 1920 design the water level is to be held up to 194·5, so that the gates will have to be used in every month of the year.

This will turn Mr. Beale's possible silting into certain silting. This drastic change in design saves a large sum in the estimates, but will increase the danger of the river leaving its present course. The tops of the gates could be lowered, but this would necessitate a very large expenditure in lowering the beds of the seven canals which take off above the barrage.

A very strong Committee of experts was appointed to advise on the Aswan Dam design and site, but a committee is far more necessary in the case of the Sukkur Barrage, especially as the site selected and approved of by all experts for 65 years, has been suddenly abandoned, owing apparently to a misunderstanding as to the 1913 Committee's recommendations.

H.

- (1) *“Rates of work only 20 per cent. above pre-war rates. This is deliberately untrue. In the case of the barrage the increase allowed over the probable pre-war cost of the work is of the order of 150 and not 20 per cent. Work which before the war would have cost 2½ crores being now estimated to cost Rs. 5½ crores. The increases over pre-war rates adopted for the various principal classes of work are 30 per cent. for earthwork, 50 per cent. for concrete, 23 per cent. for brick work and 300 per cent. for steel, iron work and plant. The extensive use of mechanical appliances should enable the work to be executed comfortably within these rates.”*

14. Sir Sydney Crookshank has practically no experience of irrigation engineering, but he may reasonably be expected to know something about ordinary forms of engineering construction, such as concrete, masonry, earthwork, etc.

He accuses me of deliberate falsehood and in proof thereof asserts *inter alia* that the rate allowed in the barrage estimate for concrete is 50 per cent. over the pre-war rate.

Now in Volume I, dealing with the estimates for the Barrage alone, there is a schedule of rates in which the rate for lime concrete is shown as Rs. 17-8-0 per hundred cubic feet.

Does Sir Sydney maintain that this rate is 50 per cent. above pre-war rates, or, at any rate, adequate in itself?

Fortunately the reply to this question can be found in the Project Report itself.

In Volume V of the Report, dealing with the estimates for the canal systems the rate for lime concrete is shown as Rs. 26. If this be the concrete rate, the rate allowed in Volume I for the barrage itself must be 33 per cent. too low.

The columns of the *Pioneer* are not the place in which a controversy about rates of work can be suitably carried on ; but your readers will be able, from what I have written above, to judge of Sir Sydney's value as a veracious official.

He mentions that the rate allowed in the Project for steel work is 300 per cent. over pre-war rates, but he conceals the fact (as I have explained above) that the estimate of cost of the steel work, iron, plant, etc., which Mr. Gebbie, as Chief Engineer, advised the Government of Bombay to regard as adequate, was 255 lakhs of rupees less than the Government of India afterwards were obliged to regard as adequate.

In the face of facts like these, how can the Government of India place implicit reliance on the expert advice of Mr. Gebbie or of Sir Sydney Crookshank ?

As regards the cheapening of work by the use of mechanical appliances I am informed by those qualified to speak on the subject that experience acquired during the construction of the Punjab Triple Canals does not bear out this expectation. I have explained above that the ravages of war, malaria and influenza and the competition of other engineering projects concurrently in progress in Northern India, will tend to increase the cost of work and may make progress slower than it was on the Triple Canal construction 15 years ago, rather than three times as fast as assumed in the 1920 Project.

K.

“ Finally, Dr. Summers advances the following arguments in favour of his own proposal for an inundation canal :—

- (1) *“ It is the only hope for a productive work. The barrage scheme will certainly be productive.”*

15. It is asserted here that the Barrage project will certainly be productive. It must be pleasant to be an optimist, but it is likely to be unpleasant for those who are persuaded to lend money to an optimist. Anyhow I would suggest the advisability of revising the financial forecasts of the project, in the light of recent criticisms, as a preliminary to further consideration of the same. I have shown above that the Project calculations of gross revenue, simple interest, working expenses, etc., are not worth the paper they are written on. I have shown also that there are glaring errors in the project estimates of the barrage, even apart from the errors in estimating the cost of steelwork, plant, etc., which was detected by the Government of India, and on account of which 255 lakhs were added to the estimate.

Over and above these errors, there are numerous others of all descriptions scattered throughout the Project Report, some of which I may briefly mention here.

16. The capacity of the canals has been wrongly calculated. For instance, as I have shown above, it has been assumed by Sir T. Ward that each cusec of full supply in the Nara River Canals will irrigate 78 acres of cotton and other dry crops and 39 acres of rice.

These figures of 78 and 39 are termed the Full Supply Factors (F.S.F.). For comparison, as I have shown, the F.S.F. of the Jamrao Canal which has been working for 20 years is 45. Then take the case of the Lower Jhelum Canal, which Sir T. Ward has given as an example. This canal, as he shows, irrigated an average of 235,258 acres in the Kharif Season including 1,975 acres rice, in the 5 years ended 1914-15. Assuming for the moment, that rice only requires twice as much water as 'dry' crops, the average equivalent area of dry crops comes to 237,233 acres. As this canal can carry a discharge of 3,896, its F. S. F. is 60·9. Now Sir John Benton, in dealing with this project, allowed 15 per cent. more water for Sind on account of the rainfall being negligible and Sindi cultivators not being as good as Punjabis. Messrs. Baker, I.C.S., and Lane, P.W.D., proposed an allowance of 13 per cent. Deducting 15 per cent. from the Lower Jhelum, F.S.F. of 60·9, we get 52 as the corresponding F.S.F. for Sind, compared with 45 on the Jamrao.

A higher F.S.F. than 52 can be taken for these canals, but to base a project on such an unheard of F.S.F. as 78 would lead to certain disaster.

The F.S.F. of 39 for rice, as I have stated above, is still more hopeless, and cannot be applied to Sind.

As the latest 1920 Project is based on obtaining great revenues from the Nara River tract, it is evident that the errors in intensities and F.S.F. alone—not to speak of the great and sudden increases in assessment preclude any chance of a productive work.

I may mention here that Mr. R. G. Kennedy, who was an authority on 'duties' and F.S.Fs., gave me 35 as F.S.F. for rice at *distributary heads*. This agrees with Sir John Benton's figure of 34. Now Sir T. Ward has taken 39 *at canal heads*, equivalent to a 'duty' of about 50. It would only be fair to the Zamindars to let them know that if the 1920 Project is carried out, they will get less water for their crops, and pay 60 to 100 per cent. more for it.

It is useless to discuss this question of full supply factors any further.

Moreover the capacities of the Sukkur Canals have been calculated on the assumption that Kutter's coefficient of rugosity will be 0·020; whereas I am informed that on the Triple Canal System it was found necessary to put the value of the coefficient 12·5 per cent. higher; and

that in the head reaches of some of the Punjab perennial canals the value of the coefficient is about 0·027.

Thus it may be necessary to make the capacities of the Sukkur canals greater throughout than has been allowed for in the project.

17. The head regulators of the canals should have far greater width of waterway than has been allowed in the project and their cost should be greatly increased ; involving an addition of say 20 to 30 lakhs of rupees to the Project estimates.

When these and other necessary corrections have been made it is not improbable that the 1920 Project will show under 3 per cent. return on the capital invested down to the end of the 26th year.

Even then it will be a project to be condemned for other reasons.

18. The Governor of Bombay in Council, when submitting to the Government of India for sanction the Sukkur Barrage Project of 1910 drew attention to the liability of expenditure on great engineering works to exceed their estimated cost considerably, *viz.*, in the case of the Forth Bridge by 60 per cent. ; in the case of the Manchester Ship Canal by 50 per cent. and in the case of the Aswan Dam by cent. per cent. In the light of these figures the Governor agreed that it might be safe to assume that the Sukkur Barrage might in practice exceed its estimate by about cent. per cent.

