I have the honour to forward plan and section, and a tracing, showing the proposed Escape to the Fuleli Canal commencing in the 92nd mile. The Escape, including a head regulator, rapid, and three bridges, is estimated to cost two and a quarter lakhs of Rupees.

2. I am not acquainted with the District, nor experienced in canal work, therefore hope that the following remarks may be taken for what they are worth.

3. From examination of levels on plans, which I must take as approximately correct, in the absence of better data, and from information I have received, the line proposed for this Escape, running 15 degrees south of east, does not appear to me to be a good one.

4. Some of my reasons for this opinion are-

(a). The distance from the head of Escape in mile 92, to the Runn of Kutch, by this route, is 60 miles, and the total fall to mean sea level is 16.83 feet, from the lower end of the rapid, giving an average fall of only .28 feet per mile, whereas by route No. II, (see statement A) the distance to the Runn of Kutch is 41 miles, giving an average fall of .47 feet per mile. By the most direct route No. III, which might be found feasible, the distance would be about 35 miles, giving an average fall of .55 feet per mile.
(b). In 1878, a flood came from the north-east and from what I am told, ran across the line of the Escape, washing away some houses in Nindo-Shahr, a village shown on tracing, about 2 miles south of the line of Escape, therefore it appears to me dangerous to place a continuous bank, 17 miles in length, from West to East. This embankment averages 5 feet in height, and for about 2 miles in the centre, it is 9 feet in height. This is probably the portion over which the floods came. If the Escape was breached, it would be at this place, and the town of Nindo-Shahr would probably suffer.

(c). The R. L. of bed of Escape and cold weather water level of the Puran is given as 8.00, therefore, the backwater, from every foot of water coming down the Puran, would extend 2 miles along the Escape. If this Escape were made I would recommend that the neck "a b" shown on tracing, be cut, to a level 2 or 3 feet lower than bed of Escape at tail.

5. I consider that such an important work as this Escape should be carefully surveyed by a special experienced Engineer, so that if possible, the best and most economical route may be selected.

6. From the reduced levels on tracing, the bed of the Puran is R. L. 8, less depth of water in cold weather at tail of proposed Escape, while it is shown as 7, twenty-one miles further on towards the sea.

I have, etc.,

Sd. T. Summers, M.I.C.E.,

Ex: Engineer, Fuleli Canals.
### Statement A.

#### I. Proposed line JKMNP.

<table>
<thead>
<tr>
<th>Proposed Escape</th>
<th>Length in Miles</th>
<th>R.L. at head</th>
<th>R.L. at tail</th>
<th>Fall</th>
<th>Fall in feet per mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Puran' from tail of Escape to Rum of Kutch</td>
<td>17.5</td>
<td>16.83</td>
<td>8.20</td>
<td>8.63</td>
<td>0.50</td>
</tr>
<tr>
<td>Total</td>
<td>60.0</td>
<td>16.83</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average fall per mile for whole distance = $\frac{16.83}{60} = .28$ feet.

#### II. Route by Semi Luni into 'Puran' at 21 miles lower down than proposed escape. LNP

<table>
<thead>
<tr>
<th>Semi Luni commencing at 93 of Faller to Puran</th>
<th>Length in Miles</th>
<th>R.L. at head</th>
<th>R.L. at tail</th>
<th>Fall</th>
<th>Fall in feet per mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Puran' from tail to Rum of Kutch</td>
<td>42.5</td>
<td>8.20</td>
<td>0.00</td>
<td>8.20</td>
<td>0.19</td>
</tr>
<tr>
<td>Total</td>
<td>60.0</td>
<td>16.83</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average fall per mile for whole distance = $\frac{16.83}{60} = .28$ feet.

#### III. Direct route by Semi Luni, Rajpol Kothan, and Singhari Khoto to Rum of Kutch - 100

<table>
<thead>
<tr>
<th>Semi Luni Rajpol Kothan</th>
<th>Length in Miles</th>
<th>R.L. at head</th>
<th>R.L. at tail</th>
<th>Fall</th>
<th>Fall in feet per mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rajpol Kothan tail to Singhari Khoto</td>
<td>14.0</td>
<td>17.30</td>
<td>10.15</td>
<td>9.17</td>
<td>0.65</td>
</tr>
<tr>
<td>Singhari Khoto to Rum of Kutch</td>
<td>35.0</td>
<td>8.38</td>
<td>0.00</td>
<td>8.38</td>
<td>0.55</td>
</tr>
<tr>
<td>Total</td>
<td>35.0</td>
<td>19.30</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average fall per mile for whole distance = $\frac{19.30}{35} = .55$ feet.

Chas. Summers, Executive Engineer, Fallali Canals.
From
The Superintending Engineer in Sind,
To,
The Executive Engineer, Fuleli Canals.

Sir,

I have the honour to return the plans received with your No. 5016 of 8th inst. for further consideration and investigation, as the project has evidently not yet been sufficiently perfected to send on to Government.

I hope to be able to get over the most of the southern part of your District towards the end of this tour, and meantime, I request you will make a careful examination of the country, and have whatever surveys and levels you think necessary, taken, to enable me to arrive at a final decision as to the line of Escape, when in the neighbourhood.

The line should be the shortest, and follow lowest ground; it should not be used for cultivation, and of course interfere with it as little as possible; it should act as a drainage channel for the country, as well as for the Fuleli.

It will be most used in the cold season, when Puran is low.

The recurrence of a flood like 1878, need not be provided for, if any flood arrives, it must be passed down the Escape and over it.

It is not easy to arrive at what the proper size for the Escape should be, but it should be able to discharge the cold weather supply of the Fuleli, when all its branches are 'banded', and about 4 to 5 feet passing its Head Regulator.

I have, etc.,

Sd. H. W. Thompson,
Superintending Engineer.
No. 821 of 1892,
Public Works Department,
Camp Gulab Joghari, 25th February, 1892.

From
The Superintending Engineer in Sind
To
The Executive Engineer, Fuleli Canals.

Sir,

I have the honour to acknowledge receipt of your No. 5013 of 8th October last, and accompaniments, and to inform you that from my late inspection of the tails of the Fuleli, I have come to the conclusion that an Escape of the nature previously contemplated is impracticable.

2. All that can be done in this direction, is to open out the tails of the Suni Guni, Ali and Sher wahs, right into the Bun or sea. I shew in ink on plan No. 25, herewith returned, what I think ought to be done.

In the first place, an Escape channel for the Ghar Kadhah, along line 'bc' should be opened out into the Rajash.

The Rajwah Escape should be made, altered, as at 'd,' and the Suni Guni Escape changed as at 'c.' The Singhari Dhoro, and its continuation, should be cleared, and opened out to the sea. The tail of the Aliwah from X to y should be opened out, and an Escape made for the Sherwah large, somewhere about the line 'm n'.

The cost of the above works appears to be debitible to the Capital account, and the Estimates should be separate.

3. There is, however, little use in providing for Escapes, unless the Canals are at the same time put into proper order, and this would be charged against Revenue. For this purpose, levels and cross sections will be required, with a careful register of all Karias, their size and cultivation.

You ought to have no difficulty in getting the necessary Surveys and
and levels for all these finished before 1st May, as the Gaja ought to be almost done, and the Imam Janobi ought not to take more than 3 months.

I have, etc.,

SD. H. M. Thompson, M.I.C.E.,

Superintending Engineer in Sind.
EXTRACTS paragraphs 2 and 3 from the Superintending Engineer in Sind's No. 4247 of 17th October 1892.

