Irrigation Possibilities and Practice in the Natal Sugar Belt

By E. Hudson Spence

Mr. E. Hudson Spence, Circle Engineer, Natal, read the following paper on the above subject:—

1. GENERAL:

Having been requested to give a general survey of the Irrigation Possibilities and Practice in the Natal Sugar Belt, I propose to make the attempt by:—

(1) Reviewing the resources of the Sugar Belt in regard to land and water.

(2) Estimating the benefit and increased production of Sugar derived from the Irrigation of Sugar Cane.

(3) A consideration of ways and means, with an estimate of the possible cost.

(4) Finally, if time permits, we might consider present Sugar Cane Irrigation Practice in Natal and see how it can be improved.

2. RESOURCES OF THE NATAL SUGAR BELT.

(a) **Sugar Belt.**—The sugar growing areas of the Union of South Africa are entirely confined to an area extending along the Natal—Zululand Coast, from Port Shepstone in the South to the Portuguese Border in the North. This area lies between Lat. 27° and Lat. 31° South, and is the most southerly area in which sugar cane is grown; the mean temperature varies between 77° F. in the Summer and 60° F. in the Winter.

(b) **Topography.**—Topographically, the area is characterised by the land surface descending abruptly to the sea from the high altitudes, incidental to the proximity of the Drakensberg Mountains.

This steeply sloping land surface has been deeply eroded by the numerous rivers, and thus we find that the bulk of the arable land lies at a considerable elevation above the river beds, a circumstance which very seriously affects the problem of getting the water on the land.

(c) **Rainfall.**—As will be seen from the attached map, the average annual rainfall varies from 47 inches in the North to about 35 inches in the South, with an average of 41.0 inches.

As regards rainfall, the year may be divided into two fairly well defined seasons; the wet season extending from September to the end of March, during which period the monthly rainfall exceeds 3 inches, and over 78 per cent. of the annual rainfall is precipitated; and the dry season, extending from April to August, when the average rainfall is less than 2 inches per month.

A chart, showing the monthly variation of rainfall, has been prepared from the Mount Edgecombe Record, which has been kept for over 40 years. (Diagram 1.)

(d) **Rivers.**—The Sugar Belt is particularly fortunate in being intersected by numerous streams and rivers, most of which carry a perennial flow; a Schedule No. 1 is attached, giving the names of the principal streams, starting in the South and proceeding North along the Coast. On this Schedule is given particulars of the Catchment Area, Mean Rainfall on the Catchment, the Minimum Flow, as ascertained by gauging the low flows in September during the last three years, the Estimated Average Discharge (as ascertained from rainfall data), and the Annual Volume in acre feet given by the minimum flow, and finally a column entitled "Tons of Sugar," the meaning of which will be explained later.

From these tables, it will be seen that we have at our disposal a perennial flow of some 2,253 cusecs, or an annual volume is 1,630,734 acre feet.

3. EFFECT OF IRRIGATION ON SUGAR CANE:

(a) **Production and Yield of Cane under Rainfall Conditions.**—Sugar cane has been grown in Natal ever since 1848, and in Zululand since 1905. The total area under cultivation in 1928 was 264,374 acres, of which some 118,000 acres were reaped, giving a yield of some 2,482,000 short tons of cane producing 247,273 tons of sugar, say 2.1 tons sugar per acre reaped.

In estimating the production of sugar from cane, a good average figure appears to be 10 tons of sugar cane per ton of sugar.

With the exception of a small percentage grown on swamps near the mouths of certain rivers, such as the Umfolozi, the bulk of the cane is what is known as hillside cane, and is grown under dry-land conditions, the only water being obtained from the rainfall. Very little cane is at present grown under irrigation, which, as far as this country is concerned, is just emerging from the experimental stage.

Owing to its Mosaic Disease and drought resistant properties, practically the only variety of cane grown is the Uba, which was originally imported into Natal in about 1882.

The prevailing practice as regards the hillside Uba Cane is to plant from September to November; later planting does not give such a good growth. Plant cane begins to shoot about a month after planting, and, owing to rainfall and heat conditions, the maximum rate of growth is from December to January.

In April, owing partly to the decrease in rainfall and partly to cold weather setting in, the cane is retarded until September, when the increasing rainfall and temperature once more induce a vigorous growth, which is maintained until the next dry season, the cane being harvested in September, or 24 months after planting.

After cutting, the cane roots are left in the ground, and begin to shoot directly after cutting; thus giving what is known as a Ratoon Crop; this ratoon cane can be cut as early as May. The general practice appears to favour one plant crop and three ratoon crops, after which the land is replanted, that is, planting takes place every eight years. Rotation of crops does not appear to be practised to any extent in cane lands, although there is no doubt that this would be beneficial.

During the period of 24 months, the cane receives about 82 inches of rain, but, owing to its irregularity both in time and intensity, the effective rainfall can only by taken as 60 per cent. of the actual fall; in other words the amount of water applied to the crop can only be taken as 50 inches in two years, or 25 inches per annum.

Thus it will be seen that it takes 50 acre inches to produce 2.1 tons of sugar, or 24 acre inches, or 2,720 tons of water per ton of sugar, a result which compares very favourably with those obtained in Hawaii and Mauritius.

(b) Relation of Water Applied to Yield of Sugar per Acre.

In order to appreciate how vitally the quantity of water applied affects the yield of sugar from a given area of ground, attention is drawn to Diagram 2, taken from one given by Joel B. Cox, in which the total quantity of water supplied to the crop is represented by a curve obtained by plotting the yield in tons of sugar per acre vertically against the total water given in acre inches, or millions of gallons.

This curve was obtained as a result of numerous determinations in Hawaii and elsewhere, some of the most representative of which are given by circles on the Diagram.