Since the Governor of Bombay wrote as above, we have experience of expenditure on other great and recent projects :—

Triple Canals Pro- ject, Punjab.	Excess	33 per cent.	
Bombay Reclama- tion Project.	„	100	„ (Bombay Reclama- tion).
Delhi New Imperial City.	„	100	„

I may also mention that the estimates of both the White and Blue Nile Weir Projects have been increased by over 100 per cent. since 1917. In the light of what I have written above, can the Indian tax-payer feel sure that the expenditure on the 1920 Sukkur Barrage Project will not amount to more than 30 crores (£30,000,000) of rupees ?

19. When dealing with the Barrage Project of 1910, Mr. Beale, Chief Engineer, Bombay, agreed that the Rohri Canal could be designed, constructed and worked without a barrage, as a perennial canal. The only serious objection to the non-barrage canal rested on the fear that it might be thrown out of action in the winter season by deposits of silt in the summer. The science of silt exclusion at Canal heads has however advanced far since 1910 and since so much, in fact one may say everything, depends on the financial aspect of the Barrage Project, would it not be well to have the design of the Rohri Canal, as a non-barrage perennial canal to start with, fully considered by a Committee of experts. The Upper Jhelum Canal in the Punjab is a living illustration of the feasibility of the idea.

20. As regards silting, however, it may confidently be predicted that the canals of the 1920 Project, *as designed*, will certainly suffer from silt deposits in the summer. As a result of this whenever the river water level is below about 194 or 195, which occurs in every month of the year, it will not be able to give the canals their full supplies unless the gates of the Barrage are worked so as to raise the water level to about 195 or 196. When the gates are so worked during the flood months, June to September, there will be further risk of the river changing its course upstream of the Sukkur gorge.

Sir Sydney Crookshank and his adviser think that heading-up at the Barrage will affect only the water surface levels of the river for a short distance upstream. They should consider its possible effect in the direction of shoal formations a considerable distance up the river.

21. WATERLOGGING.—The problem of waterlogging has received scant consideration in the Report on the 1920 Project. Hardly a dozen lines have been written on the subject of the sub-soil water levels, and the probable effect of the new canal systems on them. Throughout the greater portion of the area included within the scope of the Project, the spring level is less than 50 feet below ground surface; whilst under a considerable portion of that area the spring level is less than 25 feet below ground level. Yet this is the kind of country into which Mr. Gebbie and Sir T. Ward propose to introduce perennial irrigation with 81 per cent. intensity.

I am informed that the Upper Chenab Canal of the Punjab Triple Canal System was designed and constructed as a perennial canal, but that hardly had it been opened for irrigation when the rapid rise of spring levels rendered it necessary to discontinue rabi irrigation from it. Before the Canal was opened the spring levels were from 25 to 50 feet below ground surface. What is to prevent this experience being repeated on the Sukkur Canals? In the case of the Sukkur canals the discontinuance of rabi irrigation would be a far heavier blow than in the case of the Upper Chenab Canal; for in most of the former the rabi irrigation is designed to be about 65 per cent. of the annual irrigation, whilst in the latter it was only 50 per cent. What will become of the financial forecasts of the Sukkur Canals Project if it should be found necessary hereafter to prohibit or reduce rabi irrigation on sanitary grounds.

The idea of designing canals to irrigate annually 81 per cent. of their culturable area, especially in the Nara Valley, with spring levels only from 10 to 40 feet below ground surface, is altogether absurd, and a curious illustration of the desperate expedients to which the framers of the Project were driven in the endeavour to present a plausible scheme on paper.

Even in Sind itself there is a standing object lesson in the effect of a canal on the levels of the sub-soil water table. The Jamrao was opened in the year 1900. At that time, if I remember rightly, the sub-soil water level was on the average 42 feet below ground surface; but within 10 years it had risen 14 feet to within 28 feet of ground surface.

This great rise occurred although the intensity of cultivation annually was only about 40 per cent. of the culturable area. What is likely to be the effect of the proposed new canals, with their 81 per cent. intensity of irrigation? I should mention that the 1920 Project is based on increasing the area irrigated annually by the Jamrao Canal from about 250,000 acres to 540,000 acres, that is by over 100 per cent.

22. A project of the magnitude of the Sukkur Barrage Project of 1920 might well have been prepared by the Chief Engineer in Sind after the excellent example set by Sir John Benton with the Punjab Triple Canal Project in 1904; instead of being left so largely to a junior Executive Engineer. This young officer has acted with great zeal and ability, which however cannot make up for his unavoidable lack of experience in irrigation. As it is, he apologizes very modestly for the shortcomings in his work, and asks that they may be excused, on the ground that he had to carry it through "as a rush job." But why was a project of this magnitude *rushed* in this fashion?

23. The Secretary of State for India had approved of the execution of the Sukkur Barrage Project of 1920, provided that the Government of India is able to satisfy him of the suitability of the financial arrangements made to raise the necessary capital, and that the project is likely to be a productive work. The latter condition cannot however be fulfilled by the project in its present form, owing amongst other reasons, to the enormous accumulation of interest charges.

The Secretary of State has no expert irrigation engineers to advise him on the merits of irrigation projects in India; whilst recent political changes have increased the independence of the Government of India and its authority to decide on such projects. When therefore the Government of India informs the Secretary of State that its expert advisers have pronounced a project to be sound and likely to be productive, the latter can hardly do otherwise than agree to the work being carried out, subject only to satisfactory financial arrangements being made.

The Government of India, however, should now realize that there are grave doubts as to the soundness of the 1920 Project, and that it is absolutely necessary in the interests of the Indian taxpayer and of the Sind Zamindar, that the Project should be exhaustively examined by a strong committee of independent experts before any further expenditure is incurred on it.

Meanwhile the Government of India have approved of the Project subject to the condition that the Bombay Government makes its own arrangements for finance. This latter Government hugs to its breast, on the strength of calculations which, in my opinion, are worthless, a concession which is said to be valuable, provided only that the necessary capital can be borrowed at 5 per cent.

Yours faithfully,

(Sd.) THOS. SUMMERS,
LATE CHIEF ENGINEER IN SIND.

Mr. Musto's Reply, dated June 1922, to Dr. Summers' articles in "The Pioneer" of 6th and 7th January.

THE SUKKUR BARRAGE AND CANALS PROJECT (1920).

Somewhere in his lengthy article, Dr. Summers speaks about "flogging a dead horse." To put the most charitable construction on his present articles, this expression very well describes the method he adopts, of repeating previous lengthy and inaccurate statements, in support of his scheme for a semi-inundation Rohri Canal. Dr. Summers seems to rely on his reputation, as an engineer with Sind experience, giving to his *ipse dixit* all the force necessary to contravert the considered and responsible opinions, of the most senior and experienced officers in Government service, (some with world-wide experience), on matters of technical opinion; and their statements of facts and figures, on which the project was based.

This is to view his articles in the most charitable light, but after studying them carefully, and comparing them with actual facts, one may be excused for wondering whether Dr. Summers is genuinely confused and ignorant, or is maliciously omitting, misrepresenting, and distorting, facts and figures, for the purpose of "creating alarm and despondency" among the general public, for some ulterior motive of his own. Those who are able to follow both sides of the question will doubtless form their own opinions on this matter.

Dr. Summers is a past-master in the art of controversy, and is indefatigable in pursuit of his own theories. His criticisms of the present Sukkur Barrage and Canals Project (1920), which are dealt with in this note, are most convincing, and damaging to the project, when read even by men with technical irrigation experience, unless they happen to have the time, and the references necessary, for checking his statements. But these statements are so false and misleading that it is necessary to answer them on this occasion, in order to show the general public how utterly unreliable his criticisms may be, as a guide to judging the merits of the scheme. Judging by his past record, Dr. Summers will probably again reply to this note with further misrepresentations, but having once shown his insincerity and inaccuracy, it is not proposed to honour his articles with any further reply.