2. Believing in common with all officers who have had anything to do with the Fuleli, that an Escape for its surplus waters is most urgently required, I differ from some, however, in considering that an Escape, to be of any practical good, must be used solely for the purpose of getting rid of water, not required for cultivation, and that no other duty should be expected of it. This condition, which in my opinion is essential, precludes at once the construction of an Escape, except through land where the necessary interference with vested rights would be slight, and compensation small. The sphere of selection is thus greatly narrowed, and in this case is practically reduced to the area between the Alibahr Karo and Wangiwh, and which, the line A.B. on the accompanying sketch plan has been chosen, surveyed and estimated. The cost of an Escape on this line would exceed two lakhs of Rupees and the levels were so unsatisfactory, that it would be quite possible, in the event of heavy general rain, when relief would be most wanted, for the channel not to act at all, or even to flow back into the Fuleli.

3. For these reasons, I was forced to abandon all idea of any independent Escape channel. I devoted the rest of my time to an examination of the tail branches of the Fuleli, for the purpose of ascertaining how far it might be practicable and useful, to open out and extend the tails of the lower branches into the Puran, or
or other natural depressions, along the coast.

---00---

No. 180 of 1893

Public Works Department,
Commissioner's Office,
Garhi Khairo, 20th January, 1893.

True Extract forwarded to the Collector of Hyderabad for information, in reference to his letter No. 138, dated 13th January, 1893.

By order

(Signed) S laden,

Asstt. Commissioner in Sind.
To

The Superintending Engineer, Indus Left Bank Division.

Sir,

I have the honour to forward plans, and estimate amounting to Rs. 2,49,754, for an Escape to the Puleli Canal, and to recommend strongly that this work—by far the most important of the works still to be carried out on the Puleli—should be commenced this season, when labour is expected to be plentiful. I have asked for Rs. 50,000 for expenditure in 1898-1899.

2. As the old Puleli (Q) is silted up considerably, and practically only supplies the Canals in the Hyderabad Taluka, which take off above the Nareja Regulator (S), the distances referred to will be taken from the new mouth at Jamshora (N).

3. The new Puleli, which was opened in 1856, joins the old Puleli at (O), just above Hyderabad. At mile 46, the Alipur Regulator was constructed in 1892, and has proved useful in raising the level of water in some of the Guni and Dero-Mohbut Canals.

4. At Talhar, mile 58 (K), a large branch, the Mirwah Talhar, takes off, which, as the Puleli is much silted up between Talhar and the Triple Sluice, mile 81 (N), may be called the tail of the Puleli. As shown by cross section on Drawing No. 4, the depth of the Puleli being only 7 1/2 ft. at highest known flood level, and depth of silt 4 feet, while depth of the Mirwah Talhar at highest flood is 15 1/2 feet, and its bed is scoured. This Canal could be made to flow all the year round, or during any time when work
work is going on at the tail of the Fuleli.

5. At the Triple Sluice (L) the Fuleli splits up into 5 branches, the Suni Guni, Aliwah large, and Sherwah large, which, when running full, cleared as they now are, on account of scarcity of funds, from 2 to 5 ft. above their beds, can carry off together at their mouth about 1100 cubic feet per second, but at their tails they can only carry off less than 1/2 of this, so that it can be easily understood what happens when the Fuleli is running at 7000 to 8000 cubic feet per second, and rain falls.

6. When this occurs all Government Canals taking off from the Fuleli have to be kept fully open, although breaches occur, as, if any are closed, more breaches occur in branches taking off lower down, as the water must find an escape somewhere.

7. If a telegraph line were laid from the Triple sluice to the mouth of the Fuleli or from Badin to Hyderabad, the nearest large towns to these places, a little of the flooding could be saved by shutting the Head Regulator, (B) and the Head Regulator (A) at the mouth of old Fuleli, which will have to be constructed if the Escape is not made, but any reduction of water level at mouth, lowers the water level in the Hyderabad, Guni & Dero-Mahbut Talukas, in which the land is high, and therefore the irrigation suffers considerably. In 1894, when 8 feet was cut off at the mouth of the new Fuleli, the fall in the old Fuleli (A), was much increased, and breaches could not be stopped in the tail, owing to the great discharge from the old Fuleli mouth.

8. A statement (B) is enclosed, showing cost of closing breaches, loss by remissions, etc. in the Bago Tando and Badin Talukas, from 1892 to 1894, in which 3 years the breaches closed by Government averaged 57 per year, and the loss by breaches and remissions together averaged Rs.
Rs. 9000. Besides this, the Zemindars closed an average of 33 breaches each year, at their own cost.

9. There is no doubt that the present state of this large canal is very unsatisfactory, the cultivators in the upper portions being deprived of water during high floods, while those in the tail get far too much. Besides this, the Fuleli has to be practically closed for about 6 months in the year, as its tail branches have to be cleared, thus depriving the people along its bank, and their cattle, of a supply of drinking water, and the gardens of water for their irrigation.

10. To remedy, or at least to considerably improve, such a state of affairs, I propose to cut an Escape into the 'Dhoro' Puran, along the line LM, which is almost a direct continuation of the Fuleli.

11. The bed width of the Escape I have made 40 feet, and side slopes 1 to 1, which will enable it to run off 1300 cubic feet per second, when running 10 feet deep, with its fall of 1 in 8000.

12. From the diagram in Drawing No. 3, it will be seen that during nearly 5 years, from 1st January 1891 to 20th October, 1895, the depth of water at the head for about 50 months out of 58 was 5 feet or more, which gives a minimum discharge of about 1000 cubic feet per second, nearly all the year round.

13. I have shown a longitudinal section of the new Fuleli, up to the Railway bridge, from which it will be seen that the bed is scoured out considerably, and that if thought expedient at any time, the whole bed of this canal may be lowered, by lowering the bridge pavements. In or about 1860, the pavement of the Stone bridge was lowered about 2 feet, but had to be raised again in 1888, on account of the excessive scour above endangering the Iron bridge. I propose to make a
new screw pile bridge, in place of the Iron bridge, which is far too small, and contracts the waterway. When this is done, the Stone bridge pavement may again be lowered, if thought advisable.

14. On plan, I have coloured red the land which is irrigated by the Aliwah large. This shows that the Escape will interfere very little with existing cultivation, and allowance has been made in the estimate for irrigating from Aliwah large, the strips of land (a good part of which is waste, and some saltish) in miles 3 to 6, cut off from Sherwah small. The land cut off from Aliwah large in mile 10, will be irrigated from the Suni Guni direct.

15. The Escape, in mile 14, crosses a small channel called the Bhimawah, which connects the Suni Guni and the Aliwah large, but this is of no consequence, as there is no cultivation on this channel, and the Suni Guni has an independent Escape. The Bhimawah might even be left open, and allowed to flow into the Escape.

16. I have shown the tail of the Jamrao canal, and of one of its branches, on the Index map, Drawing No. 1. These also discharge their surplus water into the Dhoro Puran, which is an old river channel, the mouth of which beyond is now being cleared to a width of 80 feet, with berms of 75 feet, to allow a free run off to the Sea for water coming down the Puran.

17. I give below a few notes on the advantages which will be derived from the Escape.

(1) Drinking water.

From figures from the Mukhtiarabs, it appears that from the last census, there are 180 villages within 1/4 mile of the Fuleli, with an average population of 140 in each, so that about 25,000 persons will get a supply
supply of drinking water for themselves and their cattle, all the year round, and the construction of many wells will be saved. At present people drink water from the Puleli which has been stagnant sometimes for 3 or 4 months. One of my assistants last season informed me that there was much sickness amongst his men, but when the Puleli was opened, the health of his men improved. The villagers also told me that they are anxious to have the Puleli running, on account of the good water.

(2). Safety of villages from floods, and improvement to the land by drainage.