Some of the representative results obtained by the Medine Experimental Station, Mauritius, are shown by triangles, while the only South African determinations on a large scale, those made at Mount Edgecombe, are shown by crosses.

Allowing for variations due to climate, soil, temperature, variety of cane grown and other local circumstances, it will be seen that the curve represents a very fair average. The Mount Edgecombe experiments, as far as they go, show that, for South African conditions, the values given by the curve are conservative; also it will be noted that 50 inches corresponds to 2.1 tons of sugar per acre, which is exactly the same result as obtained above, from actual rainfall and crop returns.

If the curve is examined, it will be seen that up to an application of some 150 acre inches giving 6 tons of sugar per acre, the yield is proportional to the water applied, and that in order to obtain the maximum yield of 10.2 tons, 368 acre inches must be applied. It will be noted that in Hawaii as much as 288 acre inches have been applied, with a yield of 8.4 tons per acre.

Under ordinary conditions, however, it does not appear advisable to give more than 150 acre inches to a crop, as beyond this the quantity of water required per ton of sugar increases to some extent.

Having arrived at the conclusion that 24 acre inches (2 acre feet) is required at the field for the production of each ton of sugar up to 6 tons per acre, something must be added for losses in bringing the water to the field and in the application of the water. These losses are frequently very heavy, and would probably, on the average, amount to 50 per cent. of the effective water; thus with 24 acre inches applied plus 12 acre inches for losses, we see that up to 6 tons of sugar per acre 36 acre inches (3 acre feet) is required for the production of 1 ton of sugar. (Other equivalents are 4,080 short tons or 816,000 Imperial gallons or 977,550 American gallons per ton of sugar.)

4. Possible Tonnage of Sugar which might be Produced by the Available Water Supply.

Knowing the quantity of water required to produce a ton of sugar, it now becomes possible to estimate the tonnage of sugar which the available water supplies are capable of producing if carefully applied to the irrigation of cane.

This has been done in Column 6 under " Tons of Sugar " in Schedule No. 1, and the figures given represent the number of tons of sugar which the low flows of the various streams are capable of producing, apart from that produced by rainfall, on the basis of 3 acre feet per ton.

It will be seen that the amazing total of 372,458 tons is arrived at as the possible annual production of sugar from the various streams up to the Umfolozi, utilising only the perennial flow, provided sufficient land is forthcoming at elevations, which will permit of irrigation facilities being provided at a reasonable cost, while a further 171,119 tons would be forthcoming from the streams North of the Umfolozi to the Usutu on the Portuguese Border, making a grand total of 543,578 tons of sugar.

The total area of land required on a basis of 6 tons per acre would be some 62,000 acres up to the Umfolozi, and 28,570 acres beyond, making 90,570 acres in all.

Apart from the question of land, however, there will probably be a considerable wastage in utilising the river water, and thus we may conclude that the production of sugar will probably not exceed one half the above tonnage, or say 270,000 tons of sugar.

The above estimate has been made on a basis of using only the minimum flow, but it should be noted that, if sufficient storage can be provided, a considerably greater tonnage may be obtained, as it will be seen on referring to Schedule No. 1 that the estimated average discharge is nearly three times that of the minimum flow.

5. METHODS AND COST OF IRRIGATION:

With the pleasing prospect of a greatly increased production in view, we must now consider the highly important question of the means whereby this is to be attained.

In other words, how is the water to be brought to the cane, and at what cost?

(a) Irrigation by Gravitation or Pumping:

If only the perennial flow is to be utilised, no storage, except possibly over-night storage, to escape night irrigation, will be required, and irrigation can be effected by abstracting directly from the stream, and gravitating or pumping the water to the land.

Owing to the deep valleys eroded by the rivers, and the difficulties experienced in carrying canals along the steep sides and krantzes, pumping schemes have hitherto been generally the more feasible.

Some idea of the capital expenditure permissible in the case of a gravitation scheme may be obtained from the following consideration.

For every ton of sugar produced the grower receives on the average from £9 to £10, depending on the sucrose content and value of cargo sugar in terms of the Fahey Agreement; deducting from this an amount of say £3 to cover the working costs incidental to producing the extra tonnage under irrigation. We then find that there is a balance of from £6 to £7.

If the whole of this amount is absorbed in interest and redemption, then the scheme is on the limit of payability.

Allowing 5 per cent. interest with redemption in 20 years, the Capital represented by an annual disbursement of from £6 to £7 is from £75 to £88.

Thus we see that the absolute limit of capital investment on a gravitation scheme which would be justified, is £80 per ton of additional sugar produced by irrigation.

With a production of say 5 tons of sugar from irrigation per acre (and 1 ton from rainfall), the limit of the Capital Cost would be £400 per acre.

It is not for one moment suggested that such expensive undertakings would be justified until we know a great deal more about the production of irrigated cane under South African conditions than we do at present, but, in order to show that the irrigation of cane justifies a high capital cost, the irrigation works of the McBride Sugar Co. on the Hawaiian Island of Kauai may be cited.

These works serve an area of 300 acres at a capital cost of £96,000, giving a capital cost of £322 per acre.

(b) Pumping Plants:

In this case the annual cost of irrigation is made up of:—

(1) Interest and Redemption on the Capital Cost of the Plant.

(2) The Operating Costs and Maintenance on the Pumping Plant.

From recent estimates it appears that the cost of Crude Oil Pumping Plants is roughly £37 per B.H.P.

Also, on a basis of 3 acre feet per ton of sugar, with the Plant operating 3,000 hours per annum, the B.H.P. required per ton of sugar is $\frac{8H}{3000}$ where H is the total pumping head in feet.

Hence the Capital Cost of the Pumping Plant per ton of sugar produced is $\frac{£296}{3000}$ H say $£\frac{H}{10}$ per ton of sugar.

Repaying this Capital in 10 years at 5 per cent. interest works out at an annual charge of £.0128 H. per ton of sugar.

