SILT EXCLUSION IN IRRIGATION SYSTEMS - HANDAPANAGALA IRRIGATION SCHEME

by

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Summary

The Handapanagala Irrigation Scheme is located in the Monaragala District. It has approximately a net irrigated area of 1,000 acres and a farmer population of 1,300 families. The 3.5 mile long feeder canal to the Handapanagala reservoir has been rendered useless due to the serious problem of sediment accumulation at the intake on the left bank of the Kirindi Oya. Whatever the reasons might be, a speedy solution not being implemented for so long to alleviate the burdens of a people in one of the least developed regions of the Country is inexcusable and a matter for regret. An effective and economical solution to the problem, based on hydraulic model studies is presented.

1.0 Introduction

Handapanagala is an irrigation scheme situated in the Monaragala District, which has been rehabilitated in 1956. Irrigation releases are made from Handapanagala reservoir for paddy cultivation in the Handapanagala settlement. The lack of an adequate supply of water from the reservoir has been cited as a reason for several crop failures over the years. Hence, it had been decided to supplement flows into the reservoir by diverting water from Kirindi Oya. Under this diversion, water extracted at the Kirindi Oya Intake is to be conveyed to the Handapanagala reservoir via a 3.5 mile long feeder canal.

The intake [M/17(13.5 x 1.4)] located on the left bank of the Kirindi Oya is 3.5 miles from the Wellawaya junction, off the Wellawaya-Thanamalwila road, within the Pelawatte Sugar Co. Plantation (Figure 1). During the period 1965-1970 construction had begun on the feeder canal. A 200 ft. long concrete anicut had been constructed by the Irrigation Department across Kirindi Oya at the site of the intake in 1982. Since its construction, erosion had taken place at the left abutment, resulting in the construction of a cut-off wall at the left bank in 1985 (Figure 2).

Since the beginning of the Kirindi Oya Intake Scheme upto now, there is no evidence that the objective of supplying water to the Handapanagala reservoir was accomplished at any time. The reason for this lapse is the accumulation of large quantities of sediment that severely obstruct the mouth of the intake.

2.0 Reasons for Sediment Accumulation

Sediment carried by river waters can take two main forms, ie. bed load and suspended load. Bed load refers to material drawn along the river bed, while suspended load refers to material in suspension carried by the water.

As early as 1935, the researcher Habermas conducted model tests to determine the effect of intake location on the intrusion of bed load. Figure 3a shows different configurations and how this affects the transport of bed load into the intake. Cases 1 & 4 were found to be the most adverse as far as bed load intrusion was concerned. In the former, the intake is on a straight reach while in the latter it is on the inner side of a bend. In both cases the entire bed load was diverted into the intake. On the other hand, no bed load intrusion was observed in Case 5, with the intake arranged downstream and on the outer side of a bend. Finally, Cases 2 & 3 show the sensitivity of site location. In the former, 50% of bed load is diverted and in the latter, with the intake located at double the distance downstream, only 5% of the bed load is diverted into the intake.

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The above findings are explained by spiral flow which develops at a river bend (Figure 3b). Near the water surface, flow is toward the outer bank of the river while near the bed of the river, flow at the bottom is towards the inner bank. Surface flow in general indicates the path taken by water at the bend, while flow at the bottom indicates the direction of movement of bed load. Hence, it can be seen that at a river bend water tends to move towards the outer bank, while the bed load tends to move away from it. Therefore, an intake required to extract water relatively free of bed load should be located on the outer bank. On the other hand, if the intake is located on the inner bank we will encounter problems in diverting the required flow from the river and in preventing intrusion of bed load.

Considering the various configurations, it is not surprising to see the large scale accumulation of sediment at the Kirindi Oya Intake which is located on the inner bank of the river. The sediment accumulated severely obstructs the entrance to the feeder canal and has made the diversion scheme a dismal failure.

3.0 Design Criteria Required

A plan of the intake site is shown in Figure 2 and some relevant data are presented as follows :

Feeder Canal :-

Length = 3.5 miles
Bed level at intake = 520.00 ft +MSL
Channel capacity = 30 cusec
Distance from intake to head sluice = 300 ft.