At present a great part of the land south of the Triple Sluice is water logged, and Badin Taluka is one of the most unhealthy in Sind, owing to the annual flooding from breaches. The town of Badin itself (V) was in great danger of being flooded a few years ago. Lowari (V), Sindo Shahr (V), Kadhan (W) and several small villages and hamlets, are surrounded by marshes, some throughout the greater part of the year, and are rendered very unhealthy. Petitions are constantly being received requesting that something may be done, which is impossible in the absence of an Escape.

(3). Increasing supply of water in Hyderabad, Guni and Dero Mahobat Talukas.

Every year cultivators in these Talukas complain when the Puleli is regulated, as their supply is reduced, but when the Escape is made, the surplus water which must flow down the Puleli to give high water to these Talukas, will run off by the Escape, without doing any damage.

(4). Silting up of the Puleli bed.

For several miles above the Triple Sluice the bed of the Puleli is silted up about 4 feet in depth. This silt will be altogether, or at least partly scavenged out, as soon as the Escape is opened. In 1888-89 this portion of the Puleli was cleared at a cost of about Rs. 50,000, and it would require
require as much again to clear it now.

(5). Boats and Steam Launches.

The smaller boats, and the steam launches, ply, when the depth at mouth of Fuleli is 3 feet, therefore, as shown on diagram on Drawing No. 3, the depth would have been sufficient for 58 out of the past 58 months, as the gauge read 3 feet or above for 58 months.

(6). Gardens on the Fuleli banks.

Fruit and vegetable gardens will be irrigated along the Fuleli banks.


(1). During last year goods to the value of about 45 lakhs of rupees were carried up or down the Fuleli, by far the greater quantity being carried up to Hyderabad. The principal articles carried were:

<table>
<thead>
<tr>
<th>Value in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lakhs of Rupees.</td>
</tr>
<tr>
<td>--------------</td>
</tr>
<tr>
<td>Oil seeds about</td>
</tr>
<tr>
<td>Raw Cotton</td>
</tr>
<tr>
<td>Rice</td>
</tr>
<tr>
<td>Hides</td>
</tr>
<tr>
<td>Ghee</td>
</tr>
<tr>
<td>Groceries, dried fruit, &amp;c.</td>
</tr>
<tr>
<td>Sundries</td>
</tr>
</tbody>
</table>

A large quantity of this was carried by camels, in fact from Badin alone as much as 8000 charars, while the Fuleli was closed.

The cost of carriage of this by camel would be about Rs. 30,000, while by boat it would be less than Rs. 24,000, so that Rs. 56,000 would be saved from one Taluka. Part of this saving would come in to Government in the form of increased assessment, and perhaps a part as boat taxes, but whether it comes in to Government or not, it means increased prosperity in this
part of the country.

(2). Gold weather crops.

On the line of the Escape there are several thousands of acres now uncultivated on account of want of water, on which spring crops could be grown, and this source of revenue would probably be developed in a few years after it was opened, but at first it is proposed to use the Escape for flood water and for the cold weather supply in the Fuleli only.

(3). Cultivation in 'dhunds.'

There are many square miles of 'dhunds' close to the line of Escape which cannot be cultivated at all, as they are under water for nearly the whole year. As soon as the Escape is opened, these 'dhunds' can be cultivated, and will, I believe, produce specially fine crops, as they have been enriched by decaying vegetation for many years.

(4). Forests near the Fuleli.

There are several forests close to the Fuleli, the value of which will be increased, when there is water carriage throughout the year, so that firewood and logs can be carried to Hyderabad at any time. The increased revenue is estimated by the Forest Officer at about Rs. 1500 per annum, but in time this would be increased.

(5). Old Fuleli Head Regulator.

If the Escape is not made, it is absolutely necessary to have this regulator, which would cost about Rs. 50,000, but I think that this work should be postponed until the Escape is made, as it may be found that it is not absolutely necessary to have it then.

19. It is difficult to work out the percentage profit on capital cost.

I may be thought too sanguine, but I expect that the profit to Government will not be less than 30 or 40 per cent, as calculated very roughly and at
at low estimates below:

(1). Increased assessment in Bago Tando and Badin Talukas at 3 annas per acre on 160,000 acres, due to water-- carriage all the year round 30,000

(2). Cold weather crops, say 1000 cubic feet per second discharge

at Rs. 20 per c. ft. (a very low estimate) ------------------------ 20,000

(3). Raising water level in Hyderabad, Guni and Dero Mohbat Talukas (a low estimate) ----------------------------- 4,000

and

(4). Saving in cost of repairing embankments breaches,

and in remissions ------------------------------- 9,000

(5). Assessment on gardens -------------------------- 2,000

Rs. 85,000

20. Even if the Escape would pay 8 or 10 per cent, I think that it should not be delayed another season, as it will give a continuous supply of fresh drinking to some 25,000 people, and will turn large tracts in Bago Tando and Badin, from marshes, which are hotbeds of malaria, into a healthy country.

21. I again urge strongly that earthwork should be commenced this season, as there is 30,000,000 cubic feet to be done, and owing to the low Inundation this year, labour will be plentiful, and much work could be done at a much lower rate than in ordinary years.

22. The banks are high in about 8 miles, but in no place is the bed of Escape above ground level, as in the new mouth to Mulchand, which was opened this year, and in which only one very small breach occurred.

23. I propose to excavate all earth for banks from within the banks, a plan which makes them much safer, and much clearance is saved by the pits, which are soon filled up by silt. Work will be commenced from mile
mile 13 1/2, where the Escape crosses the Bhimawah, backward, so that as soon as a cut is made to mile 8 1/2, which would be done in the first season, many of the 'dhunds' could be drained.

24. As shewn on Drawing No. 4, the Sani Guni takes off with the Aliwah large and Sherwah large at the Triple Sluice. When the Triple Sluice was built in 1874-75, its new mouth was evidently made so as to have one sluice for all three canals, but when the Escape is made, I propose to open the old mouth, as shown, which could be done at a small expenditure, and afterwards the question could be settled as to whether an entirely new mouth should not be made, and the Sani Guni canal improved and cleared from mouth to tail, including its Escape.

25. I have shown mouth of Escape about 200 feet from Triple Sluice, as it would be difficult to clear the mouths of these canals while the Escape was running, owing to the percolation of water.

26. I regret that plans and estimates have not been prepared in greater detail, but the work had to be done during a busy season, and time could not be spared for more detail.

27. In conclusion, I beg to point out that the survey work was done by Mr. J. A. Gayer, overseer, during the hot weather, and that he did the work very expeditiously and well. Mr. Gayer, who is a very good draftsman also, made the drawings, and I think that he would be well able to carry out the work, and complete the detailed drawings which are required.

28. The cost of this survey, including:

(1). Trial line through Dhunds, in April, 1894, shewn by dotted red line.
(2). Centre line staked out in April, 1895, shewn in full red line.
(3). Cross sections shewn on plan.
(4). Mr. Gayer's pay and travelling allowance.
(8). Khalasies and coolies jungle cutting costs is less than Rs. 30 per mile, which I consider very creditable to Mr. Gayer, as a great portion of the country is covered with jungle.

29. If the estimate is sanctioned early, I hope that Rs. 5000 will be provided from some source in the current year, so that work may be commenced early.

I have, etc.,

Ed. T. Sumners, M.I.C.E.,
Ex. Engineer, Puleli Canal.
### Statement B.

Showing numbers of Breaches in 1892, 1893 and 1894, with cost of closing—also amounts of Remissions of Assessment in the Bago Tando and Badin Talukas.