From empirical data, we find that the Operating Cost of the Plant is given by $\frac{£0.935\ H^{0.61}}{S^{0.39}}$ per ton of sugar where H. is the Pumping Head and S. is the tons of sugar produced by operating the plant.

Assuming that, owing to the broken nature of the ground, an average production of 100 tons of sugar per plant, then:

Running Cost = £0.1552 H. per ton of sugar produced.

Thus the total Annual Cost per ton of sugar works out at approximately £.0128 H. + £0.1552 H.

If H. is taken as 200, this works out at £2.56 + £3.96 = £6.52, and this, as we have seen above, is about the limit of payability.

From this it will be seen that, generally speaking, it does not pay to irrigate with small plants when the lift exceeds 200 feet.

It is possible that, by use of large plants, and especially if electricity can be obtained at a low cost per unit, the limit of height, as ascertained above, may be increased.

(c) **Storage Schemes.**

Owing to the steep grades and narrow valleys of the Natal rivers, these will, generally speaking, be expensive, With the exception of the dams built by the Natal Estates for cane irrigation at Mount Edgecombe, I know of no other storage works.

It is quite possible that dams having a small storage capacity may be constructed in favourable positions in order to tide over a short period of low water.

The total annual cost of such storage works should not exceed £2 per acre foot of nett. storage.

The Fahey Conference Agreement placed the cost of cane to produce 1 ton of cargo sugar at £7 15s. 9d (·£7.7875). This will, with average prices for cane, give the grower a profit of from £1 4s. 3d. to £2 4s. 3d. with cane at from 18/- to 20/- per ton.

Estimating as before £3 per ton of sugar as the working costs of producing the extra tonnage of sugar under irrigation, we find that an amount of £4.7875 per ton of sugar can be spent in supplying water before the costs of production equal the cost of producing under rainfall conditions.

Reasoning on the same lines as before, we find that:—

Reasonable Capital Investment on Gravitation Schemes would be £60.09 per ton of additional sugar produced by irrigation, or £300 per acre with a production of 5 tons of sugar per acre from irrigation.

With Crude Oil Pumping Plants, allowing the same limit for Water Supply Costs, we find that the payable lift would be about 135 feet. In the case of storage schemes the total annual cost should not exceed £1 12s. 0d. per acre foot of storage.

These figures are based on present day prices and costs. If there is a fall in the price of cargo sugar, then the above figures would have to be amended accordingly.

6. EXAMPLE OF FIELD IRRIGATION:

As remarked above, the irrigation of cane is just emerging from the experimental stage, so that very little has been done as regards developing field technique.

The Natal Estates, who, to the best of my knowledge, have been systematically irrigating for a longer period than elsewhere, have developed the following method on their Mount Edgecombe Estate:—

The water supply is pumped to the required elevation, and from there it is conveyed by ditches to the contour furrows, which are given sufficient fall to carry the available flow.

Water is turned out from these contour furrows into the cane rows, which are generally on steep hillside slopes; the quantity of water which is allowed to pass down each row is fixed by the judgment and the experience of the irrigator.

Before the water reaches the bottom of the row, it is turned off by the irrigators working pairs, one of whom watches the water proceeding down the rows, and shouts to his mate when to cut off and turn it down another row. I am informed that, with experienced Indian irrigators, there is very little loss of water by this method.

The cane rows are planted 5 to 6 feet apart, the trash being left between every alternate row; no attempt is made to plant rows on any system to facilitate irrigation.

With a flow of 30,000 gallons per hour, the depth applied at each irrigation is from 3 to 3½ inches; the area covered by each irrigation during an 8 hour day is 3½ acre.

Apart from the usual field expenses, the special charges incidental to the production of increased yield from irrigation are as follows:—

Cost of Irrigation	26/3 per acre.
Cost of Cutting and Loading	25/- per acre.
Cost of Production at Field	51/3
Allowance for Railage and other charges	8/9
	60/-

With an increased yield of 1 ton of sugar per acre, the irrigation charge is therefore £3 per ton of sugar. With a larger tonnage per acre, the item "Cost of Irrigation" is cut down, and hence the cost per ton.

The above system of irrigation is cheap and simple, but, no doubt, with increasing experience improvements will be effected in the layout of the lands and cane rows, so as to spread the water more effectively.

To effectively distribute the water over the ground is most important, as cane is a shallow rooted plant, consequently the water soon percolates below the roots, and is wasted. It is, therefore, essential that the individual waterings should be just sufficient to provide the necessary soil moisture in the root zone and no more, if possible.

Another improvement will be in the direction of applying water so as to obtain the maximum growth; thus, during the heat of summer the growth is much more vigorous than in the winter; consequently the cane requires considerably more water during that period. In order to determine this, however, careful experiments are required in order to find how the Uba Cane responds to application of water for various months in the year.

7. CONCLUSION:

Summarising the prospects of cane under irrigation in the Sugar Belt, it would appear that:—

