SOMALI DEMOCRATIC REPUBLIC
MINISTRY OF NATIONAL PLANNING

MOGAMBO IRRIGATION PROJECT

Additional Study for an Alternative Development

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1970 1980

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Date: 10th September 1980

The Director General
Ministry of National Planning
Mogadishu
SOMALI DEMOCRATIC REPUBLIC

Dear Sir

MOGAMBO IRRIGATION PROJECT
ADDITIONAL STUDY FOR AN ALTERNATIVE DEVELOPMENT
FINAL REPORT

With reference to your letter of approval dated 25.6.1980 reference TU/MI/2076/80 and to our telex dated 13.8.1980 and in accordance with Section 4.2 of our Agreement for Engineering Services we have pleasure in submitting forty copies of the above Final Report.

Five copies of the report are being transmitted simultaneously to the Kuwait Fund for Arab Economic Development and the Kreditanstalt fur Wiederaufbau as required by the Agreement.

We should like to take this opportunity of recording our thanks and appreciation for the co-operation we have received from the Somali Authorities in carrying out this assignment.

Yours faithfully
SIR M. MACDONALD & PARTNERS LIMITED

C. D. Fielder

C. D. Fielder

cc Kuwait Fund For Arab Economic Development
Kreditanstalt fur Wiederaufbau

Registered in England No. 1263912

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ACKNOWLEDGEMENTS

Sir M. MacDonald & Partners Limited wish to thank Hunting Technical Services Limited who carried out the agricultural and economic aspects of this study.

SUMMARY

1. Background

The Mogambo Irrigation Project was first formulated in a feasibility study undertaken by TAMS/FINTECS (May 1977) and then studied in further detail in a Supplementary Feasibility Study carried out by Sir M. MacDonald & Partners (August 1979).

The draft study was submitted on 6th September 1979 and comments were received from the State Planning Commission (SPC) in December 1979. A meeting with the SPC and the funding agencies, to be held in Cambridge, was then arranged for mid January 1980. Unfortunately, the representative from SPC was unable to attend. During these discussions on 21/22 January 1980, the funding agencies were concerned by the uncertainties of implementing and operating the full 6 430 ha project proposed in the Supplementary Study and suggested that a smaller development of about 2 000 ha should be considered. The SPC agreed with the funding agencies and in a telex dated 28th January 1980 reference GQQ/TU/MI/269/80 instructed the Consultant to proceed immediately with an Additional Study for an alternative smaller development.

This Additional Study now being presented should be read in conjunction with the Supplementary Study dated August 1979 which covers the full development of 6 430 ha of cultivated land.

2. The Project

The terms of reference for this Additional Study called for two alternatives (A and B) to be investigated. The development for alternative A has been based on the proposals of the Supplementary Study and allows for future expansion to the full area. The development for alternative B has been chosen as the best area to be implemented independently of any future expansion. Alternative A identifies 2 052 ha net of surface irrigation and 163 ha net of overhead irrigation, and alternative B identifies 1 809 ha net of surface irrigation and 122 ha net of overhead irrigation.

The irrigation water for either alternative would be pumped from the river Juba and conveyed to the project area in a system of earth canals from which surface irrigation by gravity will be possible. Both alternatives include a small pilot area for overhead irrigation which will be supplied with water by means of sprinkler pump stations located along the canals. The peak irrigation requirement for alternative A is 3.70 m^3/s and for alternative B is 3.26 m^3/s.

Flood protection works have been included to prevent flood damage to the project works. The existing flood relief regulator at Bulo Yaag will be rehabilitated and the channel will be re-formed and extended to discharge into the natural channel system on the western boundary. A flood bund is required for both alternatives along the western boundary of the project area. These flood protection works are essential until the Bardheere dam is constructed and flow regulation provided along the lower Juba River.

The drainage system for both alternatives consists of shallow surface drains which discharge into the natural channels on the western boundary of the project area. Disposal of the drainage water from the project area will be by gravity; it will flow southwards following the natural ground slopes and old channel systems until it finds its way to the Dhesheeg Waamo.

The project will be operated as a state farm with a management hierarchy and a paid workforce of technicians, supervisors, clerks, skilled and unskilled labourers. The project incorporates a number of benefits designed to attract and retain the labour force. These include a piped water supply, above average wage levels and permanent employment. Villagers will be expected to organise the construction of their own houses but will be provided with assistance and materials.

Two crop rotations have been selected based on the arguments presented in the Supplementary Study. These are:-

Crop Rotation 1

Surface irrigation	100%	paddy rice (gu season)
	75%	maize (der season)
Overhead irrigation	100%	cotton (der season)

Crop Rotation 2

Surface irrigation	75%	paddy rice (gu season)
	75%	paddy rice (der season)
Overhead irrigation	100%	cotton (der season)

The rice/maize combination is a simpler crop rotation to manage. The maize crop requires less sophisticated management and has a shorter growing season than the rice varieties proposed. Maize will not be subject to bird attack, and the inclusion of maize in the rotation will ensure that the problems of a build-up of aquatic weeds, which can arise when paddy rice fields are subject to prolonged flooding, will not occur.

Double cropped rice offers an economic advantage over the rice/maize combination, allowing complete specialisation in agricultural equipment and farm operations. A reduction in intensity to 75% in each growing season still exploits these advantages and is considered to allow a sufficient fallow period to avoid weed problems. Subsequent introduction of short maturing rice varieties would also ease the time constraints and may reduce the occurrence of bird attack.

Perennial crops have not been included in either rotation because their cultivation would depend on the implementation of Bardheere dam.

A small area of levee soils will be planted for cotton under overhead irrigation so that the potential of development on the levee soils can be investigated.

As in the Supplementary Study, most of the agricultural operations will be mechanised and include aerial spraying of crops. A base agricultural labour force of 345 unskilled workers will be employed annually, supplemented by casual labour at peak periods.

Due to the reduction in the scale of the project, the Agricultural Development Corporation will assume the responsibility for crop processing and storage, rather than the project incorporating these facilities on site. This is a modification of the proposal in the Supplementary Study.

3. Project Economics

Four development options were analysed:

A/1	alternative A with crop rotation 1
A/2	alternative A with crop rotation 2
B/1	alternative B with crop rotation 1
B/2	alternative B with crop rotation 2

The results of the economic analyses of the four options are given below:-

Economic Results of Options

Alternative	Net cropped area (ha)	Crops grown	Capital cost (SoSh '000)	Internal rate of return (%)
A/1	2 215	rice maize cotton	122 083	5.43
A/2	2 215	rice cotton	119 376	8.94
B/1	1 931	rice maize cotton	95 207	5.27
B/2	1 931	rice cotton	93 904	8.96

The capital costs for alternative A are higher than for alternative B because the irrigated area is larger and because the civil works have been designed to allow for possible future expansion without the construction of additional irrigation pump stations and supply canals.

The slightly larger area available in alternative A, due to the upstream location of the pump station site, generated sufficient extra income over 30 years to offset the higher initial capital costs. Thus there was no economic reason to adopt alternative B and since alternative A facilitated future expansion, it was chosen as the preferred option.

The double cropped rice rotation offered clear economic advantages over the rice/maize rotation, and is therefore recommended as the chosen option. Should any unforeseen technical problems occur with a double cropped rice rotation the project would be able to change into a rice/maize rotation which would still be profitable, albeit less so.

Further analyses of the recommended option of alternative A/2 gave a financial internal rate of return (IRR) of 13.45% and an economic IRR of 11.17% when the Somali shilling was shadow priced at its true international value. The project was also found to be reasonably insensitive to changes in costs and prices. A combination of a 20% rise in costs and a 10% decrease in output produced an IRR of 2% whereas a decrease of 10% in costs coupled with an increase in output of 10% raised the IRR to 14%.

4. Conclusions

Alternative A with a double cropped rice rotation is the recommended option. It has been chosen because of its high internal rate of return and because future expansion can occur with less expenditure than for alternative B.

A summary of the capital costs and operating costs for the recommended alternative, A/2, are given below.

Summary of Capital Costs for Alternative A/2
(SoSh '000)

Item	Local currency	Foreign currency	Total	
Land preparation	6 415	6 414	12 829	(13 471)
Irrigation and drainage system	22 685	31 745	54 430	(60 525)
Buildings and services	5 598	11 360	16 958	(20 349)
Operation and maintenance vehicles and machinery	500	4 505	5 005	(5 756)
Agricultural machinery	1 247	11 221	12 468	(12 468)
Engineering design and supervision of construction	3 242	6 022	9 264	(10 653)
Physical contingencies	2 948	5 474	8 422	(9 431)
Total	42 635	76 741	119 376	(132 653)

Note: Costs are 1979 economic costs and do not include taxes or duties. Financial costs are shown in parenthesis.

Summary of Operating Costs for Alternative A/2
(SoSh '000)

Item	Total cost for 30 years project life
Replacement of agricultural items	48 246
Replacement of engineering items	30 589
Agricultural inputs	155 621
Project staff	94 263
Fuel, oil and spares	119 477
Total	448 196

Note: Costs are 1979 economic costs.

4. Conclusions

Alternative A with a double cropped rice rotation is the recommended option. It has been chosen because of its high internal rate of return and because future expansion can occur with less expenditure than for alternative B.

A summary of the capital costs and operating costs for the recommended alternative, A/2, are given below.

Summary of Capital Costs for Alternative A/2
(SoSh '000)

Item	Local currency	Foreign currency	Total	
Land preparation	6 415	6 414	12 829	(13 471)
Irrigation and drainage system	22 685	31 745	54 430	(60 525)
Buildings and services	5 598	11 360	16 958	(20 349)
Operation and maintenance vehicles and machinery	500	4 505	5 005	(5 756)
Agricultural machinery	1 247	11 221	12 468	(12 468)
Engineering design and supervision of construction	3 242	6 022	9 264	(10 653)
Physical contingencies	2 948	5 474	8 422	(9 431)
Total	42 635	76 741	119 376	(132 653)

Note: Costs are 1979 economic costs and do not include taxes or duties. Financial costs are shown in parenthesis.

Summary of Operating Costs for Alternative A/2
(SoSh '000)

Item	Total cost for 30 years project life
Replacement of agricultural items	48 246
Replacement of engineering items	30 589
Agricultural inputs	155 621
Project staff	94 263
Fuel, oil and spares	119 477
Total	448 196

Note: Costs are 1979 economic costs.

CHAPTER 1

INTRODUCTION

1.1 Reasons for the Additional Study

The Mogambo project was formulated in a feasibility study undertaken by TAMS/FINTECS (May 1977), and a net irrigable area of 6 260 ha was identified. Subsequent to this study, a Supplementary Feasibility Study (Sir M. MacDonald & Partners, August 1979) was initiated in order that the proposals could be examined in more detail. In the Supplementary Study a net irrigable area of 6 430 ha was identified and the following major changes to the TAMS/FINTECS proposals were recommended:

(a) Revised cropping patterns and intensity.

(b) Overhead irrigation on 3 100 ha, surface irrigation on 3 330 ha (TAMS/FINTECS proposed all surface irrigation).

(c) Inclusion of pumped drainage for about one-third of the area.

(d) No livestock feedlot component (recommended by TAMS/FINTECS).

(e) Comprehensive flood protection measures.

(f) Night storage system for surface irrigation.

The total cost of the project was estimated in the Supplementary Study to be SoSh 334 million, which contrasts with the TAMS/FINTECS estimate of SoSh 181 million. The reasons for the differences are discussed in the Supplementary Study, but the fundamental reason is considered to be that the TAMS/FINTECS study lacked sufficient engineering detail to enable a realistic cost estimate to be made.

Following a review of the draft Supplementary Study report the State Planning Commission (SPC) submitted comments to the Consultant and these were received in December 1979. The SPC requested that a meeting be arranged in Cambridge so that representatives of the Commission, the Kuwait Fund for Arab Economic Development (KFAED), and Kreditanstalt fur Wiederaufbau (KFW) could discuss the report with the members of the study team. This meeting took place on the 21st and 22nd January, 1980, but unfortunately the representative of SPC could not attend.

During these discussions, the funding agencies KFAED and KFW considered that technical and managerial problems and uncertainties involved too great risks in implementing the whole 6 430 ha in one step. They suggested therefore that the Consultants should consider a smaller initial development for an area of about 2 000 ha of predominantly surface irrigation but including a small trial area of overhead irrigation. Terms of reference for such a study were drafted and approved by the SPC.

This report contains the findings of this Additional Study and should be read in conjunction with the Supplementary Study report (August 1979).

1.2 Terms of Reference for Additional Study

Terms of reference were discussed at the meeting held in Cambridge in January 1980 and these were communicated to the SPC by telex on the 22nd January 1980. These were as follows:-

> "In view of the uncertainties of implementing and operating the project, and arising from discussions with KFAED and KFW, we have been requested to provide the following proposal for SPC consideration for a short separate desk study report for an alternative development. This additional study will consider two cases using existing data as follows:
>
> Case One
>
> An area of about 2 000 ha which has the lowest capital cost as a first stage development of the total 6 400 ha project area. Designs to include for future development.
>
> Case Two
>
> An area of about 2 000 ha which has the lowest capital cost developed as the most economical system without reference to the total project area. Future development being independent.
>
> Both cases to be predominantly surface irrigation including small trial area of sprinkler irrigation.
>
> Study will include operation and maintenance and economic analysis and implementation to same levels as Supplementary Study".

The SPC gave instructions for the Consultant to proceed in their telex dated 28th January 1980 which read:

> "GQQ/TU/M1/269*80. Ref your telex dated 23 Jan 80 concerning the proposal for an additional desk study for Mogambo project. Wish to inform you that Somali Government approves such study and urges immediate start of the study. Kindly inform also KFAED and KFW. Hussein Elabe Fahie Director General State Planning Commission".

1.3 Alternative Development

The terms of reference requested that two cases be considered in order to determine the most appropriate alternative development.

In this report, these two cases are referred to as alternative A and alternative B.

Also this alternative development is considered to be Phase I of the full development of 6 430 ha, described in the Supplementary Study (August 1979). Phase II refers to development of the area remaining upon completion of Phase I.

CHAPTER 2

THE ALTERNATIVES

2.1 Introduction

The two alternatives (A and B) adopted were based on surface irrigation because this would be cheaper to construct and operate than the overhead system and since higher value crops can be grown on the soils irrigated by surface methods (before Bardheere dam is implemented). A small area of overhead irrigation has been included to demonstrate its technical feasibility and carry out research into design details, crops grown and operating techniques before further capital is invested in sprinkler irrigated areas.

2.2 Alternative A

This alternative is based on the designs prepared for the full project and assumes that future expansion of up to 6 400 ha would take place. A total net irrigable area of 2 215 ha has been selected comprising:

76 surface irrigation units	=	2 052 ha
4 overhead irrigation units	=	163 ha
Total	=	2 215 ha

The area chosen is basically that block of land to the south of the flood relief channel which has predominantly basin clay soils. The overhead irrigation units are at the northern end of this block located on either side of the flood channel. The irrigation layout is as for the full study but the drainage system has been modified to keep costs to a minimum. This is discussed in more detail in Chapter 4.

One village area would be provided, and this combined with the project headquarters (PHQ), will be located adjacent to the main road opposite the village of Mogambo (Village A location in Supplementary Study). The area allocated for the PHQ in the Supplementary Study has been incorporated in the irrigated area.

All works will be designed to permit future expansion without involving major alterations. For example, the main canal siphon under the flood relief channel will be constructed to its full size because later modifications would be extremely difficult. However the main pump station would only be built to meet the needs of the first stage since this can be extended at a later date without difficulty.