<table>
<thead>
<tr>
<th></th>
<th>1892</th>
<th>1893</th>
<th>1894</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bago Tando Taluka.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breaches</td>
<td>Rs 12</td>
<td>Rs 26</td>
<td>Rs 51</td>
</tr>
<tr>
<td>Cost to Government in Closing</td>
<td>Rs 946</td>
<td>Rs 487</td>
<td>Rs 1634</td>
</tr>
<tr>
<td>Remissions</td>
<td>Rs 371</td>
<td>Rs 1143</td>
<td>Rs 76</td>
</tr>
<tr>
<td><strong>Badin Taluka.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breaches</td>
<td>Rs 76</td>
<td>Rs 22</td>
<td>Rs 88</td>
</tr>
<tr>
<td>Cost to Govt. in Closing</td>
<td>Rs 2750</td>
<td>Rs 949</td>
<td>Rs 4503</td>
</tr>
<tr>
<td>Remissions</td>
<td>Rs 3372</td>
<td>Rs 1099</td>
<td>Rs 6184</td>
</tr>
<tr>
<td><strong>Total Rs</strong></td>
<td>Rs 11,039</td>
<td>Rs 3,680</td>
<td>Rs 12,321</td>
</tr>
</tbody>
</table>

**Average of 3 years Rs 9,013.**

---

**Detail of Breaches:**

<table>
<thead>
<tr>
<th>Year</th>
<th>Name of Taluka</th>
<th>Closed at Govt.</th>
<th>Closed at Cultivators</th>
<th>Total.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1892</td>
<td>Bago Tando</td>
<td>10</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Badin</td>
<td>39</td>
<td>37</td>
<td>76</td>
</tr>
<tr>
<td>1893</td>
<td>Bago Tando</td>
<td>9</td>
<td>17</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Badin</td>
<td>22</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>1894</td>
<td>Bago Tando</td>
<td>31</td>
<td>20</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>Badin</td>
<td>57</td>
<td>27</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>170</strong></td>
<td><strong>105</strong></td>
<td><strong>275</strong></td>
</tr>
</tbody>
</table>

**Average of 3 years** 57 35 92.

---

*Hon. Surveyor & Exec. Engineer, Field's Canals.*
No. 1145 of 1898,
Public Works Department,
Camp, Hyderabad, 31st March, 1898.

To

The Secretary to Government,
Public Works Department,
Bombay.

Sir,

I have the honour to forward, for consideration, an estimate, amounting to Rs. 2,49,754, (Rs. 1,95,540 for works, Rs. 44,978 for establishment, Rs. 2933 for tools and plant, and Rs. 6,297 for indirect charges) for constructing an Escape to the Fuleli, the survey of which was sanctioned in G.R. No. 185 A.I -1134 of the 16th July, 1895. The estimate is accompanied by 6 plans, and I also send a copy of the Executive Engineer's No. 5206 of the 22nd October, 1805, submitting it, and of the Collector of Hyderabad's No. 5409 of the 24th Idem, passing it on.

2. I did not send on the estimate at once, as I wished to look up the old correspondence on the subject, and till quite lately, I have not had an opportunity of discussing with Mr. Summers, various points on which I thought explanation was required.

3. The question of providing the Fuleli with Escapes has received attention from, I should think, every officer who has had any connection with it. In 1885 the Deputy Collector of Tando Mahomed Khan, in reporting on certain proposals for increasing the supply in the Fuleli, and its continuation the Guni, gave an account of a very interesting conversation he had had with Mir Mahomed Khan, in which he detailed the manner in which the conflicting interests of the tribes living on the bank of the Canal had
had resulted in its ruin, wrote; "one remark of his I think worth recording

"with a lac of rupees" he said "the Sirkar may have the Guni, as before,

flowing throughout the year. There is neither Manickane nor Shahdadani;

the Sirkar is one, but begin at the tail, and open that out, so that the

water may flow into the Runn, any money spent on the mouth, before this is

thoroughly done, may as well be thrown into the river Indus."

4. Since 1855, many schemes have been investigated for providing the
necessary Escapes, but with the exception of some small ones of local
interest, none have been carried out. Either the fall proved to be insuf-
ficient, or it was found that the vested interests that would be interfered
with were so large, that the idea was abandoned. The favourite plan was
an Escape to the Eastward from a point on the Guni somewhere near Wahnai.

One line here was surveyed by me in 1885, under the direction of General
Le Mesurier, the then Superintending Engineer, and another in 1891, when
Mr. Thompson had charge of the Division. The survey of 1885 did not
warrant the recommendation of any Escape on this line being carried out,
and the second one resulted in Mr. Thompson's reporting in para. 2 of his
No. 4247 of the 17th October, 1892, to your address, that the levels were
so unsatisfactory, that it would be quite possible, in the event of heavy
general rain, when relief would be most wanted, for the channel not to act
back at all, or even to flow into the Pulali.

5. Mr. Summers has hit upon a line which interferes but very slight-
ly, if at all, with vested interests, and has at the same time a good
slope, and, as recommended by Mir Mahomed khan in 1855, it attacks the
tail. He has very fully described the existing conditions, and his pro-
posed remedy for them, in his letter, and estimate, and on the plans.
His Escape will leave the Guni, as the lower portion of the Fuleli is called, at the place where it divides into three channels, the Suni Guni, the Sherwah and the Aliwah. It will pass between the Suni Guni and the Aliwah, and fall into the Puran, after a course of 18 miles. The bed width of the channel will be 40 feet, and gradient 1 in 8,000. At a depth of 10 feet it will discharge 1,300 cubic feet per second.

6. I attach a statement (c) showing approximately the quantity of water that has to be dealt with at a period of flood. On the 30th August 1394, when about 9,000 cusecs were passing Hyderabad, the discharge in the Fuleli above Talhar was 6,300. Of this 1,058 cusecs passed into the Mirwah Talhar, and the balance was distributed amongst the canals lower down, as shown in the table. A depth of 1.70 feet was cut off from the Mirwah, but all the other canals were fully open, the three tail ones taking off 1080 cusecs between them. The water in all the canals was at a dangerous level, but none of them could be closed, without forcing more water into the others, and intensifying the mischief. If the Escape had then been in existence, it would have been opened, with the result of at once enabling the water in the canals 8 to 15, being reduced to a safe level, and in all probability considerably improving the condition of Hos. 3, 5, 6 and 7. It is difficult to say what would be the exact effect of opening the Escape, on the level of the water at the head of the Mirwah Talhar, 22 miles higher up the canal, but there can be no doubt that if, as anticipated, one result of the excavation of the Escape is to clear out the silt deposit in the lower portion of the Fuleli, the difficulty of dealing with all the canals, from Talhar downwards, will be greatly decreased. This silt is now 4 feet deep at the tail, about the same as
as it was in 1889, when clearance to the extent of Rs. 48,000 had to be
carried out, the bed being kept at a level 2 feet above the original one.
A similar clearance must soon be carried out unless measures, such as the
Escape will provide, for increasing the scour, are taken.

7. Mr. Summers' estimate is in full detail, except as regards the
head sluice for which he has made a lump sum provision of Rs. 12,000. This
seems to me sufficient, as do the rates generally.

8. The only part of the design which calls for remark is the water
level in the Escape at the tail, and the heights of the banks there.
Unless a very expensive masonry work was erected, the bed and water levels
shown on the section near the Puran could not be maintained, and no doubt,
if the Escape is carried out as designed, there will be a rapid formed at
the lower part, which will result in the bed being scoured, and the fall in
the water surface increased. If the point were of any great importance,
the difficulty might be got over by widening out the Escape at the tail,
so as to give the necessary discharging power, with a less depth of water.
I find that to reduce the depth at 18 miles to 51/2 feet, it would be
necessary to make the bed width there 90 feet, and the average bed width
of the channel would be increased from 40 feet, to over 65 feet. If the
channel were not so much in cutting, this would be an economical change,
but with the ground levels as they are, the extra cost of the widening
would be very large. The formation of a steeper slope at the tail will
be no disadvantage, and the Escape may be safely left to adjust itself.
Mr. Summers proposes to use the left bank of the Sherwah small as the
right bank of the Escape, from about two and a half miles, to the seventh
mile. No detailed section along this bank has been taken, and I have
have some doubts as to its being strong enough to answer the purpose.