1. The water supply is sufficient for a greatly increased production, estimated at some 270,000 tons of sugar.

2. To produce this quantity of sugar, an area of 45,000 to 270,000 acres of good land will be required.

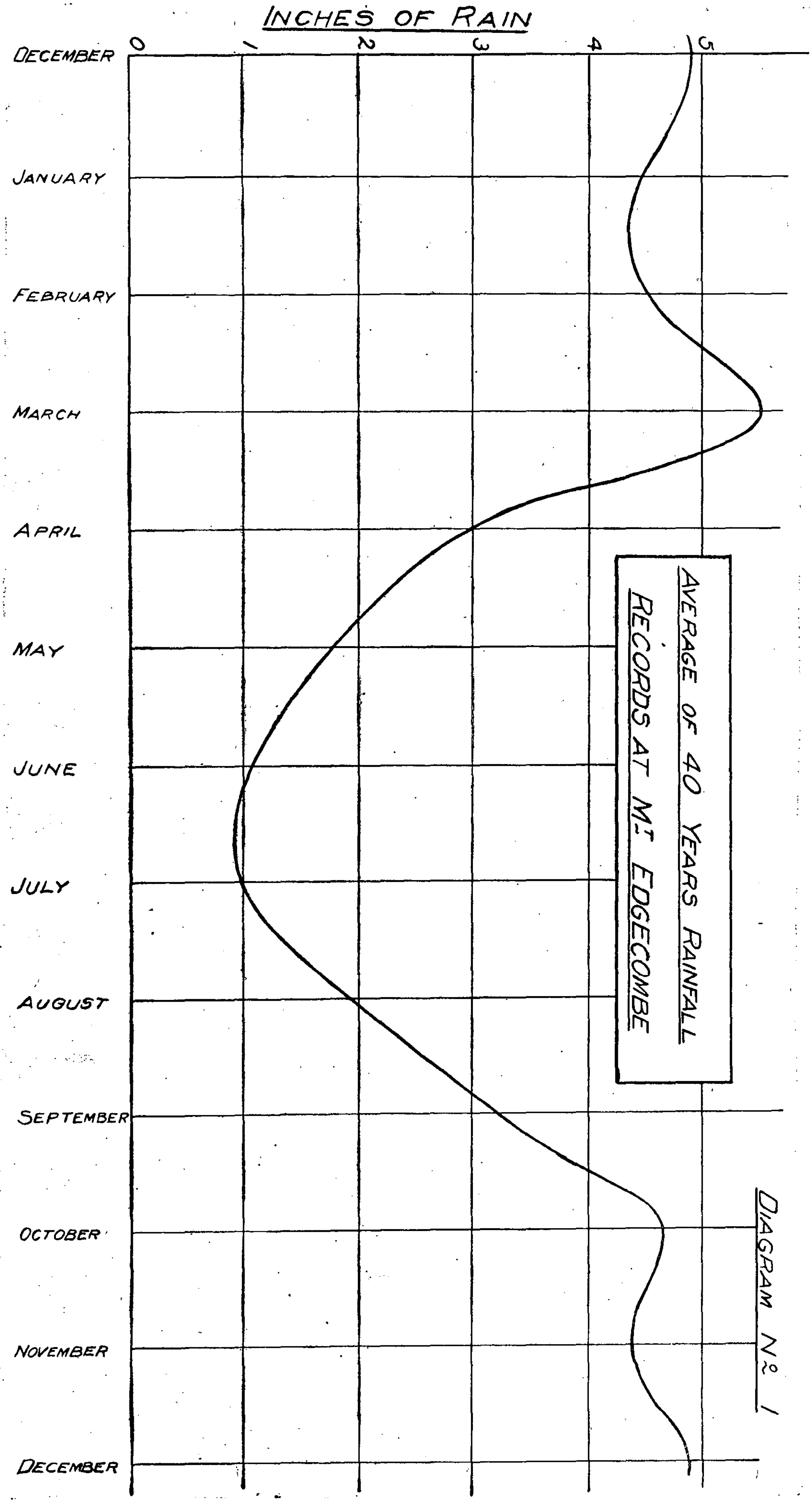
3. Owing to the topography of the Sugar Belt irrigation schemes will, generally speaking, be expensive.

4. On the other hand, owing to the excellent response which cane makes to irrigation, schemes for the irrigation of cane will bear high Capital and Annual Charges.

5. As the coastal rivers have eroded deep valleys, pumping will have to be resorted to in many instances; from the rough estimate made, it appears that from 135 to 200 feet would represent the economic lift for Crude Oil Plants, running at a cost of 0.6d. per B.H.P. hour. With a cheaper form of power, higher lifts will be economically possible.

6. Further experiments are required to determine how Uba Cane responds to the application of water with various types of soil, degrees of fertility, etc.

Department of Irrigation,
Pietermaritzburg.



INCHES OF RAIN
0
1
2
3
4
5
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
AVERAGE OF 40 YEARS RAINFALL
RECORDS AT MT EDGECOMBE
DIAGRAM No 1