2.3 Alternative B

The second alternative aims to cut costs to the minimum possible by designing solely for the smaller area without provision for future expansion.

The irrigation and drainage layout has been prepared based on the revised position of the pump station. This is located more centrally to the area, on one of the reaches of the river nearest to the selected areas. The irrigated area itself in fundamentally the same as for alternative A, but some areas of higher ground have been excluded to reduce canal fill requirements and the pumping head required, and no land to the north of the flood relief channel has been incorporated. The net irrigable area is thus 1 931 ha made up of:

67 surface irrigation units	=	1 809 ha
3 overhaed irrigation units	=	122 ha
Total	=	1 931 ha

2.4 Future Development

Any future development at Mogambo, following on from either alternative A or alternative B, will involve a greater expenditure on engineering works than for the initial development. However, in the case of alternative A, the design of the first phase will be such as to permit extension of the existing system without major changes to the engineering works. For this alternative therefore the costs of expansion should not be too different from the costs for the first phase, depending on the location and size of the extension areas.

Areas which require overhead irrigation require a greater capital investment than the surface irrigated areas, but with only some 2 000 ha of land developed in the first phase, there would be at least a further 1 300 ha of land suitable for surface irrigation. Some of this area is however inherently more expensive to develop because of its distance from the source of water, more dense bush coverage and the need for pumped drainage.

In the case of alternative B the first phase is planned without provision for future development although the design does not, of course, preclude future expansion. The cost of such expansion would necessarily be higher than for alternative A because additional pump station(s) and canal systems would be required and the drainage and flood protection works for the first phase would require some revision (depending on the location of the extension area).

However, once the first phase is complete and is operating there will be an established infrastructure which will facilitate future development. For example access into the area will be much improved and there will be a larger labour force available for construction works. Futhermore the expertise in management and operation will be available, which will ease the problems of implementation of the new areas.

The same degree of expatriate assistance would probably not be necessary for the management of the new areas as is proposed for the first phase. Experience gained in the construction and implementation of the first phase would clearly help in later phase development.

CHAPTER 3

AGRICULTURE

3.1 Introduction

For the alternative development detailed in this report the agricultural proposals do not vary significantly from those described in the Supplementary Study.

The choice of crops is based on the studies and investigations presented in the Supplementary Study. Basically the aim is to minimise the number of crops in order to simplify management and as far as possible to incorporate those crops which show the best economic returns. Two crop rotations are presented. These are:

Crop rotation 1

Surface irrigation	100% paddy rice (gu season) 70% maize (der season)
Overhead irrigation	100% cotton

Crop rotation 2

Surface irrigation	75% paddy rice (gu season) 75% paddy rice (der season)
Overhead irrigation	100% cotton

These are discussed in more detail in the following section. The requirements for agricultural labour and machinery, and farm inputs are discussed in subsequent sections.

The crop yields assumed for the chosen crops are as given in the Supplementary Study and are listed below in Table 3.1.

TABLE 3.1

Crop Yields (quintals/ha)

Crop	Year 1	2	3	4 onwards
Paddy rice	25	30	35	40
Maize	25	30	35	40
Cotton	12	16	20	25

TABLE 3.2

Summary of Alternatives - Cropped Areas (ha net)

	Year 2		Year 3		Year 4		Year 5 onwards	
	gu	der	gu	der	gu	der	gu	der
Alternative A - 2 215 ha								
Rotation 1								
Paddy rice	-	-	459	-	1 431	-	2 052	-
Maize	-	216	-	918	-	1 377	-	1 458
Cotton	-	163	-	163	-	163	-	163
	Overall cropping intensity (Year 5 onwards) = 166%							
Alternative A - 2 215 ha								
Rotation 2								
Paddy rice	-	216	459	918	1 215	1 539	1 593	1 539
Cotton	-	163	-	163	-	163	-	163
	Overall cropping intensity (Year 5 onwards) = 149%							
Alternative B - 1 931 ha								
Rotation 1								
Paddy rice	-	-	459	-	999	-	1 809	-
Maize	-	189	-	783	-	1 296	-	1 296
Cotton	-	122	-	122	-	122	-	122
	Overall cropping intensity (Year 5 onwards) = 167%							
Alternative B - 1 931 ha								
Rotation 2								
Paddy rice	-	189	459	972	1 188	1 215	1 404	1 377
Cotton	-	122	-	122	-	122	-	122
	Overall cropping intensity (Year 5 onwards) = 150%							

Notes: Figures based on implementation schedules presented in Chapter 8.

3.2 Cropping Patterns

The rice/maize combination for the surface irrigated soils is considered to be appropriate (rotation 1) but, because double cropping of rice has some advantages, and has proved feasible in other countries, it has been included (rotation 2) so that the economics of the two proposals can be compared. In order to ease management problems and also in an attempt to avoid the build-up of aquatic weeds, 25% of the area of surface irrigation will be fallow in any season for rotation 2.

For the small area of overhead irrigated soils, cotton in the der season has been assumed for 100% of the area each year. However, it is recommended that small areas of other crops are introduced on a trial basis to demonstrate the applicability of this system of irrigation. Such crops should include upland rice and maize and possibly other crops of which there is little experience in Somalia.

Full details of the crop rotations for each alternative are given in Table 3.2 which also shows the build-up in cropped area during project implementation (See also Chapter 8).

The advantages of the double cropped rice system are that it allows complete specialisation in agricultural equipment and farm operations. It will obviously be easier to manage if short maturing rice varieties are used, otherwise timing of operations may be difficult, especially if there is a delay in the planting of the gu season crop.

The rotation of rice with maize should be an easier system to manage. The maize crop is less demanding in the management required and is not subject to bird damage to the same extent as the rice crop. Although the degree to which bird damage is likely is unknown and the timing of attacks is uncertain, there is no doubt that there is a problem. Until rice crops have been grown at Mogambo for some years it is impossible to predict whether the damage will be severe enough to exclude rice from one season or to alter the timing of the rice harvest.

The inclusion of maize crop following rice will also ensure that the problems due to the growth of aquatic weeds, which can occur under conditions of prolonged flooding of paddy fields, will not occur. Again the extent of such problems can only be determined by trials when the project is underway.

The inclusion of perennial crops in the cropping patterns has not been considered because these would depend on the implementation of Bardheere dam and, in any case, were only proposed for the levee soils of which only a small area is included in this alternative development. However it is recommended that trials are carried out on small areas using overhead irrigation.

This should be possible if only a few hectares are planted to bananas because there will be sufficient storage in the system to guarantee perennial supplies.

3.3 Labour and Machinery Requirements

3.3.1 Labour

Unskilled labour requirements for the four alternatives have been calculated and are presented in Appendices II to V. Table 3.3 below summarises the requirements at full development. The base data and methodology from the Supplementary Study were employed.

Requirements for machinery operators are calculated in Section 3.3.2, and management and skilled staff requirements are set out in Section 6.4.

TABLE 3.3

Summary of Unskilled Labour Requirements (at Full Development)

Alternative crop rotation	Base labour force (men/year)	Extra man years required	Total man years
A/1	370	23	393
A/2	330	29	359
B/1	320	21	341
B/2	300	24	324

3.3.2 Machinery

The same machinery specification and performance data as in the Supplementary Study have been used to calculate the requirements for the four alternatives. The detailed calculations are set out in Appendices II to V and the requirements at full development are shown in Table 3.4.

TABLE 3.4

Machinery Requirements at Full Development

Item	Alternative			
	A/1	A/2	B/1	B/2
150 hp crawler tractor	6	6	5	5
110 hp 4 wd tractor	11	10	9	9
75 hp 2 wd tractor	5	3	4	3
Chisel ripper	3	4	3	3
Soil saver plough	3	-	3	-
Disc harrows	3	4	3	4
Land plane	3	3	3	3
Fertiliser broadcaster	2	2	2	2
Combine drill	4	4	3	3
Inter-row cultivator	3	1	2	1
Border disc	3	2	2	2
Flail	4	4	3	3
Trailer - 10 tonne	9	8	8	7
Trailer - 5 tonne	5	5	4	4
Base combine units	10	7	8	7
Rice attachments	10	7	8	7
Maize attachments	6	-	5	-
Operators	80	65	65	60

3.4 Machinery Support Services

The two components of the machinery support services will be the servicing and repair facilities and the operator training facilities.

3.4.1 Servicing and Repair Facilities

The servicing and repair facilities would comprise a workshop and store at the project headquarters and one mobile workshop. The main workshop would be provided with the following:-

- machinery for mechanical repairs
- body and paintwork repair facilities
- electrical repair facilities
- lubrication store
- store for spare parts

The mobile workshop would comprise of a long wheel base four wheel drive pick up vehicle equipped with an air compressor, generator, welding plant and small crane. A low loader trailer with a winch will also be provided to transport machinery that cannot be repaired by the mobile workshop back to the permanent workshop at the project headquarters.

3.4.2 Training Facilities

A training manager will be responsible for all aspects of training such as the organisation of formal training courses with institutions and manufacturers, and the monitoring of progress of the trainees.

The project staff mainly involved with the training programme would be the workshop staff, drivers and machine operators. Training would then be carried out by using the trainees as assistants to the more skilled and experienced members of staff.

3.5 Farm Buildings

No crop processing or crop storage buildings are to be provided; all crops are to be sold direct from the fields to the Agricultural Development Corporation (ADC) (see section 3.6).

Other buildings required are as follows:-

(i) A main store will be required for the storage of incoming goods at the project headquarters. A building of about 360 m^2 should be adequate for storage, office and toilet space.

(ii) A workshop with a floor area of about 900 m^2. A sketch of the proposed workshop is given in Chapter 5, Figure Nr 5.3.

(iii) Areas of covered hardstanding and open hardstanding have been provided for vehicles, agricultural machinery and maintenance machinery.

3.6 Crop Processing and Storage

Since the Project has been reduced to one third of the original scale proposed, it is considered that it is no longer necessary for the project to own and operate its own crop processing and storage facilities. Instead, this function will be the responsibility of ADC. Since the project will now be selling directly from the field to ADC, a price for raw grain rather than dried and processed has been derived (see Chapter 7). The project will purchase seed from ADC rather than operate its own seed preparation plant.

ADC will almost certainly be required to invest in new facilities to deal with the increase in production not only from Mogambo but from other projects in the Lower Juba valley. It is possible that ADC may decide to site some new facilities at Mogambo.

3.7 Net Margins

The crop net margins derived in the Supplementary Study have been adjusted in the cases of rice and maize to reflect prices for unprocessed grain, and are summarised in Table 3.5, below. Otherwise, data are as in the Supplementary Study.

TABLE 3.5

Summary of Crop Net Margins (SoSh)

Crop	Per hectare		Per 1 000 m^3 of irrigation water	
	Financial	Economic	Financial	Economic
Paddy rice	9 469	6 392	692	467
Upland rice	7 905	5 242	1 192	791
Maize - surface	1 233	2 357	124	237
Maize - sprinkler	1 325	2 424	178	325
Sesame - surface	47	811	8	138
Sesame - sprinkler	47	811	6	110
Cotton - hand harvested	3 245	4 550	322	451
Cotton - machine harvested	1 880	2 753	186	273
Bananas	4 464	9 631	182	393

3.8 Crop Water Requirements

Crop water requirements are unchanged from the Supplementary Study except that the requirements for der season paddy rice have been calculated and the results shown in Table 3.6.

TABLE 3.6

Crop Water Requirements - Der Season Paddy Rice

	Aug	Sep	Oct	Nov	Dec	Jan
Evapotranspiration, ETo (mm)	147	157	160	147	161	179
Effective rainfall, Re (mm)	8	0	0	0	0	0
Crop factor	-	1.10	1.10	1.10	1.00	0.95
Consumptive use (mm)	-	173	176	162	161	170
Average cropped area(1)	-	0.38	0.96	1.00	0.63	0.04
Prewatering (mm)	25	75	-	-	-	-
Flooding (mm)	-	40	110	-	-	-
Percolation (mm)(2)	-	20	95	150	95	20
Net requirement	17	201	374	312	196	27

Notes : (1) Cropped area based on that receiving irrigation. Last irrigation takes place 3 months after sowing.

(2) Deep percolation adjusted for average cropped area. Based on rate of 5 mm/d.

(3) Table assumes sowing starts on 1st September and continues for 40 days. First prewatering starts 20th August.

It can be seen that the peak monthly net requirement occurs in October and is 374 mm. This is greater than the equivalent for gu season rice (355 mm) because in the der season rainfall is less reliable and evapotranspiration is greater. This will not affect the overall irrigation requirement since for rotation 2 only 75% intensity is proposed compared with 100% for rotation 1.

The irrigation requirements for alternatives A and B are given in Tables 3.7 and 3.8 respectively. The field requirements have been calculated by dividing the net requirement by the field efficiency. The field efficiencies are as detailed in the Supplementary Study.

	Crop	Field efficiency
Surface irrigation	paddy rice	0.80
	maize	0.60
Overhead irrigation	cotton	0.75

TABLE 3.7

Irrigation Requirements - Alternative A

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ETo (mm)	179	170	195	157	145	129	132	147	157	160	147	161
Re (mm)	0	0	0	17	22	36	32	8	0	0	0	0
Field requirements (mm)												
Surface irrigation												
(i) Crop rotation 1												
paddy rice (2 052 ha)				230	444	320	244	21				
maize (1 458 ha)	45								213	173	245	237
(ii) Crop rotation 2												
paddy rice (1 539 ha)				230	444	320	244	21				
paddy rice (1 539 ha)	34							21	251	467	390	245
Overhead irrigation:												
cotton (163 ha)	40						56	135	103	184	212	199
Main canal flow (m^3/s) (including cotton)												
rotation 1	0.29	-	-	1.98	3.70	2.75	2.07	0.26	1.37	1.15	1.64	1.53
rotation 2	0.24	-	-	1.48	2.77	2.07	1.56	0.35	1.69	3.04	2.66	1.66

$$\text{Main canal flow } (m^3/s) = \frac{\sum[\text{field requirement (mm)} \times \text{area (ha)}] \times 10}{\text{days in month} \times 24 \times 3\,600 \times 0.92}$$

0.92 = coefficient to allow for distribution losses

TABLE 3.8

Irrigation Requirements - Alternative B

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ETo (mm)	179	170	195	157	145	129	132	147	157	160	147	161
Re (mm)	0	0	0	17	22	36	32	8	0	0	0	0
Field requirements (mm)												
Surface irrigation :												
(i) Crop rotation 1												
paddy rice (1 809 ha)				230	444	320	244	21				
maize (1 296 ha)	45								213	173	245	237
(ii) Crop rotation 2												
paddy rice (1 377 ha)				230	444	320	244	21				
paddy rice (1 377 ha)	34							21	251	467	390	245
Overhead irrigation:												
cotton (122 ha)	40						56	135	103	184	212	199
Main canal flow (m^3/s) (including cotton)												
rotation 1	0.26	-	-	1.74	3.26	2.42	1.82	0.22	1.21	1.00	1.44	1.35
rotation 2	0.21	-	-	1.33	2.48	1.85	1.39	0.30	1.50	2.70	2.36	1.47

$$\text{Main canal flow } (m^3/s) = \frac{\sum [\text{field requirement (mm)} \times \text{area (ha)}] \times 10}{\text{days in month} \times 24 \times 3\,600 \times 0.92}$$

0.92 = coefficient to allow for distribution losses

CHAPTER 4

ENGINEERING

4.1 Bush Clearance and Land Levelling

4.1.1 Bush Clearance

A description of natural vegetation within the project area and a discussion of methods of bush clearance are included in the Supplementary Study.