Mr. Summers, however, assures me that he is satisfied it is sufficiently strong, except in a few low places, which can be raised, from he expects on the various items in the estimate.

9. I now turn to the Financial prospects of the scheme, and I may say first, that even if we could not show that an increased area of cultivation, and consequent revenue, would be the result of its execution, the propriety of its sanction could be strongly urged on other grounds. The uncertainty of the cultivation in the Badin and Tande Bago Talukas has often been brought to notice, and the irrigation cannot be said to be in a satisfactory condition, when the low lying lands are liable to be flooded at any time, when rain falls concurrently with a high canal water level. There, however, can be no doubt that the scheme will be financially profitable. Taking the cost at Rs. 2,50,000, the interest charges will be about Rs. 10,000, and the maintenance charges may be taken at Rs. 5,000 annually, in all Rs. 15,000. Mr. Summers in his 19th paragraph puts the annual return at the lowest, at Rs. 65,000. This seems a rather sanguine estimate, but the Collector characterizes it as an extremely moderate one. Without going so far as this, I am satisfied that the project will return a good profit, and at the same time confer very great benefit, which cannot be measured by money values, on the population living on the banks of the Fuleli, and in the tracts, the cultivation of which will be improved.

10. I have the honour, in conclusion, to urge very strongly, that the construction of the Escape be sanctioned at a very early date, and that if possible, funds for its commencement may be granted in the current
current year. It does not seem necessary to prepare a revised estimate for the whole Fuleli Project, till the orders of the Government of Bombay on the estimate now submitted are given.

I have, etc.,

Sd. John Tate, M.I.C.E.,
Superintending Engineer, I.L.B.D.
<table>
<thead>
<tr>
<th>No.</th>
<th>Name of Canal</th>
<th>Stage Readings</th>
<th>Discharge in Cubic Feet per Second</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fuleli</td>
<td>21.8</td>
<td>15.0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Fuleli</td>
<td>21.6</td>
<td>15.0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Mirnab Talhar</td>
<td>15.0</td>
<td>13.4</td>
<td>1,053</td>
</tr>
<tr>
<td>4</td>
<td>Fuleli</td>
<td></td>
<td></td>
<td>5,782</td>
</tr>
<tr>
<td>5</td>
<td>Kasa Gudo</td>
<td>12.8</td>
<td>1.622</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Mauk</td>
<td>10.7</td>
<td>828</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Shadi Large</td>
<td>10.8</td>
<td>633</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Saida</td>
<td>6.7</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Kanzia New</td>
<td>11.5</td>
<td>800</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Alibaker Karo</td>
<td>10.0</td>
<td>468</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Shar Kadhan</td>
<td>6.0</td>
<td>117</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Wangi</td>
<td>6.0</td>
<td>112</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Suni Guni</td>
<td>11.1</td>
<td>520</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Ali Large</td>
<td>11.1</td>
<td>278</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Sher Large</td>
<td>11.1</td>
<td>282</td>
<td></td>
</tr>
</tbody>
</table>

Total of Nos. 1 to 15: 5,782 Cubic Feet.
To The Superintending Engineer, I.L.B. Division.

Sir,

With reference to our recent consultation with Colonel Ottley, I have the honour to propose that the design of the Fuleli Escape should be altered.

Bedwidth 40'  
From Side slopes 1 to 1  
Depth of water 10'

Bedwidth 62'  
To Side slopes ½ to 1  
Depth of water 7'

2. The reason for this proposed alteration is that, according to Kennedy's Graphic Hydraulic Diagrams, which are sent with this, for submission to Government, and may please be returned, the section chosen, from Diagram No.4, will not silt, while that as originally designed will silt, as shown in Diagram No.2.

3. It will also be seen from Diagram 4, that this channel will run with its non-silting and non-scouring velocity down to a depth of between two and three feet.

4. The calculated discharge by Ganguillet and Kutter's formula taking

\[ N = 0.025 \] for original channel
\[ m = \frac{438.39}{77.64} = 5.7 \text{ and } \sqrt{m} = 2.3' \]
\[ i = \frac{1.175}{1000} \]
\[ v = \frac{(41.6 + \frac{1.811 + 0.00281}{2}) \sqrt{m} - \frac{m i}{\sqrt{m} + (41.6 + 0.00281 n)}}{n} \]

and Discharge = 458.5 \times 2.61 = 1197 Cusecs

If \( N \) is taken = 0.0225, as it would be for a new straight channel such as this, then discharge becomes = 1318 cusecs.

5. Velocities and discharges of original and proposed channels at different depths, are given below:-
With these velocities, in original channel silt will be deposited, while the velocities in proposed channel are non-silting and non-scouring.

6. The fall of Escape has been increased from \( \frac{1}{8000} \) to \( \frac{1}{5714} \), by raising its bed 2.67 feet at the mouth, and lowering it by 2 feet at the tail.

7. Although the bed is raised about 2 feet above the original bed of the Fuleli, it is still 1\( \frac{1}{2} \) feet below the present silted bed, at which the Fuleli has been working for some time.

8. The estimate has not been altered, as, from attached revised earthwork quantities, it will be seen that the total quantity is the same, cuttings being increased and banks reduced by 50 lakhs of cubic feet. The other items have also been allowed to remain, as the bridges, although widened, will be lowered.

9. The slopes of bank have been reduced to 1\( \frac{1}{2} \) to 1 in front and rear, the top width being increased to 7 feet. This is probably strong enough, if they are carefully made, and even if a breach did occur, the breach water would be let into the Escape again further on, and would run off into the Puran, as it could not spread far, being kept in by the Suni Guni banks on the right, and by the Aliwah banks on the left.

10. Work could be conveniently carried on during the inundation season at the tail, as there the climate is good, and there is plenty of water, and I hope that funds will be procurable, as such a large quantity of earthwork requires time, if it is to be done cheaply.

I have, etc., etc.

(Sd)

T. SUMMERS,

Executive Engineer. F.C.
To The Superintending Engineer I.L.B. Division.

Sir,

In continuation of my No. 2573 of 2nd inst. I have the honor to forward a section, to a scale of 5000 feet to 1 inch, showing original proposed bed as a black dotted line, and the first alternative bed at 1 in 5714 as a full red line. A tracing of last mile of original section is also enclosed.

2. From enquiries made on the spot, 11.50 R.L. appears to be the highest water level which has occurred for several years back. It is the highest water level of 1895. The Escape will be most used when the level of water in Puran is low.

3. In the calculations of discharge for the channel as originally designed, and for the first alternative, the constant $N.$ has been taken as .025, but I think it might safely be taken as .0225 for a channel of this description, as .025 is certainly high, if not too high.

4. Taking the constant as .0225 the gradient can be made 1 in 7000, as shown in the second alternative section, which raises the bed at tail from 4.90, R.L. of bed of first alternative to 7.90, i.e., by 3 feet.

5. I am strongly of opinion that this alteration should be made for the following reasons:

1. It should give the non-scouring and non-silting velocity.

2. The bed is raised by 3 feet at tail.

3. There will be a saving of about 15,000; and if at any time it is thought expedient to increase the fall, which I think is impossible, by increasing the gradient, it can be done without any loss of money.

6. I give below a statement comparing levels in original, and in the two alternative proposals.

I have etc., etc.