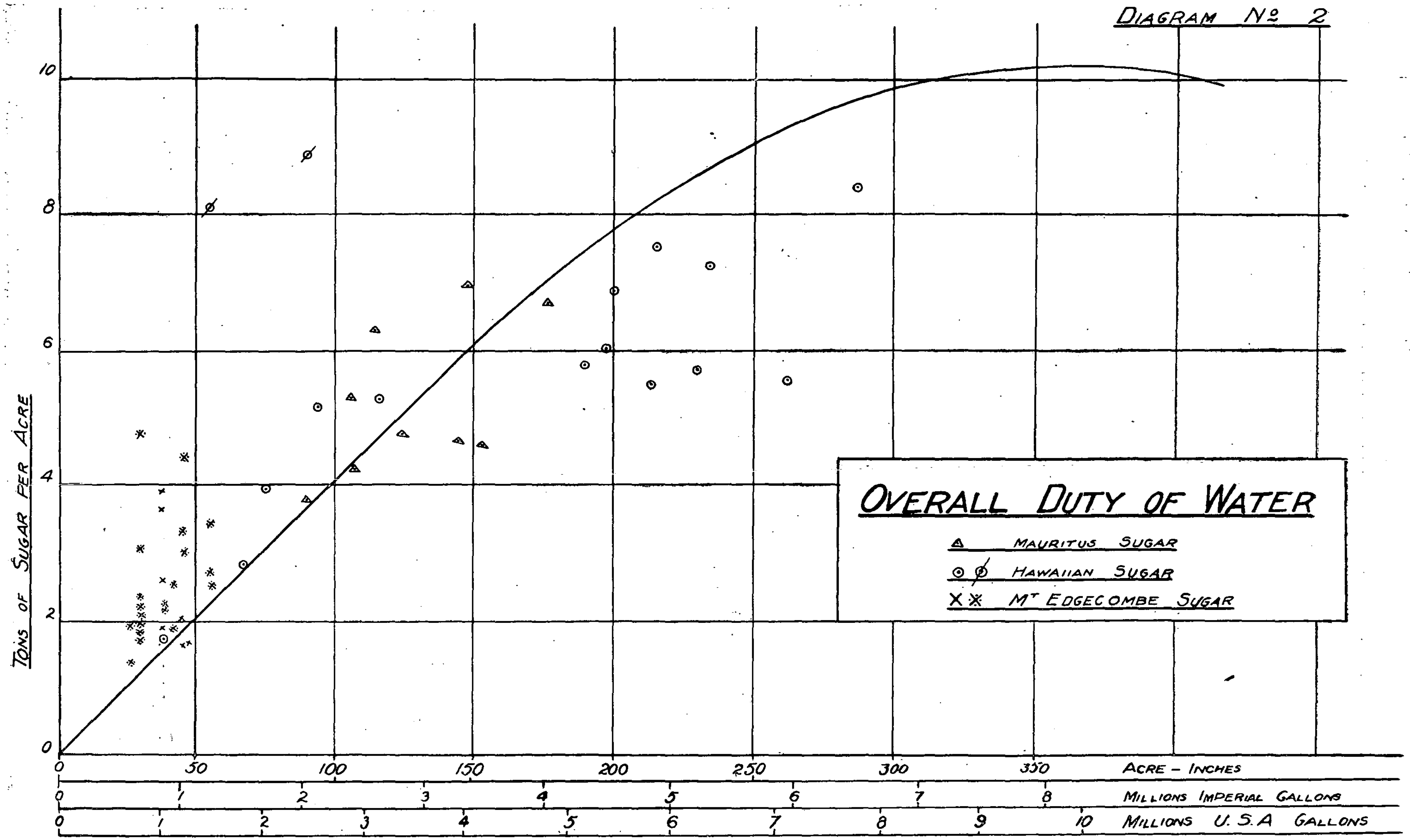
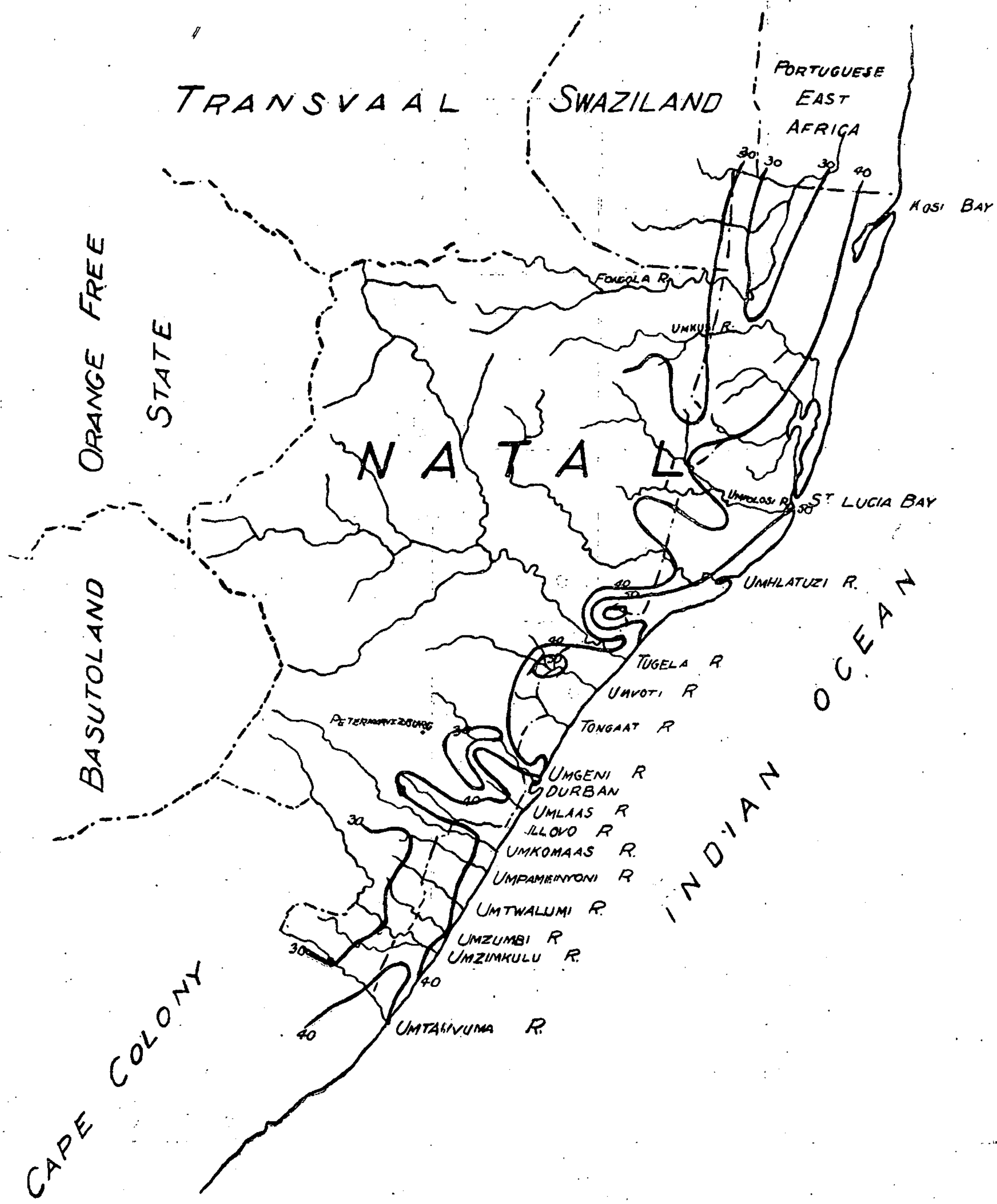
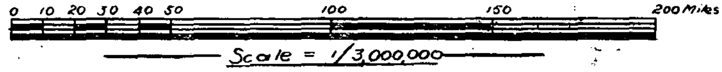