It is hoped that all volumes of the Report on the Project, which are still in the Press, will shortly be available for issue, so that those interested in the scheme will be able to obtain first hand information, and so avoid Dr. Summers' distorted pictures and romances.

Extract A and Dr. Summers' comments thereon.

The extract quoted by Dr. Summers is as follows :—

“ Sind, at present, depends for its irrigation upon canals from the Indus, the supply of which canals fluctuates daily with the rise and fall of the water level in the river, there being no means of regulating this level artificially, as is done in the case of all other great canals of India.”

Dr. Summers' comments on this are as follows :—

“ The writer of the article appears to be unaware that the rabi water supply of the Punjab Triple Canal Project is obtained principally from the river Jhelum at Mangla without the help of a weir or barrage across the river. The Upper Jhelum Canal, the main winter source of water supply of the Triple Canal Project is an inundation canal, in as far as it has no barrage but it is also a perennial canal, and the conditions existing at Sukkur on the river Indus are more favourable than those at Mangla on the river Jhelum, for the construction of a successful Left Bank Canal of this type.”

Let us now examine this statement of Dr. Summers.

Either he does not understand the conditions at Mangla, and the régime of the Upper Jhelum Canal, or he is deliberately misrepresenting them.

In the first place, the Upper Jhelum Canal has dual functions. It is not only an irrigation canal, but is primarily a feeder channel, or bye pass, from the Jhelum river at Mangla, to the Chenab river at Khanki, where it is headed up by a weir. It is this latter function which makes all its working conditions fundamentally different to those of the Rohri canal, which is purely and solely an irrigation canal, ending in a tail distributary, and thence on the fields. At every point, throughout its length, the Rohri Canal must give its supply at full designed level, or cause disaster to the cultivation depending on it.

Actually, as designed by Dr. Summers without a barrage, the Rohri Canal will not run at full supply, nor at full supply level, all the year round, even if all Dr. Summers' anticipations as to the level of the river at its head, and the satisfactory action of the canal, were realized. Dr. Summers' own project shows the Rabi F. S. L. 5·3' lower than the maximum kharif F. S. L., on which he relies for commanding the land, while the designed Rabi discharge is less than half the kharif discharge. So that if the canal were headed up to F. S. L. in sections, to give rotations at full supply, it must run at less than half the designed non-silting velocity, and silting is bound to occur. The Indus at Rohri cannot give the full supply level to the Rohri Canal (as designed by Dr. Summers) in the rabi season, and it was for this reason that Dr. Summers had to adopt a rabi F. S. L. 5' lower than the required level, and to depend on rotational

working, and heading up, to get command of the land. Even this unsatisfactory arrangement would only be possible for the small amount of rabi he has allowed, *viz.*, an area equal to kharif area. But experience, on every true perennial canal in the Punjab, shows that the demand for rabi area is two or three times the kharif area, and that while the rabi demand is constantly increasing, there is difficulty in getting the full *kharif* supply utilized. With Dr. Summers' Rohri Canal it would be impossible to give water for any more rabi than he has estimated for, because the level of the river is too low to pass a greater discharge into his canal.

To get a larger discharge, and to get F. S. L., in this season, the Barrage is indispensable even for the Rohri Canal, while it enormously cheapens the cost of that canal, and is at the same time absolutely essential, for both rabi and kharif supplies, to the Right Bank Canals and the Eastern Nara System.

Returning to the Upper Jhelum Canal with its head at Mangla, it should be stated that the lowest river level, ever recorded there, is 866·0, (with whole river discharge passing into canal), as against F. S. L. in the canal of 857·4, *i.e.*, the minimum river level is 8·6' *higher* than the required F. S. L. in canal. As shown above, the average river level at Rohri, in the Rabi season, is 5' *lower* than the F. S. L. of the Rohri Canal. The full designed discharge of the Upper Jhelum Canal is 8,500 cusecs. Of this quantity only 2,400 cusecs are required for irrigation on the canal, and the balance, 6,100 cusecs, when available or required, is emptied into the Chenab River above the Khanki weir.

It is immaterial at what *level* this water enters the Chenab, as it can be headed up by the Khanki weir to the level required for the Upper Chenab Canal, while all silt deposits, scoured out of the Upper Jhelum Canal, can be passed down the natural river.

During the kharif season, the full discharge into the Chenab is seldom required, and during the rabi season, the supply in the Jhelum river, which is often deficient, has to be divided between the Upper and the Lower Jhelum Canals. Thus the conditions at Mangla, where the required *level* can always be obtained, are fundamentally different to those at Rohri, where the required level cannot be obtained from the natural river.

Hence the Barrage is required to guarantee the required level, and an economically large supply, in the rabi season, to the Rohri Canal.

EXTRACT B AND DR. SUMMERS' COMMENTS THEREON.

The essential weakness of Dr. Summers' reply to this extract is found in his first sentence.

He says, "This object (*i.e.*, to give an assured water supply) can be assured, *so far as the tract to be irrigated by the Rohri Canal is concerned*, without going to the enormous expense of building the barrage *before it is required for the other canals which it is to serve.*"

Assuming for the moment that the Rohri canal could be supplied satisfactorily without a Barrage, (this is disproved in the preceding and following sections), yet the Barrage is required for the other canals *immediately* the Rohri Canal is opened. Otherwise all the existing canals, now supplying the lands to be irrigated by the other proposed canals, would immediately suffer from the great take-off of the Rohri Canal; and in any case, their development is just as important as that of the Rohri Canal. In fact more so, since the other canals will command an area of over 4,000,000 culturable acres, as against only 2,500,000 culturable acres on the Rohri Canal. But Dr. Summers' fetish has always been the Rohri Canal, and he is willing to sacrifice everything else, to pushing through a very dubious design for this canal alone.

Again and again, Dr. Summers talks about the Barrage being "completed several years before the completion of any of the canal systems which it is to serve." The apparent intention of this assertion is to give the impression that the Barrage will remain useless for several years after completion, *i.e.*, until the canal systems are completed. Such is not the case, as Dr. Summers thoroughly understands. At the time the Barrage is completed, considerable portions of all the canal systems will be completed, and ready at once to utilize the assured high-level supply, given by the Barrage, for very large areas of land. The areas of existing cultivation to be benefited, and of new cultivation anticipated, on each canal system, at this stage, are shown below :—

In 7th year, i.e., first year Barrage operates—

	Area of existing cultivation benefited.	New cultivation anticipated.
	Acres.	Acres.
<i>Rohri Canal System</i> ..	210,320	88,000
<i>Eastern Nara Canal System</i> ..	480,279	75,471
<i>Right Bank Central Canal</i> ..	Nil.	Nil.
<i>R. B. North-Western Canal</i> ..	248,531	68,047
<i>R. B. South-Eastern Canal</i> ..	198,851	3,988
Total ..	1,137,981	235,506

The remaining 897,655 acres, of present cultivation, will remain on their present supplies, unbenefited, till further sections of the new canals are opened, and will remain at their present rates of assessment till such time. The remaining area of anticipated new cultivation, 3,273,000 acres, will gradually come under irrigation during the next 33 years. This omits all benefit to the Khairpur State Canals, which can be given full supply as soon as the Barrage is ready, to all existing canals, and such portions of their improvements as are ready.

If the Barrage construction were delayed, and it was not ready to operate when the canals had reached this stage of construction, none of the new canals, as now designed, could irrigate the areas then commanded. Under Dr. Summers' scheme it might be possible to give to the Rohri Canal alone, if differently designed, a supply, depending on the natural river level, without a Barrage; but no improved supply could be given, in any way, to all the other systems; and on the contrary, their existing supplies would be injured. At the same time, the change necessary in the design of the Rohri Canal, as compared with the design in conjunction with a Barrage, would enormously increase its cost, and it would have to be reconverted after the Barrage was built, at a further great expenditure, besides disorganizing the methods of cultivation.