(Ed) T. SUMMERS, M.I.C.E.
Executive Engineer, Fuladi Canals.
<table>
<thead>
<tr>
<th></th>
<th>Original Proposal</th>
<th>1st Alternative</th>
<th>2nd Alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradient of bed</td>
<td>14.800</td>
<td>14.5714</td>
<td>14.700</td>
</tr>
<tr>
<td>Reduced level of bed at mouth</td>
<td>18.33</td>
<td>21.00</td>
<td>21.00</td>
</tr>
<tr>
<td>Highest known water level in Varan</td>
<td>11.50</td>
<td>11.50</td>
<td>11.50</td>
</tr>
<tr>
<td>Reduced level of bed at tail</td>
<td>6.83</td>
<td>4.90</td>
<td>7.90</td>
</tr>
<tr>
<td>Depth of highest known water level in Varan, above bed, at tail</td>
<td>4.67</td>
<td>6.60</td>
<td>5.60</td>
</tr>
</tbody>
</table>

7. The discharge, taking \( n = 0.0225 \), comes to 1201 cusecs, the same as for the first alternative, taking \( n = 0.025 \).

\[
\begin{align*}
V &= \frac{41.6 + \frac{1.811 + 0.00281}{0.025}}{\sqrt{0.00281}} \times 0.029 \\
&= \frac{41.6 + 80.44 + 19.67}{2.43} \\
&= 2.62 \text{ feet per second.}
\end{align*}
\]

And discharge = 458.5 \times 2.62 = 1201 cusecs

I have \( \frac{\text{C}}{\text{C}} \)

Tho. Summers, M.C.B.
Executive Engineer
To J. TATE, Esq.,
Superintending Engineer, I.L.B. Division.

Sir,

I have the honour to refer you to my No. 2819 and 2939 of 15th and 23rd May 1896 respectively, and to state that I am still of opinion that the bed of the Fuleli Escape should be kept at 1 in 7000, for the reasons given in above letters.

2. The reduced level of water in the Puran has kept up to between 11 and 12, throughout the season, and was 11.50 when I saw it last month.

3. I think we are going unnecessarily low, and that it is a pity to expend so much, unless there is a necessity for it, besides it would be very easy to lower the bed afterwards, although I am sure that there will be no occasion for this.

4. If you will not sanction this deviation, I shall be obliged if you will allow me to make a slight change in the gradient from 1 in 5714 to 1 in 6000, as even this will save about Rs 8000, by raising the bed only 9 inches at the tail, and the discharge will only be reduced by 69 cusecs, and velocity from 2.61 to 2.55 feet per second.

5. The levels will then be

<table>
<thead>
<tr>
<th>Reduced Level at Mouth</th>
<th>Sanctified 1 in 5714</th>
<th>Proposed 1 in 5714</th>
<th>Proposed 1 in 6000</th>
<th>Proposed 1 in 7000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21.00</td>
<td>21.00</td>
<td>21.00</td>
<td></td>
</tr>
</tbody>
</table>

6. A gradient of 1 in 7000 is 9 inches per mile, and of 1 in 6000, 10½ inches per mile, while that of the Fuleli, Mirwah Talhar, Kazia new and Nasirwah which do not silt, but in which scour takes place, is from 5" to 6" per mile.

7. I have again taken the liberty of requesting this, as I feel convinced that the fall proposed is sufficient, and
and that much may be lost, but nothing gained, by taking the bed so far below the water level in the Puran.

8. I shall be much obliged by an early reply, so that the necessary orders as to alterations can be given. As no bank dressing has been done, and the long cutting is not commenced, the change can be easily made.

9. The tracing shewing gradients is enclosed for reference.

I have etc., etc.

(Sd) THOS. SUMMERS, M.I.C.E.
Executive Engineer, Fuleli Canals.
Camp KARACHI. 5th June, 1897.

To The Executive Engineer, Fuleli Canals.

Subject.- FULELI ESCAPE.

Sir,

I have the honour, with reference to your No.1385 of the 18th March last, to say that I cannot agree with you in considering that the sanctioned gradients of the Fuleli Escape should be altered.

The question was very fully considered at the time the designs were before Government, and the reasons for making the gradient 1 in 5714 are given in your No.2531 of the 29th April 96. In your No.2819 of the 15th May 1896, you proposed for certain reasons, that the gradient should be altered to 1 in 7000. This proposal was laid before Government and regarding it I wrote as follows in para.5 of my No.1831 of June 3rd 1896.

"5. Since Mr Summers wrote his letter above noted, he has made another proposal in his No.2819 of the 15th ultimo, a copy of which is attached. I have had some semi-official correspondence with the Executive Engineer regarding this scheme which has caused some delay in sending on this report. It is true that the co-efficient might be taken at .0225, but Mr Summers has overlooked the fact that Mr Kennedy has calculated his channel velocities with a co-efficient of 0.0250 and that a velocity of 2.92 is required by the theory, while the velocity in the escape, taking the co-efficient as 0.025, is only 2.61. If the theory is correct, this channel with a fall of 1 in 7000 would certainly silt, and I cannot therefore recommend it."

"I think it right, however, to lay Mr Summers' proposal before Government, and may add that he considers that as the escape will be mostly used in the cold weather, when the water is comparatively free of silt, the lesser velocity may be accepted. I, however, do not agree with him as to this."

I can find nothing in any of your letters which leads me to think that my opinion on the question is wrong. So long as the water in the Escape is higher than that in the Puran, the
the latter cannot reduce the calculated discharges. I think any rapid at the Escape tail should so far as possible be avoided, as one would cause scour, and heavy silt deposit in the Puran. The Puran must be cleared of jungle, and when this is done, or even without it, I have no doubt that the extra water brought down by the Escape would be cleared off to the sea or low-lying lands near it, without any great rise in the water level at the Escape tail.

2. The two tracings are returned.

I have, etc., etc.

(Sd) JOHN TATE, M.Inst. C.E.

Suptg. Engineer, Indus Left Bank Division.

P.S. Please report whether there is any leakage from the ascent into the escape.
To The Executive Engineer, Fulheli Canals.

Sir,

I have the honour to return herewith approved the revised plan and estimate for the regulator at the head of the Fulheli Escape.

I am of opinion that the left abutment and two piers contiguous to it, should not have been founded on the old Sani Guni pavement, as there may be uneven settlement; where the nature of the foundation is the same throughout, the settlement is likely to be the same, without affecting the superstructure, but where the foundations are dissimilar, there may be uneven settlement, which would affect the superstructure. The work should be very carefully watched.

Regarding the double set of needles for openings, I am of opinion that with the double set, even without earth or clay between, there will be less leakage. It would, I think, be advisable to make a few experiments at one of the 10 feet openings, to ascertain what is the most convenient and economical way of making the opening watertight; this might with advantage be done when water can be spared. A trial might be made with tarpaulins, rice straw, etc., and with earth or clay up to different heights. The results should be reported.

I have, etc., etc.

(Sd) F. B. MACLAREN, M.Inst. C.E.

Suptg. Engineer, I.L.B. Division.

P.S.

Please report whether there is any leakage from the Aliwah into the Escape.
To The Superintending Engineer, L.L.E.Division.

Sir,

With reference to your No.2714 dated 23rd July, 1898, I have the honour to inform you that I lately, i.e., on the 31st July, 1898, inspected the Escape regulator carefully and found that there were no cracks or signs of unequal settlement anywhere, and I hope and trust there would be none hereafter.

2. All the openings were carefully closed with the double set of needles, and the crevices were properly filled up with rice straw, matings, etc., before the water was admitted into the tail canals; but when the canals flowed there was some leakage, and to stop it, the space between the two sets was filled up with earth and then the whole became perfectly staunch. The one objection urged against the arrangement is that the regulator cannot be instantly opened or closed, as it could have been, if provided with the sluice gates, but there would have been other evils in the latter arrangement such as the frequent jamming, etc., besides the heavy initial cost,—I propose to have one set of needles of channel iron, and the other set of teak wood, 6" + 3", as the wooden needles slightly expand when soaked in water, and afterwards fit in closely and firmly, thus preventing leakage through the lines of contact.