From the natural vegetation map (plate 2 of the Supplementary Study report), it is estimated that for both alternative A and B 5% of the project area is dense or medium bush and 95% is light or open bush.

The bush clearance requirements are summarised below:-

Alternative	Gross project area (ha)	Area of dense and medium bush (ha)	Area of open or light bush (ha)
A	2 700	135	2 565
B	2 350	117	2 233

4.1.2 Land Levelling

Land levelling is required for the surface irrigation areas to produce horizontal basins. The size of each basin is 1 ha and thus the minimum size of plot to be levelled is also 1 ha. The maximum size of plot to be levelled should be determined by earthwork quantities, soil classification and efficiency of machine operations. Ground levels will be determined on site from the results of a semi-detailed land levelling survey on a 50 m grid. For areas where the existing topography is very uneven it is proposed that a 25 m grid survey is carried out.

An analysis of sample land levelling areas was discussed in the Supplementary Study and the volumes of earthworks required per hectare were estimated as given below:-

M1 and M2	Microrelief	Average = 450 m^3/ha
M3	Microrelief	Average = 775 m^3/ha

By studying the land class maps produced for the Supplementary Study and the layouts for alternatives A and B it is possible to make an estimate of the areas of each class of microrelief. For the purposes of estimating the costs of alternatives A and B an average volume of earthworks for land levelling has been taken as 500 m^3/ha (based on the areas of each class of microrelief occurring in the project area).

4.1.3 Land Planing

Land planing is required prior to field preparation for the first planting and for basin irrigation it should be carried out after land levelling. For areas irrigated by sprinkler, land planing is required to even out the microtopography and it should be carried out after the removal of any termitaria.

4.2 Irrigation System

4.2.1 Alternative A

The irrigation system for alternative A is based on the designs prepared for the full project (Annex 5, Supplementary Study) and assumes that future expansion to 6 400 ha is a possibility. A total net irrigable area of 2 215 ha is proposed comprising:-

76 surface irrigation units	=	2 052 ha
4 overhead irrigation units	=	163 ha

The irrigation and drainage layout for alternative A is shown on Plate Nr 1.

The engineering works will be constructed to permit future expansion. Thus the main and distributary canals and all canal structures will be constructed to their full size. The main irrigation pump station, the sprinkler pump station and the settling basin will only be constructed for the requirements of the phase I development since they can be expanded at a later date without difficulty.

The differences between the designs proposed for the full project in the Supplementary Study and those proposed for alternative A are given below:-

(a) Main Irrigation Pump Station

The pumps recommended for the full project to pump a peak discharge of 6.5 m^3/s were three 36 inch pumps and two 24 inch pumps with one of the 36 inch pumps as a standby. To produce the required peak flow for alternative A of 3.7 m^3/s (Table 3.7, Chapter 3) it is not feasible to use such large pumps since there would be too small a number of units to obtain the required range of discharges. Instead it is proposed to use three 24 inch pumps (one as a standby) and two 16 inch pumps. Under a design (maximum) static head of 6.1 m the design discharges of the 24 inch and 16 inch pumps are 1.25 m^3/s and 0.55 m^3/s, respectively. Adjustments to the engine speeds can achieve a flow variation of 0.80 Q to 1.05 Q where Q is the design flow. Table 4.1 shows the range of discharges which can be achieved with the pumps selected, assuming constant static head.

Flood lifter type pumps have been chosen as the most suitable form of pumps for this installation. A discussion on pump selection was included in Annex 5 of the Supplementary Study.

TABLE 4.1

Pump Station Discharge Characteristics - Alternative A

Pump size				Flow (m^3/s)	Step (m^3/s)
16 in	16 in	24 in	24 in		
80%	-	-	-	0.44	-
105%	-	-	-	0.58	0.30
80%	80%	-	-	0.88	-
105%	105%	-	-	1.16	0.28
80%	-	80%	-	1.44	-
105%	-	105%	-	1.89	-
80%	80%	80%	-	1.88	-
105%	105%	105%	-	2.47	-
80%	-	80%	80%	2.44	-
105%	-	105%	105%	3.20	-
80%	80%	80%	80%	2.88	-
105%	105%	105%	105%	3.78	-

(b) Settling Basin

The same procedure as given in the Supplementary Study for determining the size of the settling basin was carried out for alternatives A and B. The results of the computer program gave a required storage of about half the required storage for the full project. The size of the basin chosen was 36 m bed width and 200 m length. In the event of future expansion to the full project the settling basin could easily be increased in size to the required length of 400 m. Further details of the design are given in Section 4.2.2.

(c) Distributary Canal Embankments

The bank top width for both banks of the distributary was designed as 4 m for the full project. To reduce earthwork costs for alternative A it is recommended to reduce one bank to a bank top width of 1 m whilst the other remains with a bank top width of 4 m (Figure 4.1). However the hydraulic gradient for both banks between design water level and the outer toe of the canal embankment remains at 1 in 5.

(d) Main Canal Design Flows

The main canal will be constructed with a capacity for peak flow for the full project of 6.5 m^3/s, however the design discharges for alternative A will be less than for the full project. The main canal flows have been calculated in a similar manner to that described in the Supplementary Study by using the monthly irrigation requirements. Table 3.7 in Chapter 3 gives the main canal flows for each month for both crop rotations.

(e) Sprinkler Pump Stations

A small sprinkler pump station (P1 location in Supplementary Study) is required to supply the pilot overhead irrigation area of 163 ha net. The design requirement of 70 l/s per overhead irrigation unit is as discussed in the Supplementary Study. The required capacity of the sprinkler pump station for alternative A is thus 0.28 m^3/s. Two diesel engined pump units are recommended and a layout of the proposed pump station is shown on Plate Nr 7. The design of the sprinkler pump station for alternative A is simpler than the design for the full project as shown in Supplementary Study due to its smaller size. The pump station is located adjacent to the main canal and will thus be able to draw its water at any time. This will enable the overhead irrigation system to operate either at night or during the day.

The modifications required to expand the irrigation system to supply the full project of 6 400 ha are not difficult. The expansion would follow the layout proposed for the full development as described in the Supplementary Study.

4.2.2 Alternative B

The irrigation system for alternative B has been designed to be the most economical system for a project area of about 2 000 ha. No provision has been made in the proposed system for future expansion and any such expansion would be a separate project(s) supplied by its own pump station(s) on the river.

The irrigated area is fundamentally the same land as for alternative A, both alternatives being predominantly surface irrigation located on the basin clays. The proposed irrigation and drainage layouts for alternative B are shown on Plates Nr 2, 3, 4 and 5. A total net irrigable area of 1 931 ha is proposed comprising:

67 surface irrigation units	=	1 809 ha
3 overhead irrigation units	=	122 ha

Although the irrigated land for both alternatives is similar, the area for alternative B is less than for alternative A. This is because the layout proposed for alternative B has been designed to keep earthwork costs to a minimum and so some high areas which could be irrigated have been omitted. Also only 3 overhead irrigation units are proposed for alternative B as the irrigated area has been limited to land to the south of the flood relief channel.

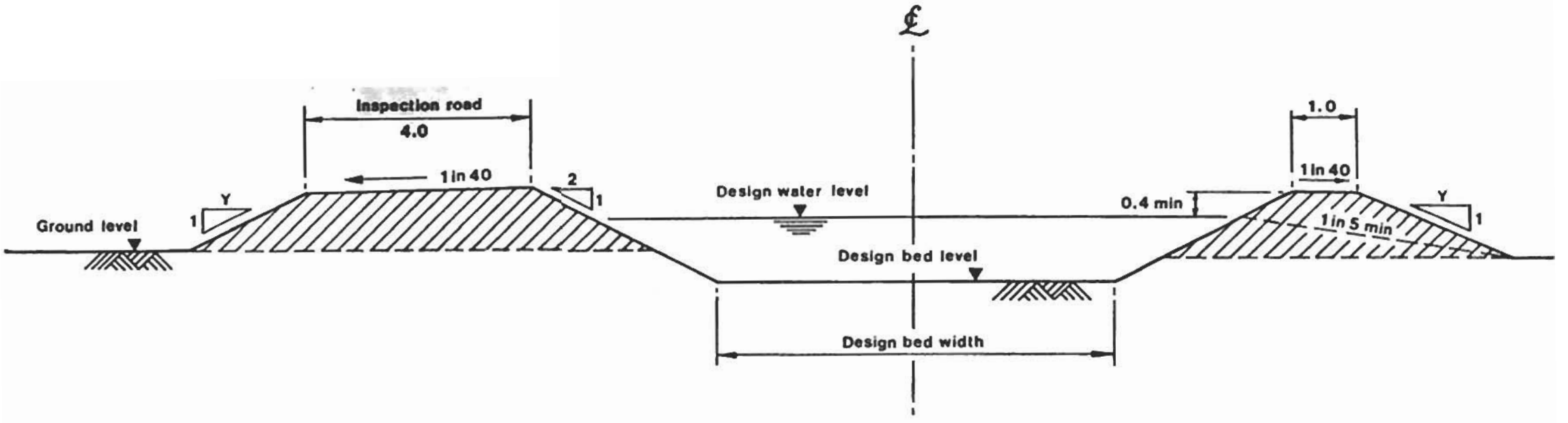
Discussions on the various components of the irrigation system for alternative B are given below.

(a) Field Units

The field units for both surface and sprinkler irrigation are the same as discussed in the Supplementary Study.

(b) Unit Channel Design

Fourteen hours irrigation per day is proposed for the peak month(s) so that the storage requirement, capacity of the distributary canals and size of the unit channel can be reduced.



4m Bank top width

Height of bank (m)	Y
< 2.0	2.0
< 2.5	2.5
< 3.0	3.0
< 4.0	3.5
> 4.0	3.5

1m Bank top width

Height of bank (m)	Y
< 1.3	2.0
< 1.5	2.5
< 2.0	3.0
< 2.5	3.5
> 2.5	3.75

Approximate scale 1:100

Typical distributary canal cross section

4.1

The design capacity of the unit channel is calculated for each crop rotation as follows:

Crop rotation 1

$$q = \frac{444 \times 27 \times 10^4}{31 \times 14 \times 3\,600} = 77 \text{ l/s}$$

where 444 = peak gross monthly requirement (May) (mm)

27×10^4 = unit area (m^2)

31 = number of days in month

$14 \times 3\,600$ = length of irrigation period (seconds)

Crop rotation 2

$$q = \frac{467 \times 27 \times 10^4}{31 \times 14 \times 3\,600} = 81 \text{ l/s}$$

where 467 = peak gross monthly requirement (October) (mm)

A design value of 80 l/s has therefore been adopted.

For prewatering, when water is applied at a high rate prior to sowing a larger unit channel capacity may be appropriate. Therefore the design section is such that a flow of 100 l/s can be carried without overtopping. This flow will not, of course, occur in more than a few unit channels on a distributary at any one time because planting dates will be staggered.

(c) Siphon Pipes

Siphon pipes are required to divert the flow from the unit channel to the basin being irrigated. To calculate the number of siphon pipes required for each surface irrigation unit the same procedure has been followed as discussed in section 4.10 of Annex 5 in the Supplementary Study.

A pipe diameter of 64 mm (2½ inches) was recommended in the Supplementary Study and under a head of 0.20 m this pipe gives a discharge of 4.2 l/s. For the design discharge of 80 l/s per unit it can be seen that 20 pipes are required for one unit. This is 2 less than for the full scheme and for alternative A. Each pipe should be 3.0 m long.

At times of prewatering when a design flow of up to 100 l/s may be required in the unit channel, it will be necessary to use more than 20 siphon pipes per unit. The additional pipes can be borrowed from other units or from a stock of spares.

(d) Distributary Canal Design

Distributary canals are designed generally as in the Supplementary Study but based on 80 l/s per unit channel. In most months the canals will flow for 12 hours per day or less. However, 14 hour irrigation will be required in May for rotation 1 and in May and October for rotation 2.

The distributary canals have a bank top width of 4 m for one bank and 1 m for the other bank as discussed in Section 4.2.1 (Figure 4.1).

The earthworks and design data for the distributary canals for alternative B are given in Appendix VII in the form of computer print-outs.

(e) Night Storage Reservoir Design

The recommended method of night storage is by means of a night storage reservoir at the head of the distributary canals. This has the advantage of requiring the minimum quantity of earthworks and of being the easiest system to operate and maintain.

Storage in the distributary canals was discounted due to the excessive amount of earthworks involved in raising canal embankments caused by long lengths of distributary canal and broken topography. It is also difficult to accommodate storage in the steeper canal reaches unless cross regulators are provided at short intervals. Storage in distributary canals is really only applicable for irrigation projects on very flat land where canal commands can be kept low.

Storage in the main canal was also considered and although this method does not result in extra earthworks, it is not recommended because to store the required volume of water the width of the main canal would have to be 70 m. A 70 m wide main canal would necessitate the removal of a greater area of valuable banana plantation and would be difficult to maintain.

Having decided to adopt the night storage reservoir system is was then an obvious choice to adopt one large reservoir at the end of the main canal.

The capacity of the storage reservoir based on 14 hours irrigation (hence 10 hours storage) during the peak months is calculated as follows:

$$\text{Storage required} = 3.26 \times 10 \times 3\,600\ (m^3)$$
$$= 117\,360\ m^3$$

where 3.26 = peak main canal discharge (m^3/s)

$10 \times 3\,600$ = length of storage (seconds)

The live storage depth is taken to be the same as for the Supplementary Study having a value of 0.75 m. Thus the required area of storage reservoir is:

$$\frac{117\,360}{0.75} = 156\,480\ m^2$$

This gives one large reservoir of 400 m by 400 m.

The maximum required water level in the storage reservoir has been determined by the maximum command requirements of the distributary canals to be 11.92 m. Adopting a freeboard of 0.5 m gives a bank top level of 12.42 m and thus an average bank height above ground level of 2.67 m (the average ground level is 9.75 m). The cross section of the reservoir embankment is as given in the Supplementary Study i.e. 4 m bank top width, 1 in 3 internal side slopes and 1 in 2 external side slopes. The seepage gradient was checked and found to be 1 in 5.

(f) Main Canal Design

The main canal is designed to flow continuously except in February and March, when river flows will generally be too low and the canal will be closed.

Three alternative designs were considered as follows:

1. Incorporate a movable weir structure at the end of the main canal as in the Supplementary Study. Because of the depth of live storage of 0.75 m in the night storage reservoir, the head loss across the movable weir will vary from morning to evening from 0.15 m (min) to 0.90 m (max) respectively.

2. Incorporate gates on the upstream wall of the inverted siphon passing the main canal under the main road. These gates will help control the flow and enable the pump station to pump to a constant head. The water level downstream of the siphon will fluctuate throughout the day by the same amount as the reservoir, that is by 0.75 m.

3. Have no gates or control along the length of the main canal. The water level in the main canal will thus fluctuate by 0.75 m and the pump station will pump to a varying head throughout the day.

Alternative 3 (no gates) is recommended because it is cheaper than both the other alternatives. No problems should arise by the fluctuating level in the main canal because the length of the canal is only 1.85 km and will thus act in a similar way to the storage reservoir. Pumping costs will be reduced because the pumps will not always be pumping to the maximum level.

The main canal has been designed using the Lacey Regime Theory as discussed in the Supplementary Study. The design was carried out for the case when the water level was a maximum with a silt factor of 0.4 thus keeping the velocity of flow quite slow (0.18 m/s). At the end of the day when the water level is lower the velocity of flow will increase to 0.36 m/s.