But Dr. Summers ignores all these points, and has never put forward any satisfactory proposals for the improvement of any of the other canal systems. He cannot see beyond the Rohri Canal, which is his alpha and omega.

He quotes Sir Michael Nethersole as being decidedly against making Barrage and canals simultaneously, but Sir Michael Nethersole was open to reason, and when he saw the outline of the present project in 1919, he was in favour of the Barrage construction:—

Again Dr. Summers says, "The Rohri Canal as stated in Appendix A of the 1920 Project Reports 'is the greatest irrigational want of the Province at present, and it is the almost universal opinion that this canal should be started first.'"

This reminds one of the devil quoting scripture. Dr. Summers omits to mention that, the appendix from which he quotes is merely a history of the previous projects, and that the passage quoted is the expression of one officer's opinion given in 1910, and recorded in this history.

Nor does he mention that, in the same paragraph, that officer recommends that "if the Barrage is required to ensure its success, it should be started simultaneously with the canal" and further recommends that a project be prepared for improving the canals on the Right Bank.

EXTRACT C AND DR. SUMMERS' COMMENTS THEREON.

Dr. Summers lays great stress on the increase in the estimates for the Barrage, from 342 lakhs, as submitted by the Government of Bombay, to 566 lakhs, as submitted to the Secretary of State by the Government of India, and he asks "what confidence can be placed in estimates to one of which amounting to only 342 lakhs, a sum of 255 lakhs has to be added for errors in estimating." Further he says, "Mr. Gebbie may not have noticed the errors in the estimates."

This is another example of Dr. Summers' methods of misrepresentation. The present Barrage Report has been placed at his disposal by the India Office, and he has gone into it pretty fully, as is shown by

his quotations. Yet he entirely omits to mention that, in the Report, it is clearly pointed out that, the estimates for steel work, machinery and plant are based on most unsatisfactory and indefinite data, as they were prepared mostly in 1918, when no business firm could forecast prices 2 years ahead ; and that for this reason, a special table was shown in the Report, giving the quantities and rates for such items, to facilitate the Government of India adding to them, whatever percentage their later information showed to be necessary. Thus the addition of 255 lakhs was not due to "errors in the estimates," but was specifically and definitely anticipated in the Report. Actually, the estimates for steel work, etc., were based on rates about 40 per cent. in excess of pre-war rates, as advised by some of the largest engineering firms in India ; whereas the actual present-day cost of most plant is from 200 per cent. to 300 per cent. above pre-war rates. This is the explanation, clearly understood by Dr. Summers, of the great addition to the estimates, by the Government of India, before they were submitted for sanction to the Secretary of State. The estimates of return on capital invested, shown by the Project, were similarly revised (and reduced) to allow for this increase of estimated cost of works.

Readers may judge whether Dr. Summers was, or was not, giving an honest presentation of the facts:—

His second point under this extract is similarly presented. He says "but even according to Sir Thos. Ward's own calculations this return (10½ per cent.) will not be obtained till 41 years after the *commencement of the work, when according to the P. W. D. Code the period should be 10 years, the test by which all productive public works have been gauged."

In the first place 41 years after commencement of the works, means 30 years after completion of the works. Secondly accordingly to the P. W. D. Code a work should pay 5 per cent. on capital invested 10 years after completion of the work.

Actually, as Dr. Summers is fully aware, Sir Thos. Ward's estimate shows that, 10 years after completion of the work, it will pay 5·57 per cent. on capital invested ; 20 years after completion it will pay 8·97 per cent.; and 30 years after completion, (*i.e.*, on full development), it will pay 10½ per cent., as stated above. Is Dr. Summers really trying to enlighten his readers as to the true facts of the project, or is he deliberately misleading them ?

(a) RATE OF PROGRESS OF CONSTRUCTION.—Dr. Summers endeavours to show that the rate of expenditure, estimated for, is impossible of attainment. Here again, in his comparisons with expenditure on other works, he omits to mention a very important qualifying factor, which is clearly pointed out in the Report placed at his disposal, *viz.*, that when work and plant are estimated at rates varying from 25 per cent., to 300 per cent., above pre-war rates, the expenditure cannot be

*Note.—The underlining is by the present writer.

compared with that actually incurred for works carried out at pre-war rates. In the case of machinery, plant and steel work, for instance, of which there is an enormous quantity in the Barrage, there is no more difficulty in obtaining Rs. 250 lakhs of plant to-day, than there was in obtaining Rs. 100 lakhs of plant in pre-war days. In fact the quantity is the same.

Secondly, Dr. Summers compares possible expenditure, (by which he represents work done), on the canals and barrage, with works carried out from 10 to 20 years ago in other parts of India, by manual labour, and he speaks of the difficulty of obtaining the necessary labour. Here his lack of knowledge of up-to-date methods leads him astray. He does not realize that, under present-day conditions in India, it is possible to substitute a machine, requiring only about a dozen men, for thousands of coolies, or hundreds of masons. The rate of progress has been estimated as well as this somewhat indefinite item can be estimated, with the best up-to-date information available, by the officers concerned. Possibly they may not prove to be strictly correct, but unlike Dr. Summers, they do not claim infallibility. They will be responsible for carrying out the programme, while Dr. Summers is an arm-chair critic, with no responsibility, but only concerned in trying to force on the country his own pet scheme, apparently to satisfy his vanity.

Dr. Summers mentions that the average annual expenditure on the Punjab Triple Canal Project, for the first six years, was only 63 lakhs per annum, but he omits to mention that in one year they spent 144 lakhs, which is equivalent, with to-day's high prices for machinery and labour, to well over 200 lakhs per annum. A very large proportion of the expenditure, on the present project, will be for high priced machinery, plant and ironwork, and there is no difficulty in obtaining such supplies to any extent, and at any speed of delivery required, either in Europe, America, or India, as the case may be. Dr. Summers does not understand the entire change in programme, which is possible with modern machinery, as compared with purely manual labour. He himself has never employed more than an odd portable engine and pump, on any of the works with which he has been connected.

(b) RATE OF INTEREST CHARGES ON CAPITAL OUTLAY.—Dr. Summers' next argument is that the rate of interest, at which charges should be calculated, is not less than 6 per cent. These charges will not begin to occur, probably, for another year or more, and capital will be gradually borrowed for many years. Already the rate of interest for money is beginning to drop in London, and quite recently a well known Indian Railway Co., renewed its 5½ per cent. debentures, without difficulty or delay, at 98. It is hoped that by the time borrowing is heavy, and interest becomes a large item, the rate will have fallen to 5 per cent.: but in any case the 5 per cent. rule had to be adopted, by the officers preparing the project, as these were then the standing orders, for all projects, issued by the Government of India. It is not

proposed to raise all the money at once, while money is dear, though no doubt Dr. Summers would like to see this done as another instance of the unreliability of the estimates. The margin of profit on the project is sufficient to cover an increase in the rate of interest, though it is hoped this will not be necessary.

(c) GROSS REVENUE RECEIPTS.—Under this heading Dr. Summers makes some most startling assertions, which, if true, would certainly show gross miscalculation in the revenue estimates. We will assume that Dr. Summers really believes these startling discoveries, though it is difficult to understand why he rushes into print with such rubbish, without taking the trouble to verify his statements from the Project Reports placed at his disposal. He states “in the eighth year the average rate per acre being raised from Rs. 2·8 to Rs. 4·0, not only on the new area (200,000 acres) irrigated from the new canals, but also on the area of 2 million acres that are receiving their irrigation from the existing inundation canals. Just think what this means !”