Anicut :-

Crest level = 522.00 ft +MSL
Sill level = 518.00 ft +MSL
Length = 200 ft
Size of gates = 5 ft x 4 ft
Location of gates : 5 gates on right bank & 5 midstream gates

Handapanagala reservoir :-

Total capacity = 5,500 Ac ft
Dead storage = 390 Ac ft
Catchment area = 12,260 Ac
Net irrigated area = 1,000 Ac

Mean monthly rainfall at Wellawaya (mm) :-

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
223	316	193	96	80	130	225	107	25	36	42	69

Maximum flood observed at intake site = 17,000 cusec

The Handapanagala reservoir has its own catchment (Figure 1) with an observed seasonal yield of about 2,000 Ac. ft. Since the capacity of the reservoir is about 5,000 Ac ft, the volume of water required from the Kirindi Oya Intake to meet the deficit in the reservoir is around 3,000 Ac ft. Field observations and examination of the monthly rainfall data indicate that this amount can be diverted from Kirindi Oya, if the siltation problem at the intake is solved. Although this volume is a small fraction of the total volume of flow in the Kirindi Oya, it will be greatly beneficial to the Handapanagala farmer population.

In identifying a suitable solution for the satisfactory functioning of the intake, three main aspects were considered.

a) Clearing the large quantity of bed load and other material that deposits near the intake.

b) Preventing water with large amounts of sediment from entering the feeder canal.

c) Delivering the feeder canal's design discharge of 30 cusec.

4.0 Recommended Solution

The provision of scour gates near the left bank along the present cut-off wall was seen as a most promising solution for fulfilling the required design criteria (Figure 4).

The location of the intake is such that prevention of bed load reaching the vicinity of the intake is virtually impossible. Hence, the need arises for some device to flush the bed load concentrating near the intake to the downstream side of the anicut. This could be achieved by scour gates located as described earlier.

In order to deliver the feeder canal's design discharge and prevent water with large quantities of sediment entering the feeder canal, a regulator will be required at the mouth of the feeder canal. A concrete structure with conduits and equipped with circular gates can be provided for this purpose. These gates will be opened only after the accumulated sediment at the intake is flushed downstream, by opening the proposed scour gates on the cut-off wall.

An earth embankment will be required to protect the reach of canal between the regulator and the head sluice from flood flows in the Kirindi Oya.

Model tests were carried out on an undistorted model of scale 1:15 of the Kirindi Oya Intake available at the

Hydraulics Laboratory of the Irrigation Department, with the above modifications. The solution will involve :

(i) Installation of three scour gates of size 5 ft x 4 ft, with a sill level of 518 ft +MSL, starting at the left corner of the cut-off wall (Figure 4).

(ii) Construction of a regulator with two nos. 2 ft. dia. (minimum) conduits equipped with circular gates at the mouth of the feeder canal.

(iii) Forming an earth embankment between the regulator and high ground near the head sluice.

The performance of the model was tested by first closing the conduits and gates in the cut-off wall and filling intake. Next, a stream flow was set-up and the scour gates were opened. The efficiency of the scour gates in flushing out sand was observed for different stream flows. The minimum stream flow required for efficient flushing out of sand was found to be approximately 500 cusec.

Once the bed level near the mouth of the conduits had fallen below the invert level of the conduits (520 ft +MSL), due to operation of the scour gates, the conduits were opened to enable the feeder canal to function. It was found that the required design discharge of the feeder canal of 30 cusec could be obtained when the Kirindi Oya flows reached approximately 800 cusec or a water surface elevation of 523 ft +MSL on the right bank, upstream of the anicut (Figures 5a & 5b).

Further model runs were conducted in order to obtain the canal discharge and the right bank stream water level for varying stream flows. Figures 5a & 5b show the graphs of canal discharge vs stream discharge and stream water level vs stream discharge with the three scour gates and the two conduits open.

In order to determine the effect of the sill level of the scour gates on the efficiency of scouring, one may repeat the experiments with a sill level of 517 ft +MSL.

5.0 Operating Procedure

The catchment upstream of the anicut receives substantial rainfall between the months of October and May, while the period from June to September is relatively dry, as can be observed from the monthly rainfall data given in Section 3.0.