DIAGRAM No 2
OVERALL DUTY OF WATER
MAURITUS SUGAR
HAWAIIAN SUGAR
Mt EDGECOMBE SUGAR
TONS OF SUGAR PER ACRE
0
2
4
6
8
10
0 50 100 150 200 250 300 350 ACRE – INCHES
0 1 2 3 4 5 6 7 8 MILLIONS IMPERIAL GALLONS
0 1 2 3 4 5 6 7 8 9 10 MILLIONS U.S.A GALLONS



—PLAN SHEWING CANE BELT IN NATAL—



Scale = 1/3,000,000

SCHEDULE No. 1.

	1	2	3	4	5	6
RIVER.	Catchment Area. Square Miles.	Mean Rainfall over Catchment. Inches.	Minimum Flow. Cusecs.	Estimated Average Discharge Cusecs.	Ann. Vol. of Min. Flow. Acre-feet.	Tons of Sugar (on basis of 3 acre-feet per ton of Sugar).
Umtamvuma	630.0	34.3	80.7	136.90	58,424	19,475
Ibezana and others	234.5	28.5	3.0	38.40	2,174	724
Umzimkulu	2561.8	37.7	404.5	433.87	292,846	97,615
Umzumbi	304.0	34.9	18.1	62.53	13,104	4,368
Umtwalumi	208.6	34.7	22.9	41.59	16,579	5,526
Ifafa	122.6	37.5	12.9	25.40	9,339	3,113
Umzinto	84.8	37.5	4.1	16.63	2,968	989
Umpambinyoni	259.2	34.1	3.8	51.44	2,751	917
Umkomaas	1516.8	41.9	188.8	347.55	136,686	45,562
Illovo..	410.2	45.0	22.0	111.55	15,927	5,309
Umbogintwini	83.3	41.9	1.8	81.51	1,303	434
Umlaas	390.6	35.7	2.2	83.21	1,593	531
Umhlatuzan	100.9	45.0	4.7	24.42	3,403	1,134
Umgeni	1,689.8	38.5	136.0	237.83	98,460	32,820
Umhlanga	42.9	41.0	0.7	9.20	507	169
Umhloti	145.6	45.0	34.2	37.17	24,760	8,253
Tongaat	192.5	45.0	19.2	49.78	14,045	4,682
Umhlali	103.8	45.0	5.8	25.12	4,199	1,400
Umvoti	1092.8	37.4	109.7	252.91	79,420	26,473
Nonoti	69.2	47.6	4.7	17.47	3,403	1,134
Sinkwazi	22.8	45.0	No record	5.36	..	..
Tugela	11,317.8	35.8	300.8	1,074.55	217,770	72,590
Inyoni	34.2	45.0	No record	7.94	..	..
Matikulu	349.4	46.1	13.2	96.11	9,556	3,185
Umlalazi	169.4	55.0	3.9	52.16	2,823	941
Umhlatuzi	1,580.6	39.5	103.7	263.35	75,076	25,025
Umfolosi	3,470.5	36.9	41.8	508.11	30,262	10,087
Total for Rivers South of the Umfolosi			1,543.6	4,291.96	1,117,376	372,458
Umlalazi	237.7	43.0	Nil.	58.73	..	..
Hluhluwe	381.0	40.9	4.3	94.13	3,106	1,036
Umsinene	319.8	40.0	0.3	75.39	217	72
Mkuzi..	2,048.0	33.4	20.3	372.90	14,697	4,899
Pongola	4,422.0	32.5	265.7	434.08	192,358	64,119
*Usutu	6,096.0	30.2	418.5	542.50	302,980	100,994
Total for Rivers North of the Umfolosi			709.1	1,577.73	513,358	171,119
GRAND TOTAL			2,252.7	5,869.69	1,630,734	543,578

*Half flow taken on the assumption that the flow in this river is divided equally with the Portuguese Territory.

Chairman: As you know, we have a Committee of this Association to deal specifically with the problem of irrigation and drainage of the soil, but unfortunately during the past season it was impossible to find any suitable member who would consent to act as convenor. Therefore the work of that Committee has been in abeyance. But fortunately Mr. Hudson Spence has stepped into the breach and given us this most comprehensive paper on the possibilities of irrigation. I think it is an eye-opener to all of us. We all have the vague idea that the output and production of our cane fields could be very largely increased by irrigation, but this, so far as I know, is the first time that any accurate survey has been made of the possibilities, and it is surprising to learn that the output of sugar in Natal could easily be more than doubled. There are many interesting points arising out of this paper that I am sure you will want to discuss.