It is a pity Dr. Summers himself did not think, and verify his statements, as he could have done. Here it may be explained that, in the estimates, the revenue in eighth year, corresponds to the cultivation in the seventh year, and similarly the cultivation in any year is credited in the following year's financial statement. This is explained in para. 247 of Volume V. Actually, in the eighth year's revenue, (seventh year's cultivation), only those areas of existing cultivation which will have been converted to the improved supply, by that year, are charged at the increased rates; the balance of existing cultivation being charged at only present rates, as shown above, in the reply to Extract B.

Dr. Summers says that “from the 8th to 12th years, the existing canals will to a greater or less extent be receiving their supplies from the existing canal system. Why then should they be assessed at the higher water rates of the new system ?”

This statement is incorrect. Each existing canal will be converted to the new system entirely during one rabi season, and thereafter will receive water only from the new system. Until such change is completed, in any one section or canal, the old water rates will remain in force. Thereafter, with the new assured supply, the new rates will apply.

He says, “The new barrage canals will undoubtedly benefit the 700,000 acres of rabi irrigation, (existing), but it is not clear how they can be expected to very greatly benefit the kharif” (existing).

If the latter point is not clear to Dr. Summers, he has failed entirely to grasp the difference between an uncertain inundation supply, fluctuating greatly in quantity and level, and the absolutely assured supply, at the constant level necessary to command the land, which can be guaranteed only by the barrage.

During the disastrously low inundation of 1918, and the very poor one of 1920, hundreds of thousands of acres of kharif crops perished, or

could not be sown, owing to the fluctuation of the river, and its failure to rise to a fair irrigating level, for the existing inundation canals; yet an immense volume of water was flowing in the river, at too low a level to be of any use. Had the Barrage and its Canals been in existence, there would not have been the slightest deficiency in the irrigation supply for present cultivation, or for the anticipated future developments, either in the kharif or rabi seasons.

Yet Dr. Summers cannot see how the Barrage Canals "can be expected to very greatly benefit the kharif."

(d) REVENUE FROM NARA RIVER CANALS.—Dr. Summers expresses grave alarm and surprise at the increase, in area and assessment estimated for, in the project, on this system of Canals, only two years after the completion of the Barrage.

He omits to give any explanation of how these increases are arrived at, or what they really represent in development of the tract.

In the first place, it should be explained that all the canals on this system depend for their supply on the Nara Supply Channel, which takes off from the River Indus at Rohri, and of which the level and supply fluctuate with the natural level of the Indus.

A reading of 12 feet, on the Bukkur gauge at Rohri, is required in the Indus to give full supply to all the canals; and directly the river falls below this level, (and some years it does not reach it at all), the supply of the canals falls below the full designed discharge, and Kharif cultivation suffers. In the cold weather (rabi) season, the supply in the Nara River, for all canals, fluctuates within very wide limits, and in several years recently has almost, or entirely, failed; so that rabi cultivation, on all the canals of the system, is at present a pure gamble, and the cultivator can never foresee his crop arrangements, or be sure of maturing the crop he has planted.

Under the present project it will be possible to guarantee, a larger supply than is at present required, both in the Kharif and Rabi seasons, the moment the Barrage comes into operation; so that even without any improvements to the existing canals, (but with the new head to the Nara River, which is to be completed simultaneously with the Barrage), all the canals could at once work up to their full present capacity, with the certainty of being able to mature all crops sown. All cultivators will be eagerly watching the progress of the works, and will be fully informed, in the previous year, when the guaranteed supply will be available. It might be assumed therefore, very reasonably, that the area of cultivation that year, and still more in the following year, would be at least equal to the maximum cultivation hitherto done on the existing canals with a very uncertain supply. Actually, as will be shown later, a much more moderate assumption has been made, in the forecast of cultivation for the project. Dr. Summers quotes the cultivation figures for the 2nd year after completion of the Barrage, *i.e.*, four years before the completion of all the canal improvements. Let us see the state of all canals in that year.

THE JAMRAO CANAL.—The improvements to this canal will be one-third completed, and the remainder of the existing canal will be able to obtain its present maximum supply.

MITHRAO CANAL.—Same as above.

THAR CANAL.—The enlargement of this canal will be completed the same year as the Barrage, and it will be able to take the full improved supply, directly the Barrage operates. It is to be worked as a kharif canal only, and will be given a supply of 3,400 cusecs, for rice cultivation on 85 per cent., and for other kharif on 5 per cent., of the culturable area. Its present designed full supply is 1,500 cusecs only, but it has carried, once, as much as 1,864 cusecs. Rice is an eagerly grown crop whenever water is available, and it might have been reasonably assumed, that nearly the full area would be in cultivation two years after opening. This has not been assumed, however, and only 25 per cent. of the ultimate increase has been credited.

KHIPRA CANAL.—This is to be a new branch. Construction to commence one year before completion of Barrage, and to be spread over 4 years. Half the canal will therefore be ready for operation in the 2nd year after completion of the Barrage. It will command 332,000 acres of culturable land, and the designed discharge 1,423 cusecs, provides for 269,000 acres of cultivation annually. But, for safe estimating, no cultivation is allowed for, until final completion of the Canal, 2 years later.

HERAN AND HIRAL CANALS.—No improvements or alterations are necessary. These canals will benefit by an assured full supply, directly the Barrage operates.

KARIAS EX EASTERN-NARA.—These will be commenced one year previous to the completion of the Barrage, and be completed in 4 years. Hence in the 2nd year after the Barrage operates, half the karias will be in use.

Now let us examine Dr. Summers' startling figures. He shows that the 'present' area of cultivation on the system is 484,679 acres. This "present area," as explained in the project, is the average of the five years ending 1918-19, as per Government orders for preparing projects.

Dr. Summers goes on to show that two years after the completion of the Barrage, and four years before the completion of all canals, (when they will be in the state described above), it is estimated that the cultivation will become 560,150 acres; and he exclaims over this increase of 75,471 acres, or 16 per cent. increase. Now, as already shown, it would have been reasonable to assume, at this stage, that cultivation had reached at least the maximum, hitherto recorded on the existing canals, with their uncertain supply. In two of the best years, 1903-04 and 1905-06, the actual cultivation was as shown in the attached statement.

Beside these figures, for comparison, the estimated cultivation, 2 years after bringing the Barrage into operation, is shown.

Readers may judge whether these figures are as startling and unrealizable as Dr. Summers would have them believe.

Eastern Nara System. Name of Canal.	Actual Cultivation <i>excluding</i> Dubari.						Estimated cultivation in Barrage Project 1920, 2 years after Barrage operates.			Remarks on Project Estimate.
	1903-1904			1905-1906			Kharif.	Rabi.	Total.	
	Kharif.	Rabi.	Total.	Kharif.	Rabi.	Total.				
Jamrao	180,532	90,969	271,501	175,069	119,106	294,175	163,600	120,000	283,600	Less than actual in 1905-06.
Mithrao	115,598	24,550	140,148	121,499	38,940	160,439	106,000	30,000	136,000	Do. do.
Thar	47,894	4,256	52,150	50,978	7,944	58,922	Rice 64,000 other kharif 7,250	<i>Nil.</i>	71,250	Estimated increase entirely in rice.
Khipro	3,152	1,690	4,842	4,667	1,589	6,256	<i>Nil.</i>	<i>Nil.</i>	<i>Nil.</i>	No cultivation credited, but a large area probable this year.
Heran	1,516	245	1,761	1,749	105	1,854	700	600	1,300	Less than actual in 1905-06.
Hiral	12,195	8,126	20,321	23,536	10,405	33,941	10,000	10,000	20,000	Do. do.
Karias ex Eastern Nara	25,097	16,339	41,436	39,567	22,719	62,286	28,000	20,000	48,000	Do. do.
	385,984	146,075	532,059	417,065	200,808	617,873	379,550	180,600	560,150	Do. do.