During dry periods, stream flows in Kirindi Oya are low, resulting in the deposition of large quantities of sediment in the vicinity of the intake. Further, the low flows in the river are insufficient for flushing out the sediment through the three scour gates. Hence, during the dry season it is necessary to keep the conduits and scour gates closed, which will result in a gradual build-up of sediment near the intake. The five midstream gates will be kept open during the dry season in order to allow the low flows in the river to proceed downstream.

With the onset of the rainy season :

(a) The five midstream gates will be closed, causing the water level to rise on the upstream side of the anicut. As flows in the river increase, the anicut will be overtopped.

(b) When the water level behind the anicut reaches 523 ft +MSL, the three scour gates will be opened to flush out accumulated sediment onto the downstream side of the anicut. This situation corresponds to a stream discharge of approximately 500 cusec.

(c) When the bed level in the vicinity of the conduits drops below 519 ft +MSL, which is 1 ft below the invert level of the conduits and 1 ft above the sill level of the anicut, the conduits will be opened to commence feeder canal flows.

(d) If Kirindi Oya flows reach flood levels, the conduits may be closed temporarily until the flood threat recedes. This action might be necessitated due to the high turbulence caused by flood flows resulting in water with a high proportion of suspended load, which if allowed to enter the feeder canal could tend to silt-up the stretch of canal between the regulator and the head sluice.

Feeder canal flows can be obtained during the wet season, while keeping the scour gates and conduits open. Once rains recede with the onset of the dry season, resulting in lower flows in the river, the conduits and the scour gates will be closed and the five midstream gates will be opened until the following wet season. The gates on the right bank will be kept closed throughout.

6.0 Conclusion

An effective and economical solution using hydraulic model tests has been found for the serious problem of siltation at the Kirindi Oya Intake. This involves the installation of 3 nos. scour gates on the existing cut-off wall, the construction of a regulating structure with 2 nos. conduits equipped with circular gates at the mouth of the feeder canal and the formation of an earth embankment between the regulator and the high ground near the head sluice. This solution deserves serious consideration and if implemented will greatly increase the economic benefits of the Handapanagala Irrigation System and will be of immense benefit to the local farmer population who have suffered long enough due to the total failure of the existing diversion.

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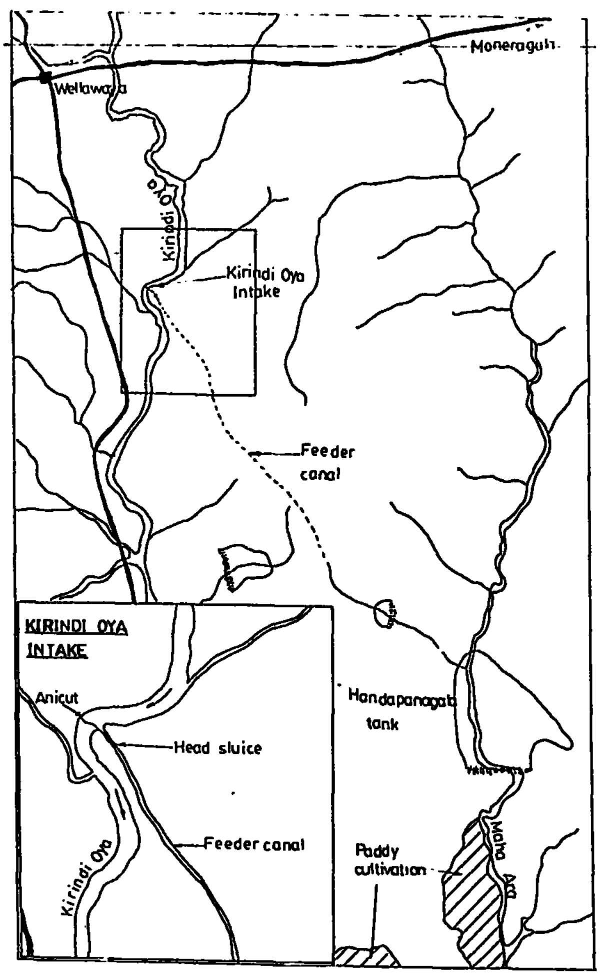