The cross section of the main canal is as for the Supplementary Study and is shown on Plate Nr 42 of the Supplementary Study.

(g) Canal Structures

The designs of all canal structures are as given in the Supplementary Study and the numbers of each type of structure are given in the cost tables in Section 4.6. Due to the reduced discharge in the main canal the size of the siphon under the main road has been changed to two 1.2 m square barrels.

(h) Main Irrigation Pump Station

To produce the required peak flow for alternative B of 3.26 m^3/s (Table 3.8, Chapter 3) it is recommended that three 24 inch pumps (one as a standby) and two 16 inch pumps should be used. Under a design (maximum) static head of 6.7 m the design discharges of the 24 inch and 16 inch pumps are 1.2 m^3/s and 0.5 m^3/s respectively. Adjustments to the engine speeds can achieve a flow variation of 0.80 Q to 1.05 Q where Q is the design flow. Table 4.2 shows the range of discharges which can be achieved economically with the pumps selected, assuming constant static head.

The pump station for alternative B has been located on a section of the river which, from a study of the aerial photographs, appears to be stable. This site is also positioned in a suitable location to supply water to the project area via a short length of main canal. The proposed location of the pump station site must however, be verified by a field survey at the detailed design stage.

The outlet arrangement of the pump station for alternative B is different to that for the Supplementary Study. This is because the settling basin water level will fluctuate and so the pumps will be operating to a variable head. The outlet consists of two chambers, the first incorporating a hinged flap gate to prevent reverse flow and the second a penstock gate to close off the pipes. The hinged flap gate can also be raised to allow back flushing of any sediment depositing in the pipes and pumps and removal of any debris which may have collected on the inlet screen. Details of the design of the pump station for alternative B are shown on Plate Nr 6.

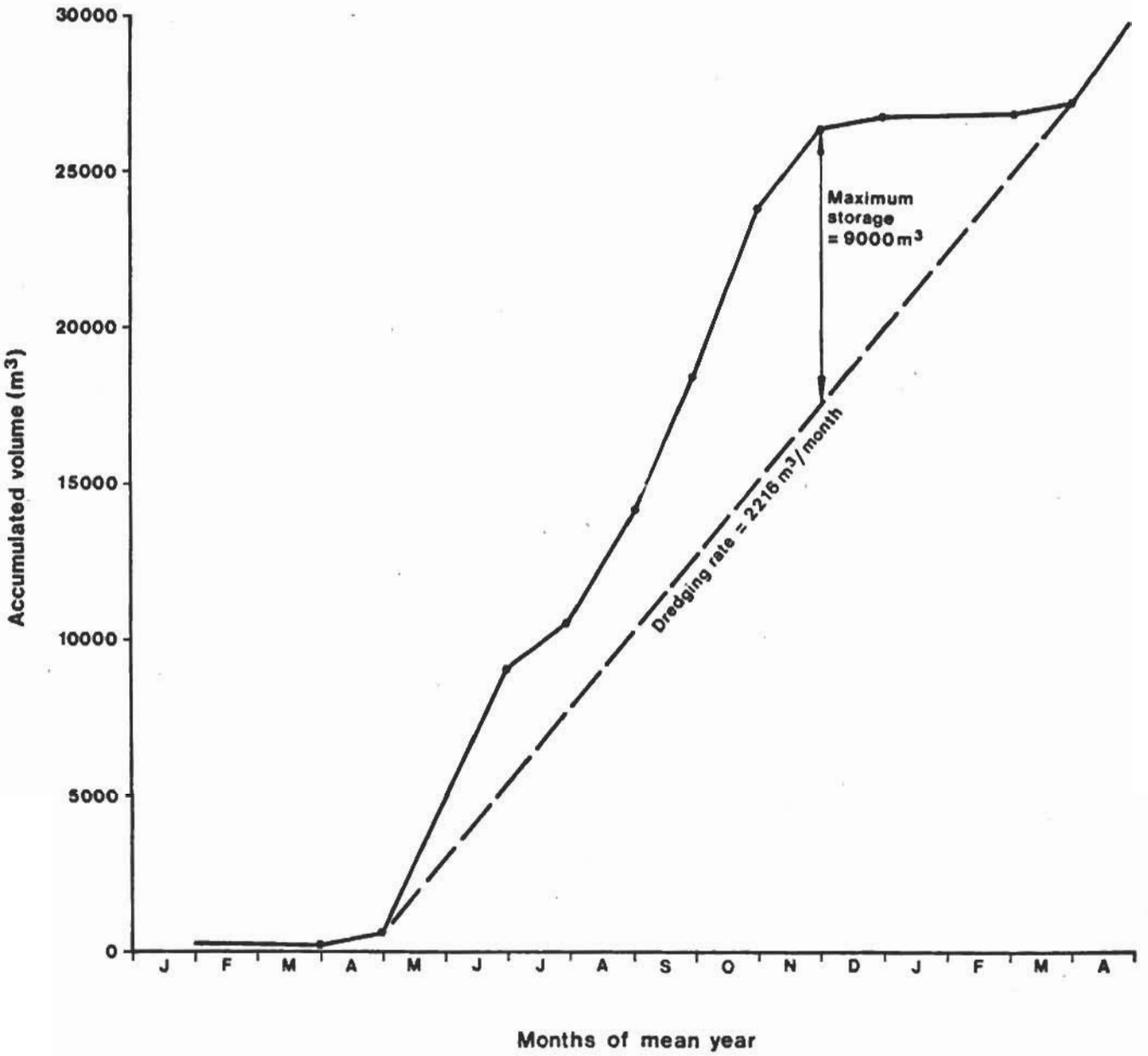
TABLE 4.2

Pump Station Discharge Characteristics - Alternative B

Pump size				Flow (m^3/s)	Step (m^3/s)
16 in.	16 in.	24 in.	24 in.		
80%	-	-	-	0.40	
105%	-	-	-	0.53	0.27
80%	80%	-	-	0.80	
105%	105%	-	-	1.05	0.31
80%	-	80%	-	1.36	
105%	-	105%	-	1.79	
80%	80%	80%	-	1.76	
105%	105%	105%	-	2.31	0.01
80%	-	80%	80%	2.32	
105%	-	105%	105%	3.05	
80%	80%	80%	80%	2.72	
105%	105%	105%	105%	3.57	

Settling basin : sediment mass curve

4.2



Dimensions of basin :—

Bed width	= 36.00m
Length	= 200m
Side slope	= 1 in 2
Depth	= 2.7m

(i) Settling Basin Design

The design method for the settling basin is described in Chapter 4, Annex 5 of the Supplementary Study where the computer program 'BUNKER' based on TR Camp's method has been used to calculate the volume of sediment trapped for various sizes of basin. For alternatives A and B, the optimum size of basin was found to have a bed width of 36 m, side slopes of 1 in 2, length of 200 m and a maximum water depth of 2.7 m. The optimum size is determined by the requirement that 99% or more of all sediment of 0.06 mm diameter and larger must be trapped.

The water level in the main canal will fluctuate throughout the day, therefore the water level in the settling basin will also fluctuate. The size of the basin has been checked for minimum water level as well as maximum and has proved to be sufficient for both cases.

The results from the computer analysis for the chosen size of settling basin have been plotted in Figure 4.2 which shows the monthly accumulation of sediment in the settling basin. The dredging rate of 2 216 m^3/month is calculated as the rate sufficient to prevent any long term build up of sediment in the settling basin. From this the required storage of 9 000 m^3 is determined as the maximum difference between the monthly dredging rate and the monthly accumulation of sediment. This storage is required to allow the basin to operate at design efficiency at all times and is easily provided by the selected size of settling basin.

(j) Dredging Requirement

The settling basin has been designed such that all the sediment except the wash load (less than 0.06 mm diameter) passing into the canal system will be deposited in the basin. The main canal and distributaries have been designed so that little sediment should settle out along their length and so it is assumed that all the sediment passing through the settling basin will settle out in the storage reservoirs. This can be considered as an over estimate since some of the finer sediment sizes will remain in suspension. The quantity of sediment passing into the storage reservoirs can be determined using the sand, silt and clay proportions of the total load passing into the canal system as determined in the Supplementary Study,

i.e. 32.5% sand

37.8% silt

29.7% clay.

It is assumed that all the sand (32.5%) is deposited in the settling basin and this quantity is given in 'BUNKER'. From this, the proportional quantities of the total silt and clay loads are determined and the difference between this total and that settling in the basin is a measure of the load passing through the settling basin and being deposited in the storage reservoir. This volume is estimated at 14 500 m^3 per annum so that a maximum depth of 0.09 m per annum will settle out in the storage reservoirs of alternatives A and B. Thus the intake channel, settling basin and storage reservoirs will all need dredging to maintain the designed flow or volume.

Two methods are proposed

1. Drag Line

One dragline operating from opposite banks with a boom length of 20 m is suffi cient to cover both the intake channel and settling basin. These would be required from the start of the project.

2. Floating Grab Dredger

A floating grab dredger as proposed in the Supplementary Study would be needed to dredge the large areas of the storage reservoir, however, a smaller grab bucket (0.35 m^3 compared with 0.50 m^3) could be used since the dredging rate required has been halved. As all the storage reservoirs have been over excavated to depths greater than 1.4 m to provide additional fill for the canal earthworks, there is sufficient dead storage in the reservoirs to delay the purchase of the floating grab dredger until year 15 (15 years x 0.09 m/year = 1.35 m).

(k) Sprinkler Pump Station

The sprinkler pump station is required to supply the pilot overhead irrigation area of 122 ha. Each overhead irrigation unit (40.8 ha net) has a design discharge requirement of 70 l/s giving a required capacity for the pump station of 0.21 m^3/s. Two diesel engined pump units are recommended and a layout for the proposed pump station is shown on Plate Nr 7. The sprinkler pump station for alternative B is located near the end of distributary canal C2.

(l) Sprinkler Storage Reservoir

The overhead irrigation area is intended as a pilot scheme for the possible future use of sprinklers. The system should therefore be as flexible as possible. A small storage reservoir constructed near the end of distributary canal C2 from which the sprinkler pump station can draw its water is recommended. It will enable the overhead irrigation system to operate either at night or during the day. The required size of reservoir is calculated as follows:-

Peak storage volume (m^3) = 0.21 x 3 600 x 12
= 9 072 m^3 for 12 hours irrigation

A storage depth of 1.2 m requires a reservoir area of 7 560 m^2.

4.3 Drainage System

4.3.1 General

The drainage systems in both alternatives A and B were selected so that the need for pumped drainage was reduced to the minimum. This required selection of the irrigated area so that low lying areas were avoided wherever possible. Thus in both cases, only one pump station is used and the low lying land in the southern part of the project area of the Supplementary Study has not been included.

In the design of the system the same surface drainage rates reported in the Supplementary Study were used.

i.e.	overhead irrigated areas	3.5 l/s/ha
	surface irrigated areas	1.5 l/s/ha

The minimum bedslopes were taken as:

unit drains	0.05 m/km
collector	0.10 m/km
main collector and outfall drains	0.10 m/km

The drainage system has been designed to dispose of the water through the western flood bund using pipe culverts with flap gates. The area to the south-west of this flood embankment is sufficiently low to permit the drainage water to flow away by gravity from the project area, eventually joining the existing farta system which connects into Dhesheeg Waamo (see Supplementary Study, Annex 5, Chapter 1, Figure 1.1). However, there is a critical area between the western flood bund and the marine plain where the ground levels dictate the minimum bed levels possible at the outfalls of the drains at the western flood bund. A minimum bed level of 6.3 m was taken in both alternatives and this was considered sufficient to be able to dispose of all the drainage water. Wherever possible natural drainage channels have been used although in some cases these channels require to be excavated to the necessary bed levels. These additional earthworks have been included in the earthworks' quantities for the drains. The water levels west of the western flood bund which will occur during the operation of the flood relief channel were not used in the design of the surface drainage system since the peak discharges in the drainage system occur in the gu season whilst the flood relief channel normally operates only in the der season.

4.3.2 Alternative A

The basic layout of the drainage system is very similar to that of the equivalent area in the Supplementary Study. The Mogambo Outfall Drain has however, been re-aligned to flow along the southern end of the project area and through the western flood bund. The pump station location has also slightly changed to allow for the re-alignment of the outfall drain The design discharge of the drainage pump station is 0.66 m^3/s with a static lift of 1.28 m.

4.3.3 Alternative B

The design of the drainage system follows the same principles as alternative A. However, the drains are all of smaller capacities and greater use is made of the natural channels. The lowest areas were identified in the design and two small collector drains were used to connect these areas (collector drains D1/2 and D1/2.1). Flow in D1/2 was then pumped into drain D1. The pump station discharge was thus reduced to 0.39 m^3/s with a static lift of 0.58 m.

The earthworks and design data for the drains are given in Appendix VII in the form of computer printouts.

4.4 Flood Protection Works

4.4.1 The Need for Flood Protection Works

Flooding within the project area mainly occurs when the flood escape at Bulo Yaag is in operation. The escape is used at times of high water level in the river to reduce the river flow. The water levels downstream of the escape are thus reduced and the banana plantations adjacent to the river are given protection from the rising flood water.

Two possible proposals for flood protection works were discussed in the Supplementary Study:-

(a) Rehabilitate the flood escape structure and enlarge and extend the channel so that it can pass 100 m^3/s through the project area to the western drainage system.

(b) Close the escape structure permanently and construct a protective embankment adjacent to the river.

The Supplementary Study recommended that the escape structure be kept open because of the difficulty of constructing a bund along the river bank through the banana plantations, and because of the uncertainty concerning the construction of Bardheere dam.

4.4.2 Alternative A

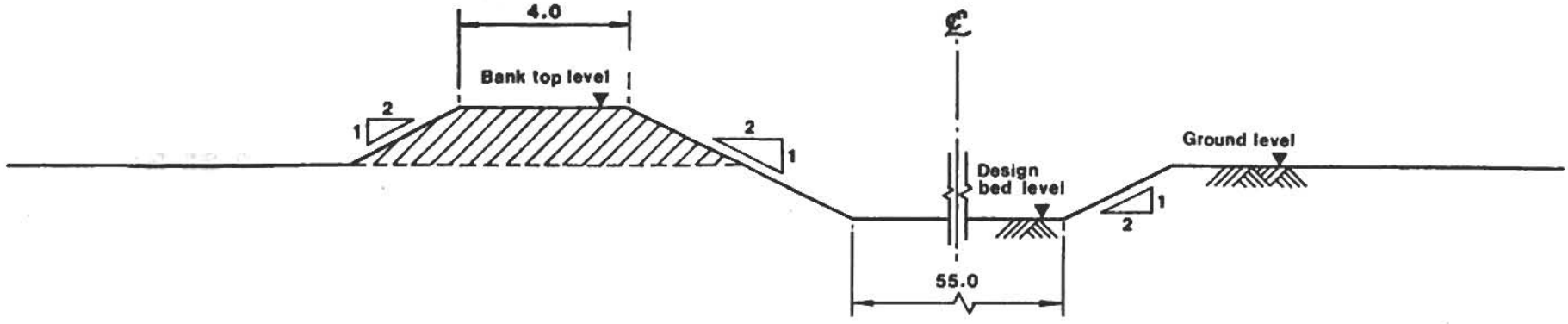
The proposed flood protection works for alternative A are based on the works for the full development thus allowing future expansion to the full development to take place with as few modifications to the works as possible.