- Note.*—1. In 1903-04 the total area of dubari cultivation, for which a small charge is made at present, (Re. 1 to 12 annas for watered crop, and annas 4 to 5 for unwatered crop) was 31,345 acres.
2. In 1905-06 the total area of dubari cultivation was 29,531 acres.
3. When the new canals, with a guaranteed and ample supply for a long kharif season, are in operation, the area of unwatered dubari will certainly increase very greatly, especially on the Thar Canal, where a great extension of rice is to be provided for. No charge will be made for this crop, and no area is credited to the Project on this account.

Dr. Summers next proceeds to analyze (or pretends to do so) the present and anticipated revenue from these canals. He divides the present total revenue by the present total area irrigated, to find the present average *assessment*. As Dr. Summers knows perfectly well, the present revenue is the *nett* revenue, *i.e.*, gross revenue minus remissions on account of shortage of water, etc.,—at present a very large and important deduction. And the present area also includes a large amount of dubari cultivation, for which a very small charge is made. He thus arrives at a present average assessment of Rs. 2·79 per acre. This is *not* the present average *assessment*, but the present average *nett* revenue per acre. This rate will vary from year to year, according to the water supply, and the amount of dubari cultivation. With the guaranteed supply from the Barrage, there should be no remission for deficiency of water; and there will be a great increase of dubari, none of which is included in the project figures for area of cultivation, and for which no charge is proposed to be made. Thus even with the *present* assessments, the future average revenue per acre, on project areas, would be considerably higher than the present. Had the dubari areas been included in the project statements, the average revenue per acre would appear much lower. Dr. Summers works out an average revenue, (he calls it assessment), from the project figures which he quotes, of Rs. 4·89 per acre.

This is pure juggling with figures, and has no real meaning. The actual assessments to be charged, and the present assessments, for each kind of crop, are clearly stated in the project. They are the same as for the Rohri Canal, whose commanded area adjoins, and they are set out in full detail in Volume XX and in Sect. III, Part IV, Vol. IX of the Project, with the reason and justification for all increases.

Dr. Summers now goes on to discuss the water-supply under the project, and starts by saying that the cultivators will not receive any increase. He proceeds to work out the Full Supply Factor on the existing Jamrao Canal. Now the term F.S.F. is little used in Sind, and is not a measure of the water supply to crops. It is a measure for designing the full section of the canal. The term was evolved in the Punjab, and has been clearly defined in the "Glossary of Terms" by Mr. H. W. Nicholson as follows:—

"FULL SUPPLY FACTOR.—The area irrigated during the crop by one cusec of capacity (authorised full supply) at the head of the channel.

Note.—The controlling factor in the *design of a channel* is the kharif F.S.F., as the kharif area is limited by the capacity of the channel, whereas the rabi area is limited by the supply available."

In the same book, on the preceding page, appears the following definition:—

"THE MEAN SUPPLY.—In a channel is the sum of the daily discharges of the channel divided by the number of days in the crop. *This, therefore, is a measure of the water used, and is the one to take as the basis of*

comparison between various years and canals, because the base is common and constant."

Dr. Summers fully understands the difference of these two expressions and has adopted the incorrect method of comparison, by F.S.F., simply because the result is misleading in favour of his argument. He adopted a similar fallacious method of argument in his 1910 Report on the Rohri Canal, in order to dispute the duties recommended by the then Chief Engineer for Irrigation, Mr. Hill (*vide* pages 29 and 30 of the 1910 Report on Rohri Canal).

Now let us examine the actual figures given by Dr. Summers.

He says, "at present the Full Supply Factor (F.S.F.) on the Jamrao Canal for dry crops is 45. This means that this canal irrigates 45 acres to each cusec of its full supply, taken at 3,470 cusecs as actually observed. Its estimated full supply was 3,200 cusecs, on which it irrigates 50 acres per cusec."

Dr. Summers omits to mention that the discharge "3,470 cusecs as actually, observed" has only occurred on *one day* (the 19th August 1903) in the whole 23 years that the canal has been in operation. The average kharif full discharge of the canal is now about 2,300 cusecs only and the maximum about 3,240 cusecs.

Again Dr. Summers very carefully omits to give the cultivation figures from which he calculates the F.S.F. of 45 on the 3,470 cusecs discharge. Actually the cultivation figure on which he has calculated is 156,575 acres of kharif (one of the lowest on record) in the year 1906-07, *i.e.*, in another year altogether to that in which the discharge he uses occurred. Could anything be more dishonest than such a statement?

It is exactly analogous to a man estimating the average cost of a number of goods, by taking the total amount spent in one year, and dividing by the number of goods purchased in another year. Actually in the year 1903-04, when the greatest discharge was measured (3,470 cusecs), the nett kharif cultivation, after allowing for all remissions, was 180,709 acres, giving a F.S.F. of 52 instead of 45 as stated by Dr. Summers.

But as already pointed out, the F.S.F. cannot be used for comparing the water supply of different canals or different years. For this purpose we must adopt the "Mean Supply." For the year 1903-04 in which the greatest discharge occurred, the mean supply during the kharif season was 3,101 cusecs, and as the area grown was 180,709 acres the duty obtained was 57, while the mean supply in 1905-1906, from which year Dr. Summers takes his area of cultivation, was 2,643 cusecs, giving a duty of 64.

In the year 1913-14 the mean kharif supply was 2,123 cusecs, and the nett kharif crops 174,971 acres, giving *an actual duty of 82* for all kharif crops.

In the year 1908-09 with mean supply 2,363 cusecs, the actual kharif duty was 77 ; in 1916-17 with 2,132 cusecs the duty was 76 ; and in 1912-13 with 2,326 cusecs the duty was 74. These are all actual duties obtained in years with a fairly satisfactory, but fluctuating, supply. Yet Dr. Summers says that for an absolutely guaranteed supply, a duty of 78, as adopted in the 1920 Project, is impracticable. Not content with this misrepresentation he goes on to further false statements. In the first place he says that 78 is the *F.S.F.* adopted in 1920 Project, and that this is equivalent to a duty of about 97 acres to each cusec of average supply. This is not so. 78 is the duty on normal full supply (2,406) at canal head, the Jamrao and all other canals of this system being treated as *branches* of the E. Nara.

This normal full supply is to be run throughout the months of May to September inclusive, *i.e.*, for five months; while during March, April and October, a smaller *kharif* supply will be run, (but at the same duty), for the smaller areas requiring water, during the sowing season, and reaping season, respectively. Including these months, the mean *kharif* supply will be 2,066 cusecs, and the mean duty on *full* kharif area will be 91. But the mean duty on the area of crops, actually standing, remains constant throughout, and is 78 at canal head. Similarly the rabi duty remains constant throughout the crop, and is 156 at canal head ; while on canals with rice cultivation, the duty for rice is a constant 39 at canal head.

Dr. Summers goes on to criticise the estimates of net revenue in the Eastern Nara system of the project, and has quoted figures which he suggests are sensational.

He states, without any arguments to support his statement, that the estimated revenue " could not possibly be obtained from this tract," and he adds that this is more than double the revenue forecast made by Mr. Lucas in 1910, and by Messrs. Baker and Lane in 1919.

He omits to mention that none of those officers made any proposals for improvements and extensions, as has been done now in the present project. Mr. Lucas retired from Government Service several years before the present project was commenced, but use has been made, and acknowledged, of his wide knowledge of the tract.

Messrs. Baker and Lane, by a misinterpretation of the Government orders, omitted in their Report to provide for any extensions and improvements of the existing Eastern Nara system of canals, except to assume that they would get an assured supply from the Barrage ; though they omitted to provide for the cost of the necessary new head to the Nara Supply Channel. This was pointed out to Mr. Baker after the submission of their Report, and the present proposals for cultivation were all decided in consultation with him, and have been agreed to by him.