Fig 1 : Site Location

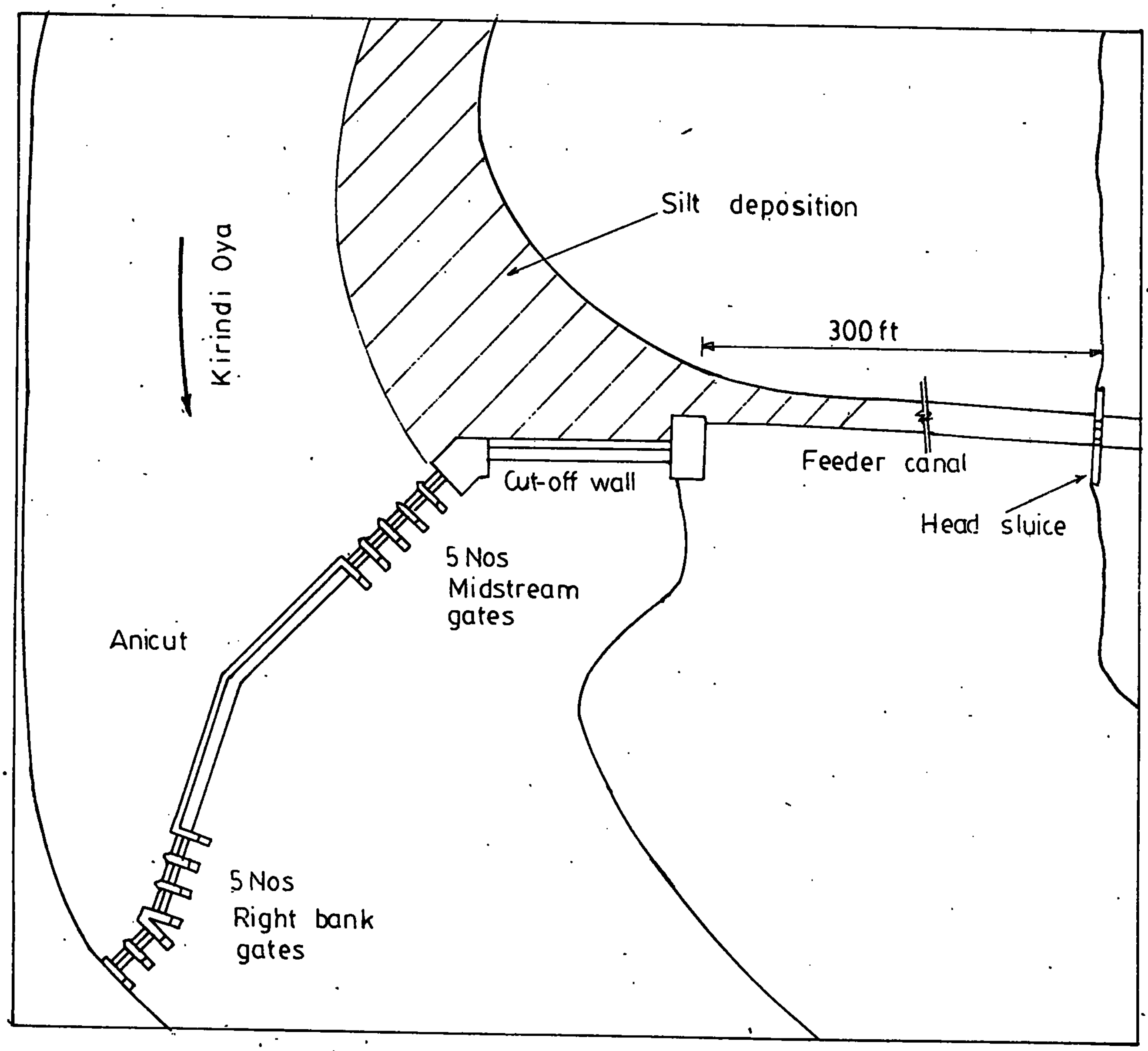


Fig 2 : Plan of Kirindi Oya Intake - present condition

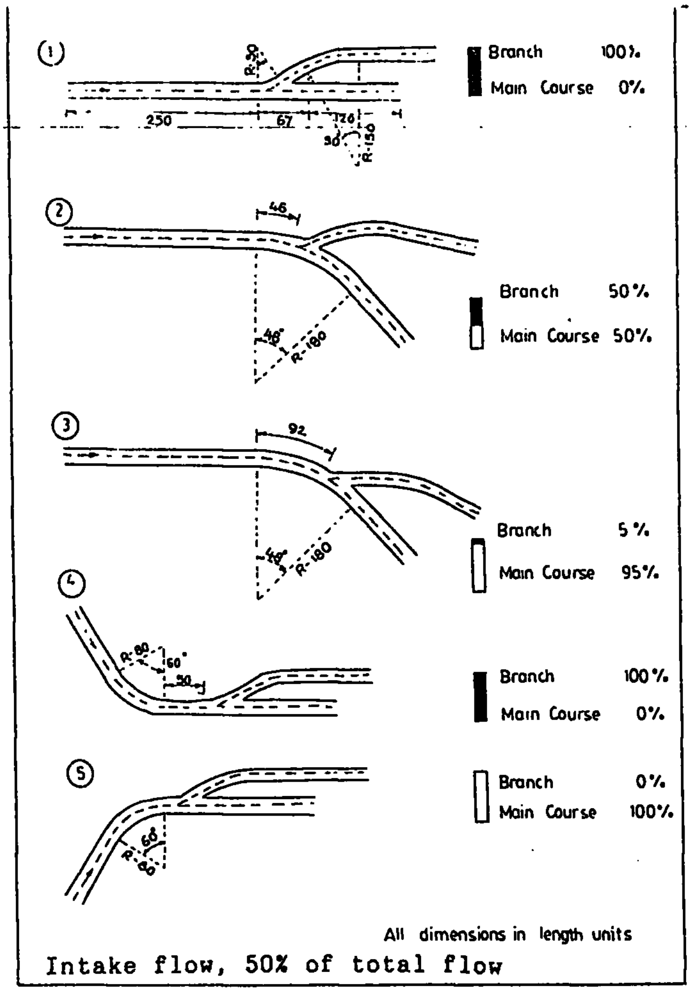