The project proposals are therefore as follows:-

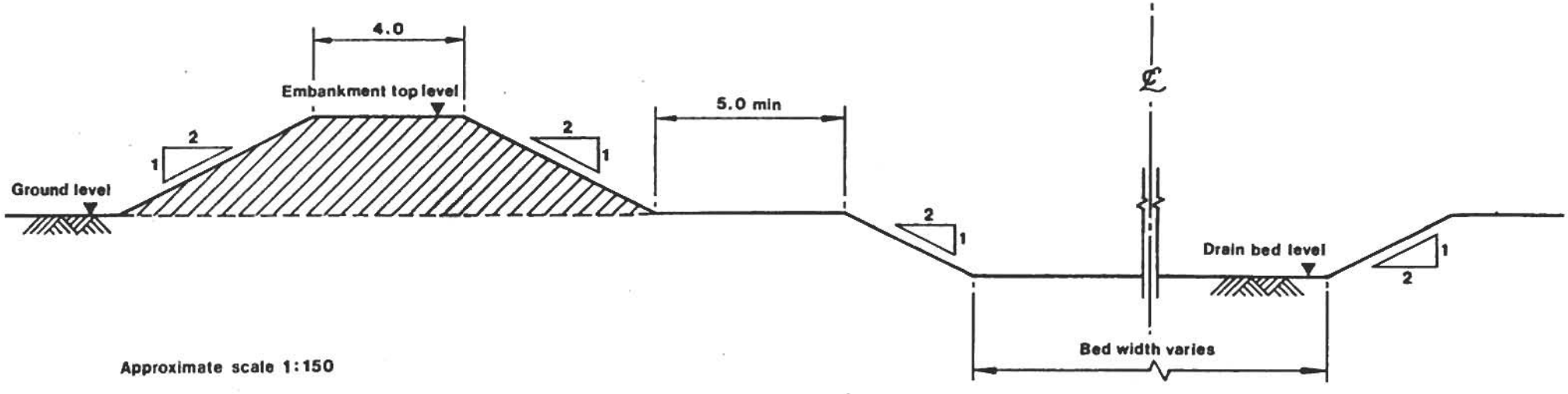
(i) Rehabilitate the flood escape structure and the main road bridge across the channel, including the provision of bed and bank protection in the vicinity of the structures.

(ii) Enlarge and extend the flood relief channel so that it can pass 100 m^3/s from the river into the drainage system and depressions on the western boundary of the project area. This work includes associated embankments on both banks of the channel to contain the flow from the river up to the point where the main canal passes under the channel through an inverted siphon. After this point the bank on the north side of the channel is no longer required and only the channel and the bank on the south side will be constructed. The northern bank of the flood relief channel is not required because the land to the north is not part of the project area for alternative A.

(iii) The western flood bund will be constructed along the western boundary of the project to protect the project area from the flood water resulting from use of the flood relief channel. The western flood bund will begin at the end of the flood relief channel and will run southwards for about 8.60 km until it reaches the extreme south of the project area, where it will turn eastwards to join the existing flood bund. The western bund would be constructed to follow the line required for the full development so that future expansion to the full development would not involve realignment of the bund.



Flood relief channel – Typical cross section



Approximate scale 1:150

Protective embankment – Typical cross section

Flood relief channel and protective embankment cross sections 4.3

(iv) The existing flood bund adjacent to the banana lands will thus become redundant and will be removed at places where it passes through the project area thus providing a source of fill for the canal embankments.

4.4.3 Alternative B

The proposed flood protection works for alternative B are shown on the layouts and are described below as follows:-

(i) Rehabilitate the flood escape structure and the main road bridge across the channel, including the provision of bed and bank protection in the vicinity of the structures.

(ii) Enlarge and extend the flood relief channel so that it can pass 100 m^3/s from the river into the natural drainage channels and depressions on the western boundary of the project area. Associated embankments on both banks of the channel are only required to contain the flow and pass it under the road bridge. After the road bridge only the embankment on the south bank of the channel is required to protect the project area. No bank is required on the northern side and water will thus flood some areas to the north. The northern bank of the flood relief channel will have an embankment from the river to the point where the existing bank ends.

(iii) The western flood bund will be constructed along the western boundary of the project area to protect the project from flood water resulting from the use of flood relief channel. The western bund will begin at the end of the flood relief channel and will run southwards for about 8.65 km until it joins the existing flood bund. The alignment of the western bund has been determined by following the most direct line (to reduce the length) and to keep to the highest ground where possible. Plates Nr 2, 3, 4 and 5 show the location of the flood bund.

(iv) The existing flood bund adjacent to the banana lands will thus become redundant and will be removed at places where it passes through the project area.

4.4.4 Earthwork Quantities for Flood Protection Works

The volumes of cut and fill for the flood relief channel and protective bunds have been estimated for both alternatives by a computer earthworks program. The embankments for both alternatives will have a bank top width of 4 m and side slopes of 1 in 2. Figure 4.3 shows the cross sections of the flood relief channel and protective embankment.

(a) Alternative A

Flood relief channel bank top level at river (km 0)	=	14.6 m
Flood relief channel bank top level at end (km 7.5)	=	11.0 m
Western bund bank top level at start (km 0)	=	11.0 m
Western bund bank top level at end (km 8.60)	=	9.4 m

The bank top level of the existing bund at the point where the western bund joins it is about 9.5 m.

Estimates of earthwork quantities are given below:-

Item	Required volume of cut (m^3)	Required volume of fill (m^3)
Flood relief channel	244 000	165 000
Western flood bund	-	170 000

(b) Alternative B

Flood relief in channel bank top level at river (km 0) = 14.6 m
Flood relief in channel bank top level at end (km 5.75) = 11.4 m
Western bund bank top level at start (km 0) = 11.4 m
Western bund bank top level at end (km 8.65) = 9.5 m

The bank top level of the existing bund at the point where the western bund joins it is about 9.9 m.

Item	Required volume of cut (m^3)	Required volume of fill (m^3)
Flood relief channel	187 000	108 000
Western flood bund	-	114 000

4.5 Operation and Maintenance

4.5.1 General

Good operation and maintenance of the system is essential for the efficient running of the Project, to prevent loss of yields, increased costs and reduced income. The same principles applied to the operation and maintenance of the irrigation and drainage system in the Supplementary Study apply in the Additional Study.

4.5.2 Operation of the Surface Irrigation System

Both alternatives A and B have been considered together, and the requirements for both cases are very similar. The main difference is that alternative A is based on a 12 hour irrigation period, whereas alternative B is based on a 14 hour irrigation period. Alternative A is designed so that the project area can be easily expanded to include areas for sprinkler irrigation which can be irrigated for 12 hours at night. Alternative B has been designed solely for 14 hours of surface irrigation during the day, and any future development to include night-time sprinkler irrigation would involve completely separate areas and pumping stations. (Plate Nr 8). The difference in irrigation period does not affect the operation of the main canal but allows a shorter overlap period between the two 8 hour shifts of the operators on the distributary canals. The operation of the field irrigation system is identical to that in the Supplementary Study but the labour requirements will be less. The monthly

TABLE 4.3

Labour Requirements for Field Irrigation

Alternative A	76 surface units	2 052 ha
	4 overhead units	163 ha

Crop Rotation 1

Month	Labourers			Foremen
	Surface	Overhead	Total	
January	23	4	27	5
February	-	-	-	-
March	-	-	-	-
April	76	0	76	13
May	152	2	154	26
June	152	4	156	26
July	118	4	122	21
August	8	4	12	2
September	53	4	57	10
October	105	8	113	19
November	105	8	113	19
December	99	8	107	18

Crop Rotation 2

January	28	4	32	6
February	-	-	-	-
March	-	-	-	-
April	57	0	57	10
May	114	2	116	20
June	114	4	118	20
July	89	4	93	10
August	28	4	32	6
September	57	4	61	10
October	110	8	118	20
November	114	8	122	21
December	72	8	80	14

TABLE 4.3 (cont.)

Alternative B — 67 surface units, 1 809 ha; 3 overhead units, 122 ha

Crop Rotation 1

Month	Labourers: Surface	Labourers: Overhead	Labourers: Total	Foremen
January	20	3	23	4
February	-	-	-	-
March	-	-	-	-
April	67	0	67	11
May	134	2	136	23
June	134	3	137	23
July	104	3	111	19
August	7	3	10	2
September	47	3	50	9
October	93	6	99	17
November	93	6	99	17
December	87	6	93	16

Crop Rotation 2

January	25	3	28	5
February	-	-	-	-
March	-	-	-	-
April	51	0	51	9
May	103	2	105	18
June	103	3	106	18
July	80	3	83	14
August	25	3	28	5
September	51	3	54	9
October	99	6	105	18
November	103	6	109	19
December	65	6	71	12

labour requirements for both alternatives and crop rotations are listed in Table 4.3. A permanent workforce for all 4 cases can be taken as 100 labourers and 17 foremen and the additional labour necessary at peak times can be recruited from the agricultural workforce. The build-up for this permanent work force is listed in Table 4.4.

TABLE 4.4

Build-up of Permanent Labour Requirements

Year	Labourers	Foremen
1981	-	-
1982	24	4
1983	66	11
1984	100	17

The operation of the main pump station is described in section 7.4.1 Annex 5 of the Supplementary Study.

4.5.3 Operation of the Overhead Irrigation System

The layout of the sprinkler system for alternatives A and B is described in section 4.2 of the Additional Study. Both areas are small and have only one pump station each, they comprise :-

Alternative A: 4 irrigation units
Alternative B: 3 irrigation units.

The operation of the sprinkler system is however very simple, being confined to moving laterals during the day and supervising the operation of the pump stations at night. This operation is fully described in section 7.3.1 and section 7.4.2 Annex 5 of the Supplementary Study.

In alternative B, the sprinkler pump station is supplied with water from a small storage reservoir. The water for the reservoir comes from distributary canal C2 via a gated pipe regulator. The operation of this regulator can be supervised by the distributary canal operators (ditch riders) during the day and by the sprinkler pump station operator during the night. The labour requirements for the overhead irrigation system have been included in Table 4.3.

4.5.4 Operation of Drainage System

The majority of the project area for alternatives A and B is drained by gravity and only one pump station is required in each case. The drainage system requires little operation although the concrete weirs in the bund at the end of each basin needs to be checked frequently to ensure that they suffer no damage. As the operation of the drainage pump station is intermittent only one operator plus a relief operator is needed in each case.

4.5.5 Maintenance of Irrigation and Drainage System

The maintenance of the system is described fully in Section 7.6, Annex 5 of the Supplementary Study. Although it is intended to use the same methods to dredge the intake channel, settling basin and reservoirs the grab dredger and split bottom barge will not be required until Year 15, as there is sufficient dead storage in the storage reservoir to accommodate any sediment deposited in this period. The drag lines should be purchased at the start of the project and can be used to dredge the intake channel and settling basin from the start of the project.

4.5.6 Overall Labour Requirements for Operation and Maintenance

The labour requirements for the operation of the irrigation system at field level are shown in Table 4.5.

TABLE 4.5

Staff Requirements for Operation of the Irrigation and Drainage System

Location	Designation	Number of staff	
		Alternative A	Alternative B
Project HQ	Irrigation engineer	1	1
Field	Irrigation supervisor	1	1
Main pump station	Operator	4	4
Sprinkler pump station	Operator	2	2
Drainage pump station	Operator	2	2
Main canal regulators	Operator	4	-
Distributary canals	Ditch riders	14	14
Field units	Block supervisors	6	6
Field units	Foreman	17	17
Field units	Labourers	100	100

The overall machinery requirements are listed in Table 4.6. This has been determined in a similar way to that described in the Supplementary Study.

4.6 Costs of Engineering Works

4.6.1 Introduction

All prices, including fuel and oil, are as given in Chapter 8 of Annex 5 in the Supplementary Study, together with the percentages of capital costs for spare parts and materials. Unit rates for the engineering works were based on current construction data at June 1979 prices.

TABLE 4.6

Vehicles and Machinery for Operation and Maintenance

Item	Use	Nr
Bicycles	Foreman irrigators	17
Motorcycles	Block supervisors	6
Motorcycles	Ditch riders	14
Motorcycle	Irrigation supervisor	1
FWD station wagon	Irrigation engineer	1
FWD pick up	Surveyor	1
FWD pick up	General maintenance	1
Truck (12 ton)	General maintenance and transport	1
Tipper truck (12 ton)	General maintenance and transport	1
Tractor and trailer	General maintenance and transport	3
Dragline	Canal and drain maintenance	2
Floating grab dredger	Settling basin and reservoirs	1
Split bottom barge	Settling basin and reservoirs	1
Grader	General	1
Bulldozer	General	1
Low loader	General	1
Water bowser	General	1
Concrete mixer	General	1
Vibrators	General	1
Compressor with tools	General	1
Mobile workshop	General	1
Water pump	General	1
Flail mowers on hydraulic arms	General	1
Circular saw	General	1

Note: Dredger and barge purchased in Year 15

The costs for agricultural machinery, fertilisers and seeds, and the salaries for all project staff are included in Chapter 7.

4.6.2 Presentation of Costs

Costs have been presented separately for alternatives A and B.

Construction costs have been divided into the proposed 2 year construction programme and shown in Tables 4.8 to 4.19 for alternative A and in Tables 4.24 to 4.35 for alternative B.

Figures 4.4 and 4.5 show the proposed construction programmes for alternatives A and B respectively.

Annual cost schedules for replacement costs, operation and maintenance costs and total engineering costs are shown in Tables 4.20 to 4.22 for alternative A and in Tables 4.36 to 4.38 for alternative B.

Both economic and financial costs are given in this section. Total Engineering economic costs are given in Table 4.22 and the corresponding financial costs in Table 4.23 for alternative A and corresponding costs for alternative B in Tables 4.38 and 4.39.

Replacement costs of major items have been built up using capital costs and expected lifespans as given in Annex 5 of the Supplementary Study.

Table 4.7 gives the unit cost, expected lifespan and numbers of vehicles and machinery purchased for the operation and maintenance of the project and is the same for both alternatives.

The method of computation of fuel costs for the main irrigation pump station is illustrated below.

Main irrigation pump station (alternative A).

The peak demand (in May) is 3.7 m^3/s at a pumping head of 6.1 m.

The power output of the pump station for the peak month is = 393.2 kW.

Power absorbed for peak month = 292 541 kW-hours.

The manufacturers quote an approximate fuel consumption of 0.3 litres per kW-hour output.

Thus:	fuel requirement for peak month	=	87 763 litres
	cost of diesel for peak month		
	including 15% for oil and lubricants	=	117 076 SoSh

The fuel costs for the other months in the year are found in a similar manner and are listed below:

		SoSh
January	=	9 177
February	=	-
March	=	-
April	=	62 653
May	=	117 076
June	=	87 019
July	=	65 502
August	=	8 227
September	=	43 351
October	=	36 390
November	=	51 895
December	=	48 414
Total annual fuel and oil cost	=	529 704 SoSh

All the fuel calculations have been based on a rice/maize cropping pattern. The fuel and oil costs for the main irrigation pump station will be different for the rice/rice crop rotation because the irrigation water requirements are different. It is estimated that the total annual fuel and oil cost for alternative A for a rice/rice rotation is 607 867 SoSh and for alternative B is 493 319 SoSh.

4.6.3 Comparison of the Alternative Schemes

Alternative A has a greater total cost than alternative B. This is mainly due to increased earthworks and canal structures, since the main canal in alternative A has been designed with a capacity for Phase II of the project. Likewise the two siphon underpasses and the main canal structures for alternative A have been designed to be large enough to allow for future expansion.