Mr. Masters: Before congratulating Mr. Hudson Spence on this very comprehensive paper he has put before us I would like to draw attention to one point for fear that would-be irrigationists might be frightened about the capital cost. Mr. Hudson Spence mentions in one part that the capital cost was £300 an acre. Certain soils can't stand that, but from our experience in South Africa I think I can safely say that the capital costs generally speaking where water is available, will not be more than £50 per acre, that is if you are dealing with 100 acres or more; you need not expect more than that amount. That, applied right through our system, is, approximately, how it has panned out to date. Dealing with the 2.1 tons of sugar per acre from Uba cane, it might be of interest to state that we are hoping to get that 2.1 tons per annum instead of every two years as we are doing at present, with the application of irrigation. We hope with the application of 25 to 30 inches put on at the right time that we will be able to get that 2.1 tons per acre per annum from fields that are under proper irrigation. From our past experience we know that we can expect it; on some of our better areas where we have been able to put on 15 inches, we have been able to get a crop of 24 to 26 tons per acre. My object in making these remarks is to draw the attention of the meeting to the fact that planters, generally speaking, should not be frightened of irrigation because the initial expenses are not nearly as much as might be anticipated. In our particular scheme, which would probably discourage the average planter, we have to remember that we have to lift the water over 500 feet, but, nevertheless, in lifting that water that distance and dealing with the area we hope to put under irrigation, which is 5,000 acres, with 40 cusecs, we still hope that our capital expenditure will not be more than £50 to £60 per acre. Might I say that I want you to bear in mind that the first part of the scheme, as you will all agree with me, is not going to be an economical outlay, that is to do a portion of the scheme to start with, and then add to it like a patchwork quilt. Therefore we have to lay out a good deal of money in the first phase of the scheme to attain the ultimate object. In the first two to three years I would not be at all surprised if our costs per acre ran up to £150, but ultimately when we have our 4,000 to 5,000 acres under irrigation, I don't think I will be far wrong in stating that it will not cost more than £50 to £60 per acre capital expenditure. The chief thing one has to consider with irrigation is the running costs. We went into this most exhaustively and found that with the cost of current at 0.7d. or 0.8d. per unit, it almost killed it. Other methods had to be considered, and we found that if we could only get our current at 0.2d. or 0.4d. we have every hope that we will be fully justified in extending in every direction. We went exhaustively into the cost with crude oil engines also, and we had figures from Port Elizabeth. I wish to support Mr. Hudson Spence in every sense of the word on irrigation for Natal areas, and I also agree with him that, generally speaking, small irrigation works do not pay. Capacity, like everything else, is what pays. The ultimate success of any capital expenditure depends on the running costs. These running costs we have got down to such a basis that before one ventures into a scheme of irrigation one can say almost mathematically what the running costs are going to be. Speaking offhand from our experience, we find that 3 to 4 units can deal with five to six acres per day, and I don't think I am wrong in stating that our method of applying water may be considered crude at the present time. But we have been in the fortunate position of being able to apply all water on hilly lands and picking it up at the bottom of the hill lands and taking it on to other areas. I feel that I want to support Mr. Hudson Spence in this irrigation problem we are faced with to-day, as there is no doubt that it is the thing of the future. We hope to get on one acre in one year what we are getting in two years now. We are irrigating areas with probably the most expensive scheme that could be thought of in Natal, and when one thinks of the other much more favourable possibilities in Natal, one stands almost aghast that opportunities are not taken more advantage of. Gentlemen, I don't want to take up too much of the time of the meeting this afternoon, but I do say that where anybody can put in a scheme that is not going to cost more than £30 to £50 per acre, and where the running costs are not going to be more than .6d. or .7d., and where you can pump to a high point and gravitate and lay your furrows out on a contour, there is no question about it; it is not a gamble; you must make money every time. I don't think there are any other points in the paper I want to comment on. There is just one remark about the water being turned off before it reaches the bottom of the furrow, in paragraph 6 (Example of Field Irrigation). There is very little loss of actual water so far as we can see by the eye, but naturally the seepage losses are a great deal more than if we had proper furrows, and then there is the evaporation losses on top of that. As to the cost of irrigation, I think Mr. Hudson Spence has quoted our figures here, and they are on the high side. Our object has been to keep the figures on the high side, and it is most gratifying to us to see that from the figures plotted in the curve by Mr. Hudson Spence our figures have been on the conservative side, and still we have come out at a profit. That has been our object, not to put any pretentious figures before anybody, but knowing that we were the only people who are really irrigating on a somewhat large scale it is gratifying to see our figures have panned out in the way we expected.

Mr. Hudson Spence: I must first of all thank Mr. Masters for the remarks he has made, and I particularly want to thank The Natal Estates, Limited, for their kindness always in letting me have such results and letting me see their work, so that I may be able to give the Association the benefit of their considerable experience in the matter. Mr. Masters mentioned that their present scheme, which will irrigate 5,000 acres, will work out at about £50 to £60 per acre capital cost. Of course don't forget this is a pumping scheme, and by capital cost Mr. Masters simply means the capital outlay for the cost of plant; that is quite apart from the running costs of the scheme. But he expects to get something up to two tons of sugar per acre from irrigation. Now it will be seen if you refer to my paper that I estimated the reasonable costs for capital investment for gravitation schemes at an amount of £6 for every ton of additional sugar produced by irrigation. Mr. Masters, of course, expects to produce two tons, so that the other ton would have to cover the working expenses so far as I can see. I think it is just a little erroneous to base the capital cost per acre on this output, because you must take into account that you need not produce only one extra ton or two extra tons, but it is quite possible to produce five or six tons; so that it would be better instead of talking about the capital cost per acre make it the capital cost per ton of sugar produced per acre. If you produce five tons of sugar per acre you can afford to spend more than the £60 per acre. As regards running costs, Mr. Masters remarked that they found .7d. to .8d. per unit of electricity, which works out at .5 to .6 B.H.P., killed their scheme. Their particular scheme is for pumping 500 feet instead of 2000 which I lay down as the maximum, so I think you will agree that Mr. Masters' experience and my paper agree on that point. On the other hand, if you get your units at a lower price then you can pump to a much greater height. Mr. Masters says they went into the cost of crude oil engines and obtained the costs of that. Was that not a few years ago?

Mr. Masters: Four years ago.

Mr. Hudson Spence: Prices were much higher then than they are now. Of course I would not be dogmatic. I took a number of plants the Department had considered, and got the average cost of what they reckoned it was going to come out at, and I arrived at my figures in that way. I wish to thank Mr. Masters very much for his remarks.