The correspondence on the subject is given in Appendix C of Volume VI which was placed at Dr. Summers' disposal. The improvements were found to be both practicable and profitable ; they are necessary to

the design of a complete and final scheme, and have therefore been included in the project.

It is curious, to say the least of it, that Dr. Summers has not a word to say against the application of identical rates of assessment, and intensity of cultivation, to the estimates for the Rohri Canal, feeding the adjoining and similar tract of country.

Nor does he take any exception to an increase of revenue on the Rohri Canal system from the present revenue—Rs. 10,75,400 to Rs. 46,44,200 in the 10th year after the completion of the Barrage. But then this, of course, is his pet canal, and nothing is too good for it. He protests that the proposed increases of assessments, which will not commence to come into operation, (and then on part only of the area), until at least 8 years hence, (*i.e.*, after completion of the Barrage), are exorbitant, and that he is convinced the zamindars will not pay them. Dr. Summers appears to forget that, not only has the cost of works increased greatly, but also that the value of crops is more than double what it was ten years ago, when the present assessments were in force, so that apart from any improvements to the water supply, there is no doubt that the cultivator can (and equitably should) pay a higher assessment to-day than 10 years ago. But the proposed assessments are for a guaranteed supply which even at the value of the crops ruling 10 years ago, would handsomely pay the cultivator for the increased assessments. The proposed assessments, during the first 10 years the new canals are open, are actually exceeded at present, in some Talukas in Sind, for rice and other kharif; while the proposed rate for *flow* rabi, with a guaranteed supply, is very little above the present rates for *lift* rabi, with a totally inadequate and unreliable supply. Messrs. Baker and Lane have dealt with this matter so fully and clearly in their Report (Volume XX of the Sukkur Barrage Project) that it is unnecessary to go any further. Those who are anxious for correct information can get it from this report without the assistance of Dr. Summers' juggling.

(e). MAINTENANCE OF WORKS.—WORKING EXPENSES.—His next attack is on the estimate of working expenses for the canals. He points out that the working expenses, on the present system of inundation canals in Sind, come to about Re. 1 per acre, and declares that the rate Re. 1·2, estimated in the project, is insufficient to meet the up-to-date administration of the new canals. He omits to point out that on the existing canals, cultivation is very thin and scattered, requiring lengthy channels and troublesome supervision, whereas on the new canals, cultivation will be far more intense, and therefore much more economical, both in water distribution and in supervision.

Nor does he point out that the working expenses which he quotes, for the Punjab Canals, includes the cost of maintenance of all their weirs, barrages, and very extravagant (because originally wrongly designed) training works. Whereas in the Sukkur Barrage estimates, a separate liberal provision is made for the maintenance of the Barrage and Head Works, *in addition to* the rate for working expenses of canals. It is pos-

sible the estimated rate may be slightly exceeded in practice, but it has been calculated with due consideration of all the facts, and assuming economical and keen supervision. The effect of a possible increase in the rate is shown in the Project Report. He further states that no provision has been made for the maintenance and repairs of the new Canals before they begin to irrigate. This is incorrect. The total provision for maintenance and repairs during construction is Rs. 11,65,133. Dr. Summers states that, on the Punjab Triple Canal Project, the estimated allowance for this purpose was about 20 lakhs of rupees. This is also incorrect. The actual amount sanctioned was Rs. 13,00,657, and the actual expenditure only Rs. 11,88,923. The Punjab Works were spread over a period of 12 years, and as they were almost entirely new canals, in uncultivated lands, the new works had to be maintained out of capital, until sections were opened. Many of the canals in the Sukkur Project already exist, and will benefit as soon as the Barrage operates, *i.e.*, after 6 years, so that the provision for maintenance of improvements, will be assisted by the provision of working expenses per acre of cultivation. By the same arrangement the extra heavy cost of running expenses, during the transition period of existing canals, to which Dr. Summers refers, is assisted by the provision for maintenance during construction.

He ends his first article by a sweeping undertaking—unbacked by any financial guarantee—to prove to the satisfaction of any committee of experts, that the project is totally unsound.

We wonder who would pay the piper for this committee, and for the enormous loss to the country, due to delaying these great extensions of cultivation, should Dr. Summers not succeed in making good this bold promise.

EXTRACT D AND DR. SUMMERS' COMMENTS THEREON.

Dr. Summers' second article (see "*Pioneer*", dated 7th January 1922) is an attempted defence of his alternative scheme for the Rohri Canal alone, without a Barrage, and omitting any provision for improving the Right Bank Canals and the Eastern Nara System.

He repeats the inaccurate statement he made in reply to extract A, (*vide* beginning of this note), *viz.*, that the Rohri Canal, as proposed by him, is not an inundation canal, but is a perennial canal of the type of the Upper-Jhelum Canal. It is only necessary to repeat that the lowest natural river level ever recorded at the head of the Upper Jhelum Canal was 8·6 feet *higher* than the Full Supply Level of the canal (invariable all through the year); whereas the lowest natural level recorded in the Indus, at the head of the proposed Rohri Canal, is 8·7 feet *lower* than the Kharif Full Supply Level required to command the land without rotations.

Again Dr. Summers attempts to show that if the Barrage is to be made at all, it should be started after the Rohri Canal. He repeats the method of misrepresentation he adopted in reply to Extract B (see *ante*) by quoting only the areas of *new* cultivation to be irrigated in the 8th, 9th, 10th & 11th years, and omitting all mention of the vast areas

of existing cultivation, which will at the same time be immensely benefited, by the guaranteed supply at Full Supply Level, as soon as the Barrage operates on the new canals. These areas are shown in the following statement, for the years quoted by Dr. Summers.

It is hoped that they show conclusively the very great advantage of having the Barrage ready to operate, directly the first sections of the canals are ready. The figures also show, incidentally, the relative importance of the Rohri Canal System, and the other Canal Systems, and why, with the Rohri Canal *alone*, it would *not* be very profitable to operate the Barrage as soon as the first section of that canal was ready.

On this canal system, there is less existing cultivation, which can benefit immediately by the Barrage, than on either of the other two canal systems.

The improved guaranteed supply, to existing cultivation, brings in an immediate and great return of revenue to the project, whereas new cultivation has to develop slowly. Much of the Rohri Canal area is very far from the head of the canal, so that a great and expensive length at the head has to be made, before there is any return.

	New cultivation.	Existing cultivation benefited.	Total cultivation benefited.	Existing cultivation un-benefited.	Total cultivation.
	Acres.	Acres.	Acres.	Acres.	Acres.
7th year—					
Rohri	88,000	210,320	298,320	446,980	745,300
E. Nara	75,471	480,279	555,750	4,400	560,150
Right Bank Canals ..	72,035	447,382	519,417	446,275	965,692
Total ..	235,506	1,137,981	1,373,487	897,655	2,271,142
8th year—					
Rohri	97,600	210,320	307,920	446,980	754,900
E. Nara	118,871	480,279	599,150	4,400	603,550
Right Bank Canals ..	101,529	576,019	677,548	317,638	995,186
Total ..	318,000	1,266,618	1,584,618	769,018	2,353,636
9th year—					
Rohri	151,200	315,380	466,580	341,920	808,500
E. Nara	192,271	484,679	676,950	....	676,950
Right Bank Canals ..	130,484	575,429	705,913	318,228	1,024,141
Total ..	473,955	1,375,488	1,849,443	660,148	2,509,591
10th year—					
Rohri	165,600	315,380	480,980	351,920	832,900
E. Nara	255,671	484,679	740,350	....	740,350
Right Bank Canals ..	243,030	743,819	986,849	149,838	1,136,687
Total ..	664,301	1,543,878	2,208,179	501,758	2,709,937
11th year—					
Rohri	338,000	604,400	942,400	52,900	995,300
E. Nara	299,071	484,679	783,750	....	783,750
Right Bank Canals ..	312,326	848,460	1,160,786	45,197	1,205,983
Total ..	949,397	1,937,539	2,886,936	98,097	2,985,033

EXTRACT E. AND DR. SUMMERS' COMMENTS THEREON.