Most other costs in alternative A are marginally larger than in alternative B due to the larger net area of alternative A. It can be seen from the annual cost schedules that after construction is completed, the recurrent costs of the two schemes are similar.

TABLE 4.7

Capital Costs for Operation and Maintenance: Vehicles and Machinery - Alternatives A and B

Item	Unit cost (SoSh)	Lifespan (years)	Number and year of purchase				
			Year 1	Year 2	Year 3	Year 4	Year 5
Dragline	715 000	15		1		1	
Grader	670 800	5		1			
Bulldozer (D6)	725 400	5			1		
Low loader	390 000	8				1	
12 ton truck	149 500	8		1			
12 ton tipper truck	202 800	8		1			
Tractor and trailer	123 500	8		2	1		
Mobile workshop	208 000	8		1			
Water bowser	136 500	8		1			
Concrete mixer	13 000	8					1
Compressor and tools	260 000	10				1	1
Vibrators	2 600	10					1
Water pump	3 900	5			1		
Flail mower on hydraulic arm	13 000	5			1		
Circular saw	2 600	5			1		
FWD station wagon (LWB)	91 000	8	1				
FWD pick up	76 700	8		1	1		
Motorcycles	7 800	5		7	7	7	
Bicycles	780	5		5	6	6	
Floating grab dredger	1 040 000						
Split bottom barge (purchased in year 15)	754 000						

Activity	Year 1	Year 2	Year 3
Bush clearance			
Land levelling			
Land planing			
Main canal earthworks and structures, - up to km 4.0			
km 4.0 to end			
Earthworks and structures for distributaries, - M1/C1,			
- M1/C3, M1/C4, M1/C4.2, M1/C6			
- M2/C1, M2/C2, M2/C2.1, M2/C4			
Drain earthworks and structures			
Storage reservoirs - S.R 1.1, S.R 1.2, S.R 2.1,			
- S.R.2.2			
Flood protection works			
Main pump station - civil works			
- pumping plant			
Drainage pump station			
Sprinkler pump station			
Sprinkler equipment			
Infield channels and structures - net area = 216 ha			
- net area = 945 ha			
- net area = 891 ha			
Primary roads			
Infrastructure (buildings and services)			

Construction programme : Alternative A

4.4

Activity	Year 1	Year 2	Year 3
Bush clearance			
Land levelling			
Land planing			
Main canal earthworks and structures			
Earthworks and structures for distributary canals - C2			
- C1, C4			
- C3			
Drain earthworks and structures			
Storage reservoir			
Flood protection works			
Main pump station - civil works			
- pumping plant			
Drainage pump station			
Sprinkler pump station			
Sprinkler storage reservoir			
Sprinkler equipment			
Infield channels and structures - net area = 1080 ha			
- net area = 729 ha			
Primary roads			
Infrastructure			

Construction programme : Alternative B

TABLE 4.8

Summary of Construction Costs - Alternative A

		Year 1			Year 2			Year 3		
		Total cost (SoSh '000) (Economic)	Foreign exchange (SoSh '000)	Total cost (SoSh '000) (Financial)	Total cost (SoSh '000) (Economic)	Foreign exchange (SoSh '000)	Total cost (SoSh '000) (Financial)	Total cost (SoSh '000) (Economic)	Foreign exchange (SoSh '000)	Total cost (SoSh '000) (Financial)
1	Land preparation	1 660	830	1 743	6 648	3 324	6 980	5 804	2 902	6 094
2	Earthworks	5 946	3 270	6 273	13 656	7 511	14 407	6 519	3 585	6 878
3	Canal structures including water control equipment	2 180	1 199	2 528	7 758	4 267	8 995	4 067	2 237	4 716
4	Drain structures	1 012	557	1 174	3 950	2 173	4 580	3 262	1 794	3 782
5	In-field structures	181	100	211	793	436	924	747	411	870
6	Pump stations	1 018	764	1 148	3 871	2 903	4 365	1 568	1 176	1 768
7	Sprinkler equipment	2 321	1 973	2 834	-	-	-	-	-	-
8	Primary road	1 024	563	1 080	-	-	-	-	-	-
9	Buildings	6 196	4 027	7 404	8 670	5 636	10 361	723	470	864
10	Services and equipment	1 947	1 460	2 385	845	634	1 035	273	205	335
11	Engineering design and supervision	2 349	1 527	2 700	4 619	3 002	5 309	2 296	1 492	2 639
Total		25 834	16 270	29 480	50 810	29 886	56 956	25 259	14 272	27 946

Total Cost (Economic) = SoSh 101 903 000
Total Foreign Exchange = SoSh 60 428 000
Total Cost (Financial) = SoSh 114 382 000

TABLE 4.9

Bill Nr 1: Land Preparation - Alternative A

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
1. Bush clearance (light)	ha	600	438	262.8	1 416	849.6	711	426.6
2. Bush clearance (dense)	ha	1 400	23	32.2	75	105	37	51.8
3. Land levelling survey	ha	70	263	18.4	1 151	80.6	1 086	76
4. Land levelling	m^3	10	108 000	1 080	472 500	4 725	445 500	4 455
5. Land planing	ha	300	386	115.8	945	2 035	891	267.3
Sub-total Economic Cost				1 509.2		6 043.7		5 276.7
Add 10% contingencies				1 660		6 648		5 804
Foreign exchange (50%)				830		3 324		2 902
Taxes and Duties (10%)				83		332		290
Total Financial Cost				1 743		6 980		6 094

TABLE 4.10

2: Earthworks - Alternative A

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
1. Excavate in flood relief channel and form associated embankments	m^3	17	75 970	1 291.5	89 096	1 514.5		
2. Excavate in flood relief channel and form canal embankments	m^3	17	42 500	722.5	36 000	612		
3. Excavate in borrow areas and form west bund	m^3	12			36 416	437	134 033	1 608.5
4. Excavate for intake channel and settling basin and form embankments	m^3	12	19 850	238.2				
5. Excavate in storage reservoirs and form associated embankments	m^3	12			61 200	734.4	38 800	465.6
6. Excavate in canals and form canal embankments	m^3	12	8 631	103.5	1 792	21.5	3 810	45.7
7. Excavate in storage reservoirs and form canal embankments	m^3	17			211 400	3 593.8	86 600	1 472.2
8. Remove existing flood bund and form canal embankments	m^3	22	63 000	1 386	25 200	554.4	27 300	600.6
9. Excavate in drains and form drain embankments	m^3	12	23 602	283.2	45 008	540.1	29 864	358.4
Carried forward				4 024.9		8 007.7		4 551

TABLE 4.10 (cont.)

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
Brought forward				4 024.9		8 007.7		4 551
10. Excavate in drain and form canal embankments haul 200 m	m^3	12	16 150	193.8	48 006	576.1	6 655	79.9
11. Excavate in drain and form canal embankments haul 200 m 500 m	m^3	17	19 381	329.5	57 607	979.3	7 987	135.8
12. Excavate in drain and form canal embankments haul 500 m	m^3	22	29 071	639.6	84 401	1 901	11 980	263.6
13. Excavate unit drains to form unit channel embankment strip	unit	24 000	8	192	35	840	33	792
14. Form unit channel section in unit channel embankment strip	km	1 500	16.8	25.2	73.5	110.3	69.3	103.9
Sub-total Economic Cost				5 405		12 414.4		5 926.2
Add 10% contingencies				5 946		13 656		6 519
Foreign exchange (55%)				3 270		7 511		3 585
Taxes and Duties (10%)				327		751		359
Total Financial Cost				6 273		14 407		6 878

Note: Cost of flood relief channel not charged to project for economic analysis (Chapter 7) because its operation benefits the banana plantations downstream of Mogambo.

TABLE 4.11

Bill Nr 3: Canal Structures Including Water Control Equipment - Alternative A

Item	Unit	Rate (SoSh '000)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
1. 2 x 1.5 x 1.5 m siphon under main road	Nr	1 100	1	1 100				
2. 2 x 1.5 x 1.8 m siphon under flood relief channel	Nr	1 650			1	1 650		
3. Movable weir regulator 2 x 3.0 m	Nr	660			1	660		
4. Movable weir regulator 1 x 4.0 m	Nr	495			1	495		
5. Movable weir regulator 1 x 3.0 m	Nr	407					1	407
6. Movable weir regulator 1 x 2.5 m	Nr	363			1	363		
7. Movable weir regulator 1 x 1.6 m	Nr	286					1	286
8. Pipe culvert 1 x 1.2 m dia.	Nr	165					1	165
9. Pipe regulator 2 x 1.2 m dia.	Nr	330			1	330		
10. Pipe regulator 2 x 1.05 m dia.	Nr	270			2	540	2	540
11. Pipe regulator 1 x 1.2 m dia.	Nr	198	1	198	4	792	2	396
12. Pipe regulator 1 x 1.05 m dia.	Nr	165	1	165	2	330	2	330
13. Pipe regulator 1 x 0.9 m dia.	Nr	143	1	143	3	429	1	143
14. Pipe regulator 1 x 0.75 m dia.	Nr	99	1	99	2	198	3	297
15. Pipe regulator 1 x 0.6 m dia.	Nr	83			1	83		
16. Tail escape 1 x 0.45 m dia.	Nr	77	1	77	4	308	4	308
17. Distributary outlets 1 x 0.375 m dia.	Nr	25	8	200	35	875	33	825
Sub-total Economic Cost				1 982		7 053		3 697
Add 10% contingencies				2 180		7 758		4 067
Foreign exchange (55%)				1 199		4 267		2 237
Taxes and Duties (29%)				348		1 237		649
Total Financial Cost				2 528		8 995		4 716

Note: Cost of siphon under flood relief channel not charged to project in economic analysis.

TABLE 4.12

Bill Nr 4: Drain Structures - Alternative A

Item	Unit	Rate (SoSh '000)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
1. Drain junction culvert 2 x 1.05 m dia.	Nr	270	1	270	1	270		
2. Drain junction culvert 1 x 1.2 m dia.	Nr	170			1	170	1	170
3. Drain junction culvert 1 x 0.9 m dia.	Nr	130			3	390	1	130
4. Drain junction culvert 1 x 0.6 m dia.	Nr	80	2	160	3	240	1	80
5. Unit drain junction culvert 1 x 0.3 m dia.	Nr	45	8	360	35	1 575	33	1 485
6. Drain road culvert 1 x 1.2 m dia.	Nr	170			1	170		
7. Drain road culvert 1 x 0.9 m dia.	Nr	130	1	130	1	130		
8. Drain road culvert 1 x 0.45 m dia.	Nr	50			1	50		
9. Drain culverts under flood bund (including flap gates) 3 x 1.2 m dia.	Nr	504					1	504
10. Drain culverts under flood bund (including flap gates) 2 x 1.05 m dia.	Nr	298			2	596	2	596
Sub-total Economic Cost				920		3 591		2 965
Add 10% contingencies				1 012		3 950		3 262
Foreign exchange (55%)				557		2 173		1 794
Taxes and duties (29%)				162		630		520
Total Financial Cost				1 174		4 580		3 782

TABLE 4.13

Bill Nr 5: In-field Structures - Alternative A

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
1. Siphon tubing	m	11.1	528	5.9	2 310	25.6	2 178	24.2
2. Portable canvas unit channel checks	Nr	650	16	10.4	70	45.5	66	42.9
3. Unit drain road crossing (Irish bridge)	Nr	5 600	24	134.4	105	588	99	554.4
4. Concrete outlet weirs for basins	Nr	65	216	14.1	945	61.4	891	57.9
Sub-total Economic Cost				164.8		720.5		679.4
Add 10% for contingencies				181		793		747
Foreign exchange (55%)				100		436		411
Taxes and Duties (30%)				30		131		123
Total Financial Cost				211		924		870

TABLE 4.14

Bill Nr 6: Pump Stations - Pumps, Engines and Associated Civil Works - Alternative A

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
1. Main pump station - civil works	Sum			800		800		
2. Main pump station - pumping plant	Sum					1 475		925
3. Sprinkler pump station P1	Sum			125		244.4		
4. Drainage pump station D1	Sum					1 000		500
Sub-total Economic Cost				925		3 519.4		1 425
Add 10% contingencies				1 018		3 871		1 568
Foreign exchange (75%)				764		2 903		1 176
Taxes and Duties (17%)				130		494		200
Total Financial Cost				1 148		4 365		1 768

TABLE 4.15

Bill Nr 7: Sprinkler Equipment - Alternative A

	Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
	Supply, install and test asbestos cement pipes, including bedding and all fittings for :								
1.	internal diameter 100 mm	m	89.8	100	9				
2.	internal diameter 150 mm	m	128.8	1 560	200.9				
3.	internal diameter 200 mm	m	197.1	1 872	369				
4.	internal diameter 225 mm	m	229.1	1 262	289.1				
5.	internal diameter 250 mm	m	253.8	652	165.5				
6.	internal diameter 300 mm	m	319.5	326	104.2				
7.	internal diameter 350 mm	m	417.8	726	303.3				
8.	internal diameter 450 mm	m	604.7	223	134.8				
9.	Supply laterals, hydrants (with protective pipes), sprinklers and all accessories	ha	3 280	163	534.6				
	Sub-total Economic Cost				2 110.4				
	Add 10% contingencies				2 321				
	Foreign exchange (85%)				1 973				
	Taxes and Duties (26%)				513				
	Total Financial Cost				2 834				

TABLE 4.16

Bill Nr 8: Primary Roads - Alternative A

Item	Unit	Rate (SoSh '000)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
Surfaced								
1. Excavate road drains and form associated subgrade including compaction	km	80	0.5	40				
2. Supply, lay and compact 0.15 m thick sub-base	km	215	0.5	107.5				
3. Supply, lay and compact 0.2 m thick road base	km	264	0.5	132				
4. Bituminous surfacing	km	150	0.5	75				
Unsurfaced								
5. Excavate road drains and form associated subgrade including compaction	km	80	7.2	576				
Sub-total Economic Cost				930.5				
Add 10% contingencies				1 024				
Foreign exchange (55%)				563				
Taxes and Duties (10%)				56				
Total Financial Cost				1 080				

TABLE 4.17

9: Buildings - Alternative A

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
Project Headquarters and Village								
Supply and erect complete:								
1. House type AA	Nr	632 500	1	632.5	1	632.5		
2. House type A	Nr	550 000	4	2 200	3	1 650		
3. House type B	Nr	255 000	5	1 275	5	1 275		
4. Office block	m^2	2 550	545	1 389.8				
5. Workshop	m^2	2 050			900	1 845		
6. Training centre	m^2	2 250					200	450
7. Operator's quarters for pump station and X-regulator (20 m^2)	m^2	2 550	40	102	60	153		
8. Meteorological station	Nr	17 000	1	17				
9. Stores warehouse and offices	m^2	2 050			360	738		
10. Security hut for stores	m^2	2 050			12	24.6		
11. Fuel station yard	m^2	250			300	75		
12. Fuel storage tank with pump (17 500 l)	Nr	35 000			1	35		
13. Fuel station office	m^2	2 550			30	76.5		
Carried forward				5 616.3		6 504.6		450

TABLE 4.17 (cont.)