Mr. Masters: I would like to refer to one point. Why I mentioned the 2.1 increase in one year is because I am not optimistic enough to be concerned with any increase over that at present. We have very little information about our soils in Natal. Where in Hawaii you might put on 150 inches it would be very optimistic on our part to think that we could put that on our coastal belt soils, without thoroughly investigating the problem. We know that on the shaly soils by the application of water we are releasing certain chemical constituents, and we expect an appreciable result from that, but at the same time we are losing a lot of water in the shale. So that when I say we expect to get 2.1 in one year which we get now in two years I am not too optimistic. I wish to be conservative in this matter.

Mr. Hudson Spence: It is a very interesting point raised by Mr. Masters. You will understand of course that these figures are simply arrived at from results obtained from abroad mostly. I have tried to test them as far as possible by the very few results we have in this country, but I think it has proved that the graph I gave you works out very well. What we really must do now is to carry out a series of experiments and find out what our soils can do under irrigation in the various parts of the sugar cane belt, and thus get a series of curves showing how the tonnage of cane per acre increases with varying applications of water in the various months in the year. Once we have a certain amount of that information then we will be able to say with a good deal more certainty what can be done; then in addition to that we have to see whether all our soils have sufficient drainage and whether their chemical and physical compositions will stand heavier applications of water. They may possibly not stand it. That is why it is necessary to carry out experiments in a matter of this kind.

Mr. Bihl: In Schedule No. 1, Rainfall Returns, it shows the minimum rainfall for Nonoti as 4.7 cusecs. We have kept careful records and find it is 2.6 minimum.

Mr. Hudson Spence: You have a small weir there now. Our gauges are not quite so accurate, and we had to take the flow gaugings as well as we could. We have, however, a three years' average record, and the wet year preceding your readings would bring it up a little probably.

Mr. Schwikkard: I would like to support Mr. Masters in what he says. There is one aspect that has not been raised and that is this: From experience in the Cape very injurious effects have been found to result from continuous irrigation. I think that opens up an important aspect of this subject. I see in Schedule No. 1 we are given information about the maximum and minimum flow of the rivers, but we have no information as to the content of injurious salts in the waters of those rivers. So that before embarking on any irrigation scheme I should imagine any practical man would have to satisfy himself that his soil would not eventually go to brack. I would also ask for a little information on the science of the application of water to the soil to prevent brack.

Mr. Hudson Spence: With regard to the toxic effect on certain soils by the application of water on the soil, I would explain that the conditions in the Cape, particularly in the Karroo, are very different from those obtaining in Natal. I don't know whether Mr. Schwikkard has been down the rivers in the Karroo, but the conditions there are such that you have throughout the year a very small rainfall, very small compared to Natal rainfall, only about a third of it, and the result is that owing to the breaking down of the soil there is a gradual accumulation of salts in the soil, not only injurious salts but beneficial salts also, which are not carried away by abundant rainfall such as they would be by Natal rainfall. The result is that when you apply water to those areas as in irrigation you simply swamp the land, penetrating the soil to considerable depth, absorbing these salts, and by capillary action lifting them to the surface, where evaporation takes place, which leaves a layer of salt on the land in which no plant will live. I might say here that in a clay soil this accumulation of brack is far more injurious than in a sandy soil, because in a sand soil it is possible by the application of large quantities of fresh water to wash these salts out again, but in clay soil it materially effects their composition and causes them to have a toxic effect. I don't think you will have the same trouble here in Natal. All the waters in these rivers appear to be quite sweet. Of course before you went in for a large scheme you would have them tested, but your rainfall is so great that I don't fear any accumulation of salts.

Chairman: We have had several samples of water from springs and coastal streams submitted to the Experiment Station for examination during the past year or two, and without exception all the coastal streams have shown compositions which were well within any danger point from brack.

Mr. Masters: In irrigation, I think the world over, where you go in for heavy irrigation it must be generally understood that you must have a definite system of rotation. If you are constantly irrigating and simultaneously with irrigation you are fertilizing heavily, you must have a definite rotation, otherwise you are going to waterlog your land sooner or later. Cane does best if you can get suitable drainage down to four feet. If you raise that water level above four feet without a proper rotation system, within a few years you are going to have trouble. With any irrigation in Natal it must be understood that we will be obliged to have a rotation system of not less than 15 to 20%.

Mr. Moberly: In connection with the system outlined for running water down the rows, does it not necessarily mean having the rows running up and down the hills? What is the effect of that in causing erosion?

Mr. Hudson Spence: You need not have the rows running directly up and down, you can have them slanting to avoid a heavy grade. As I mentioned, one would have to lay out your lands to facilitate irrigation as far as possible. From a planter's point of view I don't know how it works out. If you have a number of contours and have to be continually changing the direction of your rows it might be very awkward. I think that will be a matter to be worked out so far as field technique is concerned before we can say very much on the subject.

Chairman: I think it is generally admitted that lack of moisture is a limiting factor in the productivity of our cane fields. That being so, it is urgently necessary, in order to increase that productivity to alter that limiting factor and I think the time will surely come when the great majority of our sugar cane fields will be grown under irrigation. That time I am sure will be much hastened by such excellent papers as we have had from Mr. Hudson Spence. There is one point that has frequently occurred to me both during the original paper and the discussion that has taken place, and that is the need for experiment work in irrigation. At present, although we know little enough, goodness knows, regarding the cultivation of cane without irrigation, as a result of systematic experiment, nevertheless, at all events, a beginning of the necessary experimental work has been made, whereas as regards cultivation under irrigation, which will bring other new problems, we are still entirely in the dark and not even a beginning has been made as yet of experiment. I hope that the industry will realise the need for providing facilities for experimental work in irrigation along the main lines that have been shown to be necessary in this paper. I will now ask you to join in a very hearty vote of thanks to Mr. Hudson Spence for his excellent paper.—(Loud applause.)