The space in front of the escape regulator is now silted up to a depth of 4 or 5 feet, as per sketch accompanying, and it is difficult to carry out the experiment desired by you, but I would try and see if the silt can be cleared later on, and report the results of experiments if any.

I have, etc.

(Sd) P. K. CHITALE,
Executive Engineer, F.C.
No. 5350 of 1898.

Public Works Department,
Camp KARACHI. 12th September, 1898.

MEMO.

The accompanying notes by Mr. Summers, received by the last mail from England, are forwarded to the Executive Engineer Fuleli Canals, for perusal, and for any remarks he may wish to make.

2. The Superintending Engineer concurs in the opinion expressed regarding the excessive number of karias, and approves of the proposal to have a separate channel, taking off from the main canal and running parallel to it, from which the karias should be fed. This will bring the supply much more under control than when every zemindar has his own karia taking off direct from the canal.

3. Special attention is drawn to the note on Escape embankments, and it should be seen that the contractors finish off their work satisfactorily. It should be reported whether anything is deducted from the contractor's payments, for the dressing off of banks, in the event of the contractor not doing it; also whether for the portion completed, the dressing off has been satisfactorily done.

4. What has been done regarding the portion referred to in para. 9 of the Notes?

(Sd)  F. B. Maclaren, M. Inst. C.E.
Sup'tg. Engineer, Indus Left Bank Division.
To The Superintending Engineer, Indus Left Bank Division.

Sir,

I have the honour to request your sanction to the substitution of horizontal timbers, of sizes shewn in the accompanying sheets of calculations and in plan, for the front row of the channel iron needles, sanctioned for the Escape Head Regulator.

2. In the original estimate I proposed to have gates, which would be suitable for the five small openings, as they are only 10 feet wide, and the maximum depth of water against the gates would be about 9 feet.

3. While I was on leave some correspondence took place about these gates, and eventually a double row of channel iron needles was sanctioned in G.R. No. 18 W.I. 218 of 3rd February 1898.

4. I beg to point out that it will be very difficult, if not quite impracticable, to open and shut the Regulator if the double row of needles is provided.

5. Suppose it is proposed to open the canals on 15th May, then on that date the double row of needles will be fixed in position, with mats in front of them, to make them watertight. Silt will collect in front of the needles, and if a flood comes in August, it will be exceedingly difficult to remove the needles, and the mats will have to be destroyed. Immediately after the flood is down, all the water in the Fuleli will be required in the canals, but I do not see how the Regulator can be quickly closed without considerable expense, and am afraid that much water will be wasted in the Escape, when all is wanted in the Canals, whereas with horizontal timbers, one or more as required, can be lifted off in a few seconds.

6. When I prepared the estimate, I consulted Colonel Ottley, late Inspector General for Irrigation, who gave his opinion that both gates and one row of needles should be provided.

7. One objection to gates is the great velocity at pavement level when they are first opened, but this could be guarded against by partly filling the space between the gates and needles, before opening the gates.

8. An objection to horizontal timbers is that the water
water falling over them may damage the pavement, but this objection is removed by the row of needles, as there will be a water cushion between.

9. As shewn in the accompanying estimate, the cost of horizontal timbers is practically the same as that of channel iron needles, and as their advantages are so great, I have the honour to request your sanction to this deviation, at an early date, as they should be fixed in position before the end of April, and grooves have to be made in the cutwaters for them.

I have, etc., etc.

(Sd) THOS. SUMMERS. M.I.C.E.
Executive Engineer Fuleli Canals.
Form No. 176 n.

No. of 1899.

Fuleli Canals DISTRICT.

PUBLIC WORKS DEPARTMENT.

Dated March, 1899.

(Date)

(Service Head) Irrigation Minor Works and Navigation

(Sub-Head) Works for which Capital and Revenue Accounts are kept.

Capital Account Fuleli Canal Works.

ABSTRACT ESTIMATE framed by T. Summers.

EXECUTIVE ENGINEER, Fuleli Canals of the probable expense

that will be incurred in Providing horizontal timbers in the Head

Regulator of the Fuleli Escape.

Rs. 

(Call or Authority)

GENERAL DESCRIPTION.

In the sanctioned plan of the Escape Head Regulator, two rows of channel iron needles are provided, but as this will entail great difficulty in regulation, it is proposed to substitute horizontal timbers of dimensions shewn in accompanying plan, for the front row of needles, which will simplify the regulation.
Calculations for horizontal timbers.

Width of 5 small openings each 5 ft.
Maximum depth of water = 9 ft.
Breadth of each timber = 9 inches
Number of timbers required = 12
Deflection \( \frac{10}{40} \) of an inch = \( \frac{1}{4} \) inch

For calculation the timbers are taken in pairs.

\[
\text{Water pressure on } 2^{nd} \text{ timber} = 7.5 \times 1.25 \times 62.5 = 577
\]
\[
\text{1st} = 7.5 \times 2.625 \times 62.5 = 1230
\]
\[
\text{2nd} = 7.5 \times 4.125 \times 62.5 = 1933
\]
\[
\text{3rd} = 7.5 \times 5.625 \times 62.5 = 2636
\]
\[
\text{4th} = 7.5 \times 7.125 \times 62.5 = 3339
\]
\[
\text{5th} = 7.5 \times 8.625 \times 62.5 = 4043
\]

---

**Deflection.**

Let \( d \) = depth of timbers
\( L = 10 \) feet
\( b = 9 \) inches

Max. deflection = \( D = \frac{1}{4} \) inch

\( E \) for teakwood = 281

\[
D = \frac{5}{8} \times \frac{1}{16} \times \frac{L^3}{E \cdot b \cdot d^3}
\]

\[
\text{and } A^3 = 0.0618 \text{ in.}^3
\]

Therefore for \( 2^{nd} \) timber \( d = \sqrt[3]{0.0618 \times 577} 
\]
\[
= 3.19 \text{ say 31\frac{3}{4}\text{ inches}}
\]
For 4th timber \[ d = \sqrt[3]{0.0618 \times 1215} \]

= 4.24 \text{ say 4}^{\frac{1}{2}} \text{ inches.}

For 6th do. \[ d = \sqrt[3]{0.0618 \times 1935} \]

= 4.92 \text{ say 5 inches.}

For 8th do. \[ d = \sqrt[3]{0.0618 \times 2636} \]

= 5.46 \text{ say 5}^{\frac{1}{2}} \text{ inches.}

For 10th do. \[ d = \sqrt[3]{0.0618 \times 3359} \]

= 5.91 \text{ say 6 inches.}

For 12th do \[ d = \sqrt[3]{0.0618 \times 4043} \]

= 6.30 \text{ say 6}^{\frac{1}{2}} \text{ inches.}


---

**Strength**

Let \( W \) = Bearing weight in lbs.

\( L \) = Length in inches.

\( B \) = Breadth \( \ldots \).

\( d \) = Depth \( \ldots \).

\( K \) = Modulus of Rupture.

Then for beams with ends supported and weight distributed,

\[ W = \frac{8KBD^2}{L} \]

And \( d^2 = \frac{WL}{8KB} = \frac{120}{8 \times 2120 \times 9} W = \frac{1}{1272} W. \)

Taking a factor of safety of 8
\[
\frac{d^2}{127} \cdot \frac{w}{159} = v
\]

For 2\textsuperscript{nd} timba \( \frac{d^2}{127} \cdot 527 = 3.52 \)

and \( d = 1.82 \text{ inc} \)

Which is less than depth calculated for deflection, and so on for the other timbers.