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
Brought forward				5 616.3		6 504.6		450
14. Compacted earth hardstanding	m^2	75			200	15		
15. Covered concrete hardstanding	m^2	1 500			500	750		
16. Concrete hardstanding	m^2	250			1 700	425		
17. Fencing	m	65	230	16.3	250	16.3		
18. Provision of assistance to village housing construction	Nr	1 500			100	150	124	186
19. Water points and soakaway ($6 m^2$ each)	m^2	250			84	21	84	21
Sub-total Economic Cost				5 632.6		7 891.9		657
Add 10% contingencies				6 196		8 670		723
Foreign exchange (65%)				4 027		5 636		470
Taxes and Duties (30%)				1 208		1 691		141
Total Financial Cost				7 404		10 361		864

TABLE 4.18

10: Services and Equipment - Alternative A

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
Potable Water Supply (PHQ and Village)								
1. Boring tubewell 80 m deep	Nr	60 000	1	60	-	-	-	-
2. Tubewell screens	Nr	75 000	1	75	-	-	-	-
3. Tubewell pumps	Nr	18 000	1	18	-	-	-	-
4. Steel storage tank and supporting tower (70 m^3)	Nr	220 000	1	220	-	-	-	-
5. Pump house	Sum	-	-	45				
6. Supply and install 75 mm dia. plastic pipe and fittings	m	88	1 800	158.4				
7. Supply and install 50 mm dia. plastic pipe and fittings	m	60	2 400	144	-	-	-	-
8. Supply and install 25 mm dia. plastic pipe and fittings	m	30	2 000	60	-	-	-	-
9. Supply and install 10 mm dia. plastic pipe and fittings	m	10	1 800	18	-	-	-	-
Power Supply								
10. 2 x 100 kVA generator sets complete with fuel tank and generator house	kVA	4 810	100	481	100	481	-	-
11. Install all electric cabling and fittings as necessary	Sum	-	-	200	-	100	-	100
Carried forward				1 479.4		581		100

TABLE 4.18 (cont.)

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
Brought forward				1 479.4		581		100
Miscellaneous								
12. Office equipment and stationery	Sum	-	-	10	-	10	-	10
13. Furniture for houses, offices, etc.	Sum	-	-	150	-	100	-	50
14. Laboratory equipment	Sum	-	-	5	-	7	-	8
15. Workshop tools	Sum	-	-	50	-	70	-	80
16. Internal radio network transceiver sets	Nr	17 800	3	53.4	-	-	-	-
17. Mogambo-Mogadishu radio	Sum	-	-	22	-	-	-	-
Sub-total Economic Cost		-	-	1 769.8	-	768	-	248
Add 10% contingencies		-	-	1 947	-	845	-	273
Foreign exchange (75%)		-	-	1 460	-	634	-	205
Taxes and duties (30%)				438		190		62
Total Financial Cost				2 385		1 035		335

TABLE 4.19

Bill Nr 11: Engineering Design and Supervision of Construction - Alternative A

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
1. Estimated cost	sum			2 349		4 619.1		2 296.2
Sub-total Economic Costs				2 349		4 619		2 296
Foreign exchange (65%)				1 527		3 002		1 492
Taxes and duties (23%)				351		690		343
Total Financial Cost				2 700		5 309		2 639

TABLE 4.20

Replacement Cost Schedule - Alternative A

Item / Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
												Annual costs (economic) '000 SoSh																		
Pumps, Engines, Generators and Miscellaneous Items																														
Main pump station - pumps	-	-	-	-	-	-	-	-	-	-	-	988	620	-	-	-	-	-	-	-	-	988	620	-	-	-	-	-	-	-
Main pump station - engines	-	-	-	-	-	-	487	305	-	-	-	487	305	-	-	-	487	305	-	-	-	487	305	-	-	-	487	305	-	-
Sprinkler pump station - pump	-	-	-	-	-	-	-	-	-	-	-	156	-	-	-	-	-	-	-	-	-	156	-	-	-	-	-	-	-	-
Sprinkler pump station - engine	-	-	-	-	-	-	88	-	-	-	-	88	-	-	-	-	88	-	-	-	-	88	-	-	-	-	88	-	-	-
Drainage pump station - pump	-	-	-	-	-	-	-	-	-	-	-	244	244	-	-	-	-	-	-	-	-	244	244	-	-	-	-	-	-	-
Drainage pump station - engine	-	-	-	-	-	-	131	131	-	-	-	131	131	-	-	-	131	131	-	-	-	131	131	-	-	-	131	131	-	-
Generators for Project HQ & village	-	-	-	-	-	-	-	-	-	-	481	481	-	-	-	-	-	-	-	-	481	481	-	-	-	-	-	-	-	-
Electric pumps for potable water supply	-	-	-	-	-	-	-	-	-	-	18	-	-	-	-	-	-	-	-	-	18	-	-	-	-	-	-	-	-	-
Aluminium pipes (sprinkler laterals)	-	16	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Sprinkler heads and riser	-	3	6	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Siphon tubing and portable canvas checks	-	-	-	-	-	51	52	52	-	-	51	52	52	-	-	51	52	52	-	-	51	52	52	-	-	51	52	52	-	-
Radio communication transceivers	-	-	-	-	-	-	-	-	75	-	-	-	-	-	-	-	75	-	-	-	-	-	-	-	75	-	-	-	-	-
Sub-total(1)	-	19	36	42	42	93	800	530	117	42	592	2669	1394	42	42	93	875	530	42	42	592	2669	1394	42	117	93	800	530	42	42
Operation & Maintenance Vehicles and Machinery																														
Dragline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	715	-	715	-	-	-	-	-	-	-	-	-	-	-
Floating grab dredger	-	-	-	-	-	-	-	-	-	-	-	-	-	-	870	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Split bottom barge	-	-	-	-	-	-	-	-	-	-	-	-	-	-	754	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Grader	-	-	-	-	-	-	671	-	-	-	-	671	-	-	-	-	671	-	-	-	-	671	-	-	-	-	671	-	-	-
Bulldozer (D6)	-	-	-	-	-	-	-	725	-	-	-	-	725	-	-	-	-	725	-	-	-	-	-	725	-	-	-	725	-	-
Low loader	-	-	-	-	-	-	-	-	-	-	-	390	-	-	-	-	-	-	-	390	-	-	-	-	-	-	-	390	-	-
12 ton tipper truck	-	-	-	-	-	-	-	-	-	150	-	-	-	-	-	-	-	150	-	-	-	-	-	-	-	150	-	-	-	-
12 ton truck	-	-	-	-	-	-	-	-	-	203	-	-	-	-	-	-	-	203	-	-	-	-	-	-	-	203	-	-	-	-
Tractor and trailer	-	-	-	-	-	-	-	-	-	247	124	-	-	-	-	-	-	247	124	-	-	-	-	-	-	247	124	-	-	-
Mobile workshop	-	-	-	-	-	-	-	-	-	208	-	-	-	-	-	-	-	208	-	-	-	-	-	-	-	208	-	-	-	-
Water bowser	-	-	-	-	-	-	-	-	-	137	-	-	-	-	-	-	-	137	-	-	-	-	-	-	-	137	-	-	-	-
Concrete mixer	-	-	-	-	-	-	-	-	-	-	-	-	13	-	-	-	-	-	-	-	13	-	-	260	-	-	-	-	13	-
Compressor and tools	-	-	-	-	-	-	-	-	-	-	-	-	-	260	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
Vibrator	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water pump	-	-	-	-	-	-	4	-	-	-	-	-	4	-	-	-	-	4	-	-	-	-	4	-	-	-	-	4	-	-
Flail mower on hydraulic arm	-	-	-	-	-	-	-	13	-	-	-	-	13	-	-	-	-	13	-	-	-	-	13	-	-	-	-	13	-	-
Circular saw	-	-	-	-	-	-	-	3	-	-	-	-	3	-	-	-	-	3	-	-	-	-	3	-	-	-	-	3	-	-
FWD station wagon (L WB)	-	-	-	-	-	-	-	-	91	-	-	-	-	-	-	-	91	-	-	-	-	-	-	-	91	-	-	-	-	-
FWD pickup	-	-	-	-	-	-	-	-	-	77	77	-	-	-	-	-	-	77	77	-	-	-	-	-	-	77	77	-	-	-
Motorcycles	-	-	-	-	-	-	23	23	23	-	-	23	23	23	-	-	23	23	23	-	-	23	23	23	-	-	23	23	23	-
Bicycles	-	-	-	-	-	-	4	5	5	-	-	4	5	5	-	-	4	5	5	-	-	4	5	5	-	-	4	5	5	-
Sub-total(2)	-	-	-	-	-	-	698	773	119	1022	201	1088	986	288	1627	-	1504	1795	944	390	13	698	773	288	96	1022	899	1163	41	-
Total(1) & (2)	-	19	36	42	42	93	1498	1303	236	1064	793	3757	2380	330	1669	93	2472	2325	986	437	605	3367	2167	330	211	1115	1699	1693	83	42

TABLE 4.21

Operation and Maintenance Cost Schedule - Alternative A

Item	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Fuel and Oil														Annual costs (economic) '000 SoSh																	
Main irrigation pump station		-	106	345	500	530	530	530	530	530	530	530	530	530	530	530	530	530	530	530	530	530	530	530	530	530	530	530	530	530	530
Sprinkler pump station		-	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162
Drainage pump station		-	-	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
Generators for Project HQ		-	124	248	248	248	248	248	248	248	248	248	248	248	248	248	248	248	248	248	248	248	248	248	248	248	248	248	248	248	248
Heavy machinery * (bulldozers, graders, etc.)		-	42	67	92	92	92	92	92	92	92	92	92	92	92	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103
Trucks, tractors and water bowser		-	36	49	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
FWD Land Rovers		4	8	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Motorcycles		-	15	30	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
Mobile workshop, compressor, mixers, etc.		-	4	5	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Sub-total(1)		4	497	937	1134	1165	1165	1165	1165	1165	1165	1165	1165	1165	1165	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176
Spare Parts and Materials																															
Canal, drain and in-field structures		-	20	50	80	109	109	109	109	109	109	109	109	109	109	109	109	109	109	109	109	109	109	109	109	109	109	109	109	109	109
Primary road		-	4	8	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
Vehicles and heavy machinery		-	100	200	300	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
Pumps, engines and generators		-	10	20	30	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
Asbestos cement pipes (sprinkler mains)		-	-	4	8	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Buildings		-	-	80	160	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213	213
Sub-total(2)		-	134	362	597	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901
Total(1) & (2)		4	631	1299	1731	2066	2066	2066	2066	2066	2066	2066	2066	2066	2066	2077	2077	2077	2077	2077	2077	2077	2077	2077	2077	2077	2077	2077	2077	2077	2077

Note * includes floating grab dredger and barge from year 15 onwards

TABLE 4.22

Total Engineering Cost Schedule (Economic) - Alternative A

Item	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Capital Costs															Annual costs '000 SoSh																
Major construction (Bills 1 to 8)		15342	36676	21967	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buildings (Bill 9)		6196	8670	723	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Services and equipment (Bill 10)		1967	865	273	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Operation and maintenance vehicles and machinery		91	2467	1006	1425	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Engineering design and supervision (Bill 11)		2349	4619	2296	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sub-total (1)		25925	53277	26265	1425	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Recurrent Costs																														
Replacement of vehicles and machinery		-	-	-	-	-	-	698	773	119	1022	201	1088	786	288	1627	-	1504	1795	964	390	13	698	773	288	94	1022	899	1163	41	-
Fuel and oil		4	497	937	1134	1165	1165	1165	1165	1165	1165	1165	1165	1165	1165	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176
Spare parts and machinery		-	134	362	597	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901
Replacement of pumps, engines and miscellaneous items		-	19	36	42	42	93	888	530	117	42	592	2669	1394	42	42	93	875	530	42	42	592	2669	1394	42	117	93	800	530	42	42
Sub-total (2)		4	650	1335	1773	2108	2159	3654	3369	2302	3130	2859	5823	4246	2396	3746	2170	4456	4402	3083	2509	2682	5444	4244	2407	2288	3192	3776	3770	2160	2119
Total (1) & (2)		25929	53927	27600	3198	2124	2159	3654	3369	2302	3130	2859	5823	4246	2396	3746	2170	4456	4402	3083	2509	2682	5444	4244	2407	2288	3192	3776	3770	2160	2119

TABLE 4.23

Total Engineering Cost Schedule (Financial) - Alternative A

Item	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
Capital Costs															Annual costs '000 SoSh																
Major construction (Bills 1 to 8)		16991	40251	24108	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Buildings (Bill 9)		7404	10361	864	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Services and equipment (Bill 10)		2385	1035	335	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Operation and maintenance vehicles and machinery		105	2837	1157	1639	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Engineering design and supervision (Bill 11)		2700	5309	2639	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Sub-total (1)		29585	59793	29103	1639	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Recurrent Costs																															
Replacement of vehicles and machinery		-	-	-	-	-	-	803	889	137	1175	231	1251	906	331	1871	-	1730	2064	1086	449	15	803	889	331	108	1175	1034	1338	47	-
Fuel and oil		6	706	1331	1610	1654	1654	1654	1654	1654	1654	1654	1654	1654	1654	1670	1670	1670	1670	1670	1670	1670	1670	1670	1670	1670	1670	1670	1670	1670	1670
Spare parts and machinery		-	167	398	657	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991
Replacement of pumps, engines and miscellaneous items		-	22	41	48	48	107	920	610	135	48	681	3069	1603	48	48	107	1006	610	48	48	681	3069	1603	48	135	107	920	610	48	48
Sub-total (2)		6	875	1770	2315	2693	2752	4368	4144	2917	3868	3557	6965	5152	3024	4580	2768	5397	5335	3795	3158	3357	6533	5153	3040	2904	3963	4615	4609	2756	2709
Total (1) & (2)		29591	60668	30873	3954	2711	2752	4368	4144	2917	3868	3557	6965	5152	3024	4580	2768	5397	5335	3795	3158	3357	6533	5153	3040	2904	3963	4615	4609	2756	2709

TABLE 4.24

Summary of Construction Costs - Alternative B

		Year 1			Year 2			Year 3		
		Total cost (SoSh '000) (Economic)	Foreign exchange (SoSh '000)	Total cost (SoSh '000) (Financial)	Total cost (SoSh '000) (Economic)	Foreign exchange (SoSh '000)	Total cost (SoSh '000) (Financial)	Total cost (SoSh '000) (Economic)	Foreign exchange (SoSh '000)	Total cost (SoSh '000) (Financial)
1	Land preparation	1 542	771	1 619	7 129	3 565	7 486	3 836	1 918	4 028
2	Earthworks	8 395	4 617	8 857	6 227	3 425	6 570	3 200	1 760	3 376
3	Canal structures including water control equipment	-	-	-	4 529	2 491	5 251	3 138	1 726	3 639
4	Drain structures	-	-	-	4 397	2 418	5 098	2 313	1 272	2 682
5	In-field structures	-	-	-	903	497	1 052	610	336	711
6	Pump stations	2 086	1 565	2 352	1 678	1 259	1 892	2 118	1 589	2 388
7	Sprinkler equipment	-	-	-	1 889	1 606	2 307	-	-	-
8	Primary road	672	370	709	-	-	-	-	-	-
9	Buildings	5 311	3 452	6 347	7 449	4 842	8 902	2 774	1 803	3 315
10	Services and equipment	1 947	1 460	2 385	845	634	1 035	273	205	335
11	Engineering design and supervision	1 995	1 297	2 293	3 505	2 278	4 029	1 826	1 187	2 099
	Total	21 948	13 532	24 562	38 551	22 815	43 622	20 088	11 796	22 573

Total Costs (Economic) = 80 587 000
Total Foreign Exchange = 48 143 000
Total Cost (Financial) = 90 757 000

TABLE 4.25

Bill Nr 1: Land Preparation - Alternative B

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
1. Bush clearance (light)	ha	600	338	202.8	1 252	751.2	642	385.2
2. Bush clearance (dense)	ha	1 400					117	163.8
3. Semi-detailed land levelling survey on 50 m grid	ha	70	260	18.2	1 268	88.8	650	45.5
4. Land levelling	m^3	10	108 000	1 080	526 500	5 265	270 000	2 700
5. Land planing	ha	300	338	101.4	1 252	375.6	642	192.6
Sub-total Economic Cost				1 402		6 481		3 487
Add 10% contingencies				1 542		7 129		3 836
Foreign exchange (50%)				771		3 565		1 918
Taxes and Duties (10%)				77		357		192
Total Financial Cost				1 619		7 486		4 028

TABLE 4.26

2: Earthworks - Alternative B

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
1. Excavate in flood relief channel and form associated embankments	m^3	17	54 000	918	54 000	918		
2. Excavate in borrow areas and form flood protection bunds	m^3	12	57 100	685	57 100	685		
3. Excavate for intake channel and settling basin and form associated embankments	m^3	12	25 843	310				
4. Excavate storage reservoir and form associated embankment	m^3	12	23 827	286				
5. Excavate sprinkler storage reservoir and form associated embankment	m^3	12			5 900	71		
6. Excavate in canals and form canal embankments	m^3	12					129	2
7. Excavate in storage reservoir and form canal embankments	m^3	17	68 087	1 157	68 087	1 157		
8. Excavate in flood relief channel and form canal embankments	m^3	17	68 500	1 165				
9. Remove existing flood bund and and form canal embankments	m^3	22	34 300	755	34 300	755	34 300	755
Carried forward				5 276		3 586		757

TABLE 4.26 (cont.)