Dr. Summers says that if (the head of) the Rohri Canal is made above the gorge (at Rohri) it does not follow that the Barrage should be located above the gorge.

He gives no reasons for this extraordinary statement, which is contrary to all established practice and theory, in the design of weirs to supply canals. Either Dr. Summers is profoundly ignorant of the most vital function of a weir or barrage, or he is again trying to mislead his readers.

Every solid weir contains a certain indispensable number of scouring sluices, and a barrage proper consists of nothing but scouring sluices. These are so placed as to be able to scour away any deposits of silt that may accumulate in front of the canal head. The scouring sluices, and therefore the weir or barrage of which they form part, can only be placed at a distance from the canal head, when the depth of water is so great that accumulations of silt will not affect the head of the canal, *e.g.*, in the case of a reservoir of great depth, supplying at a level much above the river bed at site of dam. But in all works on comparatively shallow rivers, carrying great quantities of silt, like the Indus and the Punjab rivers, it is a *sine qua non* of design, that the scouring sluices must be immediately below the canal head, so as to completely control silt accumulations in front of the canal regulator. If the Sukkur Barrage were placed below the Rohri gorge and the Rohri Canal Head above the gorge, the Barrage would be utterly useless and ineffective for this purpose, and the canal would be liable to silt up completely in a few months, or perhaps weeks. Dr. Summers' suggestion is astounding, and discreditable to any irrigation engineer. He can only have made it in a spirit of sheer vindictive contradiction, to combat every possible point in the design of the present project. It is an illustration of the utter weakness of his case, and the dishonesty of his criticism.

EXTRACT F. AND DR. SUMMERS' COMMENTS THEREON.

He proceeds to quote opinions, expressed by retired engineers, many with distinguished records. Most of his quotations, however, are ancient history; others are by engineers with little or no personal knowledge of the Sukkur Scheme, and none of them have had the opportunity yet, of studying the present project, which is not yet out of the press. Their recent information has been obtained from Dr. Summers, who alone was permitted to see the copy sent to the Secretary of State. This note should show the degree of reliance which can be placed on information given by Dr. Summers.

The remainder of his reply to this extract is wearisome repetition of his previous *ex parte* statements.

EXTRACT G. AND DR. SUMMERS' COMMENTS THEREON.

Here is more wearisome repetition and vague criticism. He says that "if the flow through the gorge is interfered with in any way, as it would be by the Barrage below it, the river is likely to be diverted from its present course." The Barrage will cause no interference whatever to the flow through the gorges even in the biggest floods. Calculations show that with a flood of 1,500,000 cusecs, which is more than 50 per cent. greater than the maximum flood ever recorded, the afflux at the Barrage would be barely one foot, and that this would almost entirely disappear at the gorges 3 miles above the Barrage.

Dr. Summers quotes a note written by Mr. H. F. Beale, while Chief Engineer for Irrigation, in which he stated that, if certain works, once proposed by Mr. Hill were carried out above Rohri, these would cause a raising of the flood level above the gorges : and that in this case it would be necessary to provide protective and training works above the gorges. These works above Rohri have not been constructed, and are not now proposed. Moreover the outline of the present project, which showed there was no necessity for protective works above the gorges, was approved by Mr. Beale himself, at a later date than his note referred to above ; and the detailed project, now submitted, was prepared to his instructions as Chief Engineer for Irrigation.

Dr. Summers makes a second quotation from Mr. Beale's note, and gives it in inverted commas, to show that possible silting in the gorges "would cause further rise in flood levels, and cost for protective works."

This quotation is not Mr. Beale's own remark at all, but is a quotation he himself makes from his predecessor's note ; and which he sets out to show is *unjustified*.

Dr. Summers adds that, when Mr. Beale wrote his note, the Barrage Gates were designed to hold water up to a level of 192 only, whereas they have now been increased to 194.5.

Mr. Beale himself sanctioned, and strongly approved, this increase in the height of the gates.

Dr. Summers' statement, that with the increased height of gates, it will be necessary to operate them in every month of the year, is entirely incorrect. When the Bukkur Gauge reads 12 feet, none of the Barrage gates will need to be operated, as the natural river level will then be high enough to give Full Supply Level to all canals.

During the past 72 years, for which daily records are available, the average monthly gauge reading at Bukkur has been more than 12', as shown in the table below. In the other years, the gauge reading has been more than 12' for part of the month, as shown.

		Average monthly gauge reading over 12' during past 72 years.	Gauge reading over 12' during part of month in remaining years.	Total out of 72 years.
June	..	5 years.	28 years.	33 years.
July	..	37 "	25 "	62 "
August	..	51 "	14 "	65 "
September	..	5 "	28 "	33 "

In the months when Bukkur reads less than 12', partial regulation will be done at the Barrage; as many gates, as necessary, being closed, to head-up the river to the required level.

In such low-river seasons any slight extra silting, that may occur above, in, or below, the gorges, can do no possible harm, and will be rapidly scoured out again, by the next large flood; this action goes on every year, at present, with the natural river. Such silting, if it occurred, would have no effect on the canal supplies; as the approach channels, in front of the canal head regulators, can be kept clear of silt at any time, by the operation of the Barrage Scouring sluices.

This is one of the principal functions of the Barrage as explained previously.

Dr. Summers ends by a plea for a Committee of Experts to examine the Project. His main excuse is, that the site of the Barrage has been changed, "owing apparently to a misunderstanding as to the 1913 Committee's recommendations." There has been no such misunderstanding. A suggestion made by the Committee has been adopted, and a site selected below the gorges, not quite where they suggested, but one which has all the advantages they pointed out for such a site, and none of the disadvantages.

EXTRACT H. AND DR. SUMMERS' COMMENTS THEREON.

Dr. Summers again harps on the estimates and rates for work. In proof of the incorrectness of these rates, he shows that in Vol. I the estimated rate for concrete *on the Barrage* is only Rs. 17-8 per 100 c.ft., while in Vol. V of the same project, but dealing with *the canals*, the estimated rate for concrete is shown as Rs. 26. From this, he proves that the rate in Vol. I is 33 per cent. too low. Apparently, Dr. Summers does not know that locality, and source of supplies, makes any difference to the cost of concrete. At the Barrage, we have an unlimited supply of splendid concrete metal, available within a mile or two of the work; and vast quantities of repetition work will be done in the works-yards.

On the canals it will be sometimes necessary to carry materials many miles, or to burn bricks specially for breaking into concrete metal, on small isolated jobs. Whether each rate is sufficient, or not, this comparison of the two rates, on equal terms, is nonsense.

What is the value of such puerile "criticism"?

Is Dr. Summers appealing to an audience of silly amateurs, or is he trying to deal seriously with engineers who know the conditions?

EXTRACT K. AND DR. SUMMERS' COMMENTS THEREON.

Dr. Summers merely repeats, *ad nauseam*, the expression of his individual opinions, already given in his replies to other extracts, and these have been answered earlier in this note.

It is hoped that this lengthy note, dealing with all the points raised by Dr. Summers, will convince readers that those responsible for the project have nothing to hide, and nothing to fear from full and open discussion. To answer, and to exhibit the dishonesty of Dr. Summers' methods of "criticism," has involved the expenditure of a great deal of labour and time, which would have been unnecessary in answering an honest critic. In future his attacks will not be answered, though it may be necessary for Government to take other steps, to prevent his deliberate and injurious misrepresentations.