Fig 3a : Effect of intake site selection on bed load intrusion

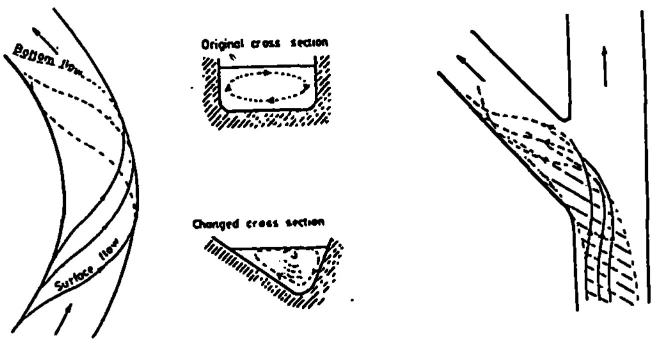


Fig 3b : Development of spiral flow at a river bend and at an intake

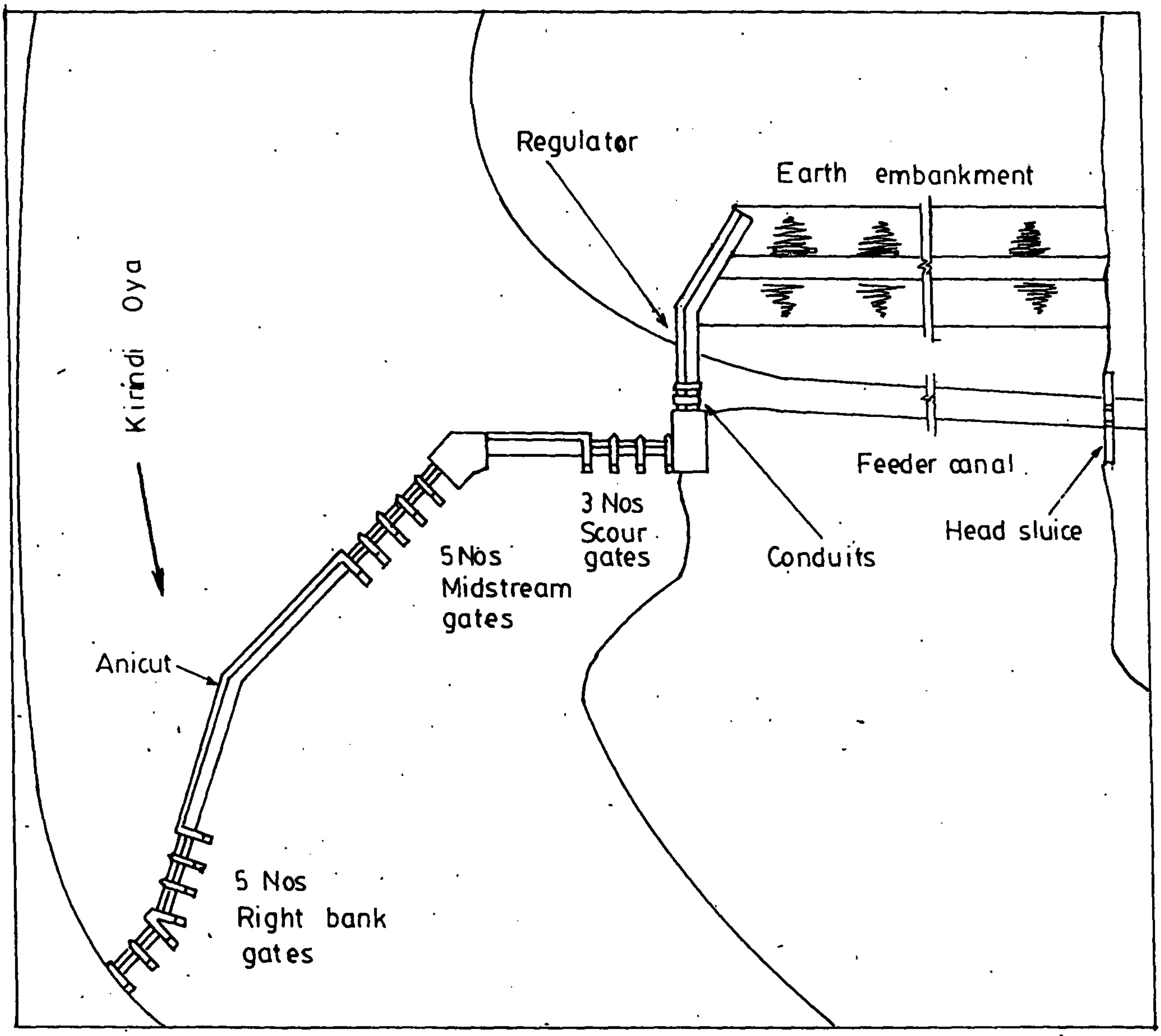
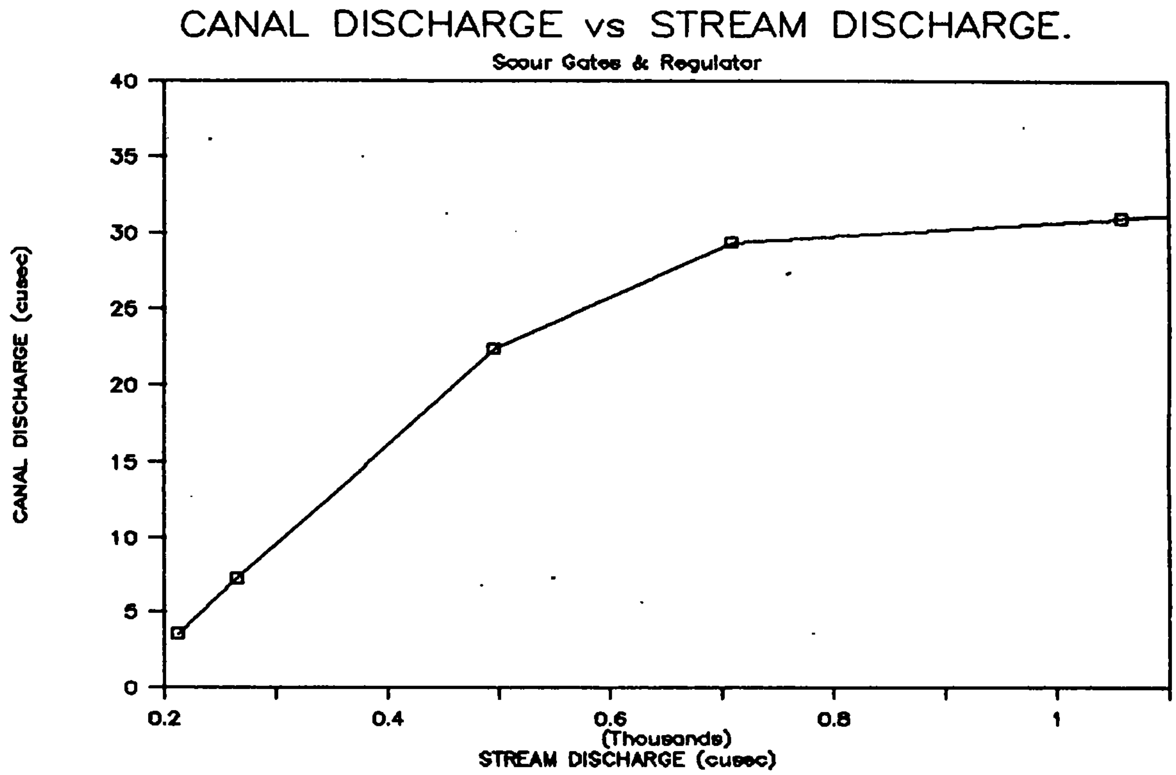
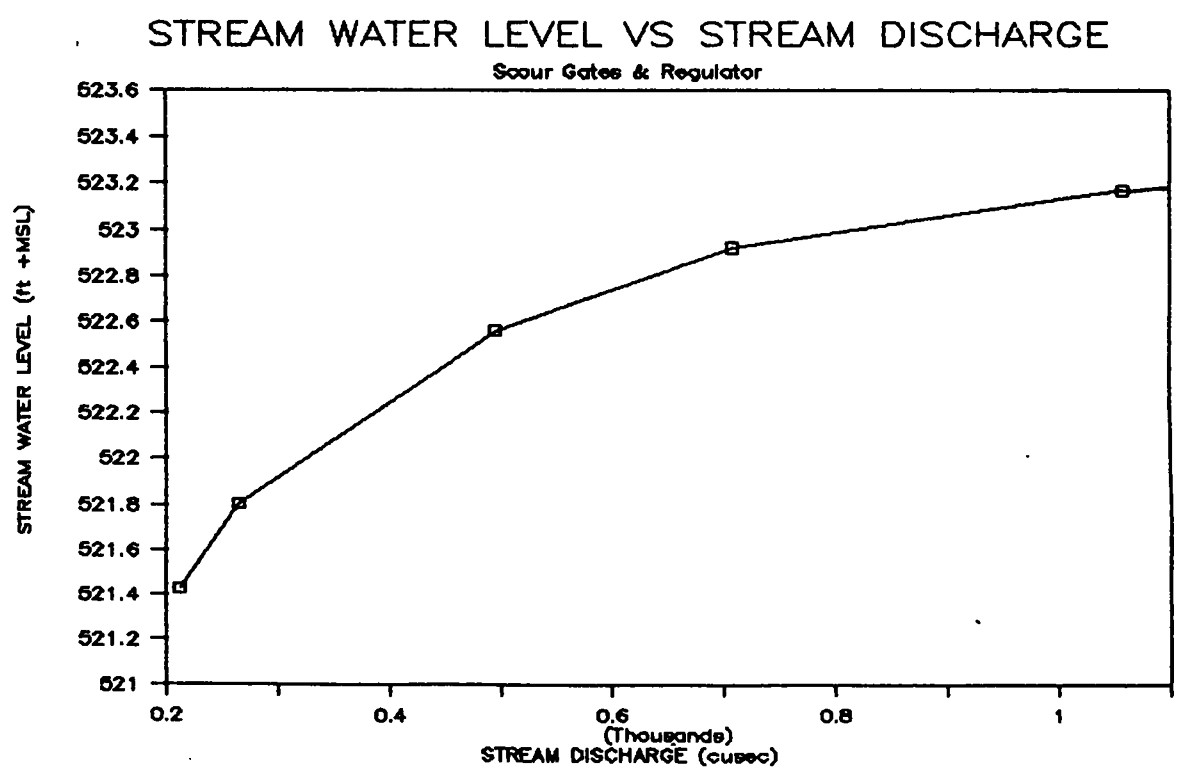


Fig 4 : Plan of Kirindi Oya Intake - incorporating solution



- with scour gates and conduits open

Fig 5a : Graph of Canal discharge vs Stream discharge



- with scour gates and conduits open

Fig 5b : Graph of Stream water level vs Stream discharge