**Boat opening.**

<table>
<thead>
<tr>
<th>Width</th>
<th>15 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. depth of water</td>
<td>9 feet</td>
</tr>
<tr>
<td>Breadth of each timber</td>
<td>9 inches</td>
</tr>
<tr>
<td>Number of timbers</td>
<td>12</td>
</tr>
<tr>
<td>Max. deflection ( \frac{d}{40} = \frac{3}{8} ) inch</td>
<td></td>
</tr>
</tbody>
</table>

For calculation, the timbers are taken in pairs.

**Water pressure** at 2\textsuperscript{nd} timba = 11.25 x 11.25 x 625 = 791\text{ lb}

\( d_0 \) \( A \text{ in} \) \( d_0 = 11.25 \times 2.625 \times 625 = 1845 \)

\( d_0 \) \( 6 \text{ in} \) \( d_0 = 11.25 \times 4.125 \times 625 = 2900 \)

\( d_0 \) \( 8 \text{ in} \) \( d_0 = 11.25 \times 5.625 \times 625 = 3957 \)

\( d_0 \) \( 10 \text{ in} \) \( d_0 = 11.25 \times 7.125 \times 625 = 5009 \)

\( d_0 \) \( 12 \text{ in} \) \( d_0 = 11.25 \times 8.625 \times 625 = 6064 \)
Deflection

\[ D = \frac{5}{8} \times \frac{1}{16} \times \frac{L^3 W}{E I d^3} \]

\[ D = \frac{3}{8} \quad L = 15'' \quad E = 281 \quad b = 9 \]

Therefore \( d^3 = 0.139 \, \text{in} \).

For 2nd timber, \( d = \sqrt[3]{0.139 \times 791} \)

\[ = 4.79'' \text{ say } 5 \text{ inches} \]

For 4th, \( d = \sqrt[3]{0.139 \times 1845} \)

\[ = 6.35 \text{ say } 6\frac{1}{2} \text{ inches} \]

For 6th, \( d = \sqrt[3]{0.139 \times 2900} \)

\[ = 7.39 \text{ say } 7\frac{1}{2} \text{ inches} \]

For 8th, \( d = \sqrt[3]{0.139 \times 5954} \)

\[ = 8.19 \text{ say } 8\frac{1}{4} \text{ inches} \]

For 10th, \( d = \sqrt[3]{0.139 \times 5009} \)

\[ = 8.86 \text{ say } 9 \text{ inches} \]

For 12th, \( d = \sqrt[3]{0.139 \times 6064} \)

\[ = 9.44 \text{ say } 9\frac{1}{2} \text{ inches} \]
Strength.

As before \( a^2 = \frac{W L}{8Kb.} = \frac{1}{106} \times W \)

For 2nd timber \( a^2 = \frac{791}{106} = 7.46 \)

\( + d = 2.73 \) inches

Which is less than depth calculated for deflecting and so on for the other timbers.
### Measurement

**Providing Horizontal baulks in the front row for the Head Regulator of the Initial Escape**

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>Length</th>
<th>Breadth</th>
<th>Dipart.</th>
<th>Zamah Serg</th>
<th>Total Serv.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cut Teakwood</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baulks No. 1 &amp; 2</td>
<td>Boat opening</td>
<td>2 16° 5′ 0″</td>
<td>5″</td>
<td>10.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 &amp; 4</td>
<td>do</td>
<td>2 16° 5′ 6″</td>
<td>6″</td>
<td>13.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 &amp; 6</td>
<td>do</td>
<td>2 16° 5′ 7″</td>
<td>5″</td>
<td>15.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 &amp; 8</td>
<td>do</td>
<td>2 16° 5′ 8″</td>
<td>6″</td>
<td>17.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 &amp; 10</td>
<td>do</td>
<td>2 16° 5′ 9″</td>
<td>6″</td>
<td>18.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 &amp; 12</td>
<td>do</td>
<td>2 16° 5′ 9″</td>
<td>6″</td>
<td>19.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baulks No. 1 &amp; 2</td>
<td>Five small openings</td>
<td>10 11° 5′ 34″</td>
<td>3″</td>
<td>23.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 &amp; 4</td>
<td>do</td>
<td>10 11° 5′ 4″</td>
<td>6″</td>
<td>32.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 &amp; 6</td>
<td>do</td>
<td>10 11° 5′ 5″</td>
<td>6″</td>
<td>35.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 &amp; 8</td>
<td>do</td>
<td>10 11° 5′ 6″</td>
<td>6″</td>
<td>39.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 &amp; 10</td>
<td>do</td>
<td>10 11° 5′ 8″</td>
<td>6″</td>
<td>43.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 &amp; 12</td>
<td>do</td>
<td>10 11° 5′ 9″</td>
<td>6″</td>
<td>46.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total eff.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>315.34</td>
<td></td>
</tr>
</tbody>
</table>

### Cutting Grooves in Brick Masonry

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Boat opening</td>
<td>9 ′ × 8 ′</td>
<td>2 9</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Five small openings</td>
<td>9 ′ × 10 ′</td>
<td>10 9</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td><strong>Total Rake</strong></td>
<td></td>
<td></td>
<td></td>
<td>108</td>
</tr>
</tbody>
</table>

### Cut Stone Work

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Over cut waters</td>
<td></td>
<td></td>
<td></td>
<td>12 3 15 5</td>
</tr>
<tr>
<td><strong>Total eff</strong></td>
<td></td>
<td></td>
<td></td>
<td>27</td>
</tr>
</tbody>
</table>
### Measurement

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Quantity</th>
<th>Length</th>
<th>Weight</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom Wales boat opening</td>
<td>1</td>
<td>17'10&quot; x 5' @ 36&quot;</td>
<td>510&quot;</td>
<td></td>
</tr>
<tr>
<td>Bottom and Middle Wales small opening</td>
<td>10</td>
<td>11'5&quot; x 4'</td>
<td>20&quot;</td>
<td>2000</td>
</tr>
<tr>
<td>Channel Steel Needles for the single set</td>
<td>150</td>
<td>11'5&quot; x 1'2&quot;</td>
<td>725&quot;</td>
<td>11965</td>
</tr>
<tr>
<td><strong>Total cut</strong></td>
<td></td>
<td></td>
<td></td>
<td>132</td>
</tr>
</tbody>
</table>

### Cut Oak Wood Work

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Quantity</th>
<th>Length</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle Wales - boat opening</td>
<td>1</td>
<td>16'12&quot;</td>
<td>8&quot;</td>
</tr>
<tr>
<td>Top Wales do</td>
<td>1</td>
<td>17'9&quot;</td>
<td>6'</td>
</tr>
<tr>
<td>do do</td>
<td>1</td>
<td>17'9&quot;</td>
<td>6'</td>
</tr>
<tr>
<td>Guide Wales small openings</td>
<td>10</td>
<td>12'6&quot;</td>
<td>6&quot;</td>
</tr>
<tr>
<td><strong>Total cubic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td>Item</td>
<td>Rate</td>
<td>Rate</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>315</td>
<td>c.ft. taka wood</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>108</td>
<td>R.t. cutting grooves in taka</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>27</td>
<td>c.ft. cut stone</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contingencies</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Seduct**

One row of needles, as sanctioned.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
<th>Rate</th>
<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>132</td>
<td>c.ft. rolled steel joints and channel iron needles</td>
<td>9</td>
<td>1</td>
<td>1188</td>
</tr>
<tr>
<td>54</td>
<td>c.ft. taka wood</td>
<td>3 12</td>
<td>1</td>
<td>202</td>
</tr>
<tr>
<td></td>
<td>Contingencies</td>
<td></td>
<td></td>
<td>1390</td>
</tr>
<tr>
<td></td>
<td>Contingencies</td>
<td></td>
<td></td>
<td>1460</td>
</tr>
</tbody>
</table>

**Exeutive Engineer - F.C.**