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
Brought forward				5 276		3 586		757
10. Excavate in drains and form drain embankments	m^3	12	26 442	317	28 368	340	26 671	320
11. Excavate in drains and form canal embankments; haul 200 m	m^3	12	23 446	281	9 120	109	12 726	153
12. Ditto; haul 200 m 500 m	m^3	17	28 033	477	10 943	186	15 271	260
13. Ditto; haul 500 m	m^3	22	42 202	928	16 415	361	22 906	504
14. Excavate unit drains to form unit channel embankment strip	unit	24 000	8	192	39	936	20	480
15. Form unit channel section in unit channel embankment strip	km	1 500	16.8	25	81.9	123	42.0	63
16. Excavate in natural channels for drainage and form canal embankments	m^2	22	6 194	136	900	20	16 887	372
Sub-total Economic Cost				7 632		5 661		2 909
Add 10% contingencies				8 395		6 227		3 200
Foreign exchange (55%)				4 617		3 425		1 760
Taxes and Duties (10%)				462		343		176
Total Financial Cost				8 857		6 570		3 376

Note: Cost of flood relief channel not charged to project for economic analysis (Chapter 7) because its operation benefits the banana plantations downstream of Mogambo.

TABLE 4.27

Bill Nr 3: Canal Structures Including Water Control Equipment Alternative B

Item	Unit	Rate (SoSh '000)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
1. Inverted siphon under main canal 2 x 1.2 x 1.2 m	Nr	750			1	750		
2. Pipe regulator 3.x 1.20 m dia.	Nr	462			2	924	1	462
3. Pipe regulator 2 x 1.20 m dia.	Nr	330			1	330		
4. Pipe regulator 2 x 1.05 m dia.	Nr	270			2	540	2	540
5. Pipe regulator 1 x 1.20 m dia.	Nr	198			1	198		
6. Pipe regulator 1 x 1.05 m dia.	Nr	165			2	330	1	165
7. Pipe regulator 1 x 0.90 m dia.	Nr	143					2	286
8. Pipe regulator 1 x 0.60 m dia.	Nr	83			2	166	2	166
9. Pipe regulator 1 x 0.45 m dia.	Nr	53					1	53
10. Tail escapes 1 x 0.45 m dia.	Nr	77			2	154	3	231
11. Distributary outlet 1 x 0.375 m dia.	Nr	25			29	725	38	950
Sub-total Economic Cost						4 117		2 853
Add 10% contingencies						4 529		3 138
Foreign exchange (55%)						2 491		1 726
Taxes and Duties (29%)						722		501
Total Financial Cost						5 251		3 639

TABLE 4.28

Bill Nr 4: Drain Structures - Alternative B

Item	Unit	Rate (SoSh '000)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
1. Drain junction culvert 1 x 0.45 m dia.	Nr	50					4	200
2. Drain junction culvert 1 x 0.60 m dia.	Nr	80			4	320	2	160
3. Drain junction culvert 1 x 0.75 m dia.	Nr	105			2	210	1	105
4. Drain junction culvert 1 x 0.90 m dia.	Nr	130			1	130		
5. Unit drain junction culvert 1 x 0.30 m dia.	Nr	45			37	1 665	30	1 350
6. Drain road culvert 1 x 1.05 m dia.	Nr	150			2	300		
7. Drain culverts under flood bund (incl. flap valves) 1 x 0.45 m dia.	Nr	62					1	62
8. Drain culverts under flood bund (incl. flap valves) 1 x 0.75 m dia.	Nr	113			1	113	2	226
9. Drain culverts under flood bund (incl. flap valves) 1 x 1.20 m dia.	Nr	188			2	376		
10. Drain culverts under flood bund (incl. flap valves) 2 x 1.05 m dia.	Nr	298			1	298		
11. Drain underpass 1 x 0.60 m dia.	Nr	123			1	123		
12. Drain underpass 1 x 0.90 m dia.	Nr	200			1	200		
13. Drain underpass 1 x 1.20 m dia.	Nr	262			1	262		
Sub-total Economic Cost						3 997		2 103
Add 10% contingencies						4 397		2 313
Foreign exchange (55%)						2 418		1 272
Taxes and Duties (29%)						701		369
Total Financial Cost						5 098		2 682

TABLE 4.29

Bill Nr 5: In-field Structures - Alternative B

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
1. Siphon tubing	m	11.1			2 400	26.6	1 620	18.0
2. Portable canvas unit channel checks	Nr	650			80	52.2	54	35.1
3. Unit drain road crossing (Irish bridge)	Nr	5 600			120	672.0	81	453.6
4. Concrete outlet weirs for basins	Nr	65			1 080	70.2	729	47.4
Sub-total Economic Cost						820.8		554.1
Add 10% for contingencies						903		610
Foreign exchange (55%)						497		336
Taxes and Duties (30%)						149		101
Total Financial Cost						1 052		711

TABLE 4.30

Bill Nr 6: Pump Stations - Pumps, Engines and Associated Civil Works - Alternative B

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
1. Main pump station - civil works	Sum			800		800		
2. Main pump station - pumping plant	Sum			750		725		925
3. Sprinkler pump station P1	Sum			346				
4. Drainage pump station D1	Sum							1 000
Sub-total Economic Cost				1 896		1 525		1 925
Add 10% contingencies				2 086		1 678		2 118
Foreign exchange (75%)				1 565		1 259		1 589
Taxes and Duties (17%)				266		214		270
Total Financial Cost				2 352		1 892		2 388

TABLE 4.31

Bill Nr 7: Sprinkler Equipment - Alternative B

	Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
	Supply, install and test asbestos cement pipes, including bedding and all fittings, for:								
1.	internal diameter 150 mm	m	128.8			1 950	251.2		
2.	internal diameter 200 mm	m	197.1			2 840	559.8		
3.	internal diameter 225 mm	m	229.1			170	38.9		
4.	internal diameter 250 mm	m	253.8			230	58.4		
5.	internal diameter 300 mm	m	319.5			80	25.6		
6.	internal diameter 350 mm	m	417.8			405	169.2		
7.	internal diameter 400 mm	m	505.2			420	212.2		
8.	Supply laterals, hydrants (with protective pipes), sprinklers and all accessories	ha	3 280			122.4	401.5		
	Sub-total Economic Cost						1 717		
	Add 10% contingencies						1 889		
	Foreign exchange (85%)						1 606		
	Taxes and Duties (26%)						418		
	Total Financial Cost						2 307		

TABLE 4.32

Bill Nr 8: Primary Roads - Alternative B

Item	Unit	Rate (SoSh '000)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
Surfaced								
1. Excavate road drains and form associated subgrade including compaction	km	80	0.5	40				
2. Supply, lay and compact 0.15 m thick sub-base	km	215	0.5	108				
3. Supply, lay and compact 0.2 m thick road base	km	264	0.5	132				
4. Bituminous surfacing	km	150	0.5	75				
Unsurfaced								
5. Excavate road drains and form associated subgrade including compaction	km	80	3.2	256				
Sub-total Economic Cost				611				
Add 10% contingencies				672				
Foreign exchange (55%)				370				
Taxes and Duties (10%)				37				
Total Financial Cost				709				

TABLE 4.33

9: Buildings - Alternative B

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
Project Headquarters and Village								
Supply and erect complete:								
1. House type AA	Nr	632 500	1	633	1	633		
2. House type A	Nr	550 000	3	1 650	2	1 100	2	1 100
3. House type B	Nr	255 000	4	1 020	3	765	3	765
4. Office block	m^2	2 550	545	1 390				
5. Workshop	m^2	2 050			900	1 845		
6. Training centre	m^2	2 250					200	450
7. Operator's quarters for pump station and X-regulator (20 m^2)	m^2	2 550	40	102	40	102		
8. Meteorological station	Nr	17 000	1	17				
9. Stores warehouse and offices	m^2	2 050			360	738		
10. Security hut for stores	m^2	2 050			12	25		
11. Fuel station yard	m^2	250			300	75		
12. Fuel storage tank with pump (17 500 l)	Nr	35 000			1	35		
13. Fuel station office	m^2	2 550			30	77		
Carried forward				4 812		5 395		2 315

TABLE 4.33 (cont.)

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
Brought forward				4 812		5 395		2 315
14. Compacted earth hardstanding	m^2	75			200	15		
15. Covered concrete hardstanding	m^2	1 500			500	750		
16. Concrete hardstanding	m^2	250			1 700	425		
17. Fencing	m	65	250	16	250	16		
18. Provision of assistance to village housing construction	Nr	1 500			100	150	124	186
19. Water points and soakaway ($6\ m^2$ each)	m^2	250			84	21	84	21
Sub-total Economic Cost				4 828		6 772		2 522
Add 10% contingencies				5 311		7 449		2 774
Foreign exchange (65%)				3 452		4 842		1 803
Taxes and Duties (30%)				1 036		1 453		541
Total Financial Cost				6 347		8 902		3 315

TABLE 4.34

10: Services and Equipment - Alternative B

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
Potable Water Supply (PHQ and Village)								
1. Boring tubewell 80 m deep	Nr	60 000	1	60	-	-	-	-
2. Tubewell screens	Nr	75 000	1	75	-	-	-	-
3. Tubewell pumps	Nr	18 000	1	18	-	-	-	-
4. Steel storage tank and supporting tower (70 m^3)	Nr	220 000	1	220	-	-	-	-
5. Pump house	Sum	-	-	45	-	-	-	-
6. Supply and install 75 mm dia. plastic pipe and fittings	m	88	1 800	158	-	-	-	-
7. Supply and install 50 mm dia. plastic pipe and fittings	m	60	2 400	144	-	-	-	-
8. Supply and install 25 mm dia. plastic pipe and fittings	m	30	2 000	60	-	-	-	-
9. Supply and install 10 mm dia. plastic pipe and fittings	m	10	1 800	18	-	-	-	-
Power Supply								
10. 2 x 100 kVA generator sets complete with fuel tank and generator house	kVA	4 810	100	481	100	481	-	-
11. Install all electric cabling and fittings as necessary	Sum	-	-	200	-	100	-	100
Carried forward				1 479		581		100

TABLE 4.34 (cont.)

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
Brought forward				1 479		581		100
Miscellaneous								
12. Office equipment and stationery	Sum	-	-	10	-	10	-	10
13. Furniture for houses, offices, etc.	Sum	-	-	150	-	100	-	50
14. Laboratory equipment	Sum	-	-	5	-	7	-	8
15. Workshop tools	Sum	-	-	50	-	70	-	80
16. Internal radio network transceiver sets	Nr	17 800	3	53	-	-	-	-
17. Mogambo-Mogadishu radio	Sum	-	-	22	-	-	-	-
Sub-total Economic Cost		-	-	1 769	-	768	-	248
Add 10% contingencies		-	-	1 947	-	845	-	273
Foreign exchange (75%)		-	-	1 460	-	634	-	205
Taxes and Duties (30%)				438		190		62
Total Financial Cost				2 385		1 035		335

TABLE 4.35

Bill Nr 11: Engineering Design and Supervision of Construction - Alternative B

Item	Unit	Rate (SoSh)	YEAR 1 Quantity	YEAR 1 Amount (SoSh '000)	YEAR 2 Quantity	YEAR 2 Amount (SoSh '000)	YEAR 3 Quantity	YEAR 3 Amount (SoSh '000)
1. Estimated cost	sum			1 995		3 505		1 826
Total Economic Cost				1 995		3 505		1 826
Foreign exchange (65%)				1 297		2 278		1 187
Taxes and Duties (23%)				298		524		273
Total Financial Cost				2 293		4 029		2 099

TABLE 4.36

Replacement Cost Schedule - Alternative B

Item	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
												Annual costs (economic) '000 SoSh																			
Pumps, Engines, Generators and Miscellaneous Items																															
Main pump station - pumps		-	-	-	-	-	-	-	-	-	-	540	540	530	-	-	-	-	-	-	-	540	540	530	-	-	-	-	-	-	-
Main pump station - engines		-	-	-	-	-	265	265	260	-	-	265	265	260	-	-	265	265	260	-	-	265	265	260	-	-	265	265	260	-	-
Sprinkler pump station - pump		-	-	-	-	-	-	-	-	-	-	221	-	-	-	-	-	-	-	-	-	221	-	-	-	-	-	-	-	-	-
Sprinkler pump station - engine		-	-	-	-	-	125	-	-	-	-	125	-	-	-	-	125	-	-	-	-	125	-	-	-	-	125	-	-	-	-
Drainage pump station - pump		-	-	-	-	-	-	-	-	-	-	-	-	654	-	-	-	-	-	-	-	-	-	654	-	-	-	-	-	-	-
Drainage pump station - engine		-	-	-	-	-	-	-	346	-	-	-	-	346	-	-	-	-	346	-	-	-	-	346	-	-	-	-	346	-	-
Generators for Project HQ & village		-	-	-	-	-	-	-	-	-	-	481	481	-	-	-	-	-	-	-	-	481	481	-	-	-	-	-	-	-	-
Electric pumps for potable water supply		-	-	-	-	-	-	-	-	-	-	18	-	-	-	-	-	-	-	-	-	18	-	-	-	-	-	-	-	-	-
Aluminium pipes (sprinkler laterals)		-	-	8	8	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Sprinkler heads and riser		-	-	4	4	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Siphon tubing and portable canvas checks		-	-	-	-	-	-	66	66	-	-	-	66	66	-	-	-	66	66	-	-	-	66	66	-	-	-	66	66	-	-
Radio communication transceivers		-	-	-	-	-	-	-	-	75	-	-	-	-	-	-	-	75	-	-	-	-	-	-	-	75	-	-	-	-	-
Sub-total(1)		-	-	12	12	33	423	364	705	108	33	1683	1385	1889	33	33	423	439	705	33	33	1683	1385	1889	33	108	423	364	705	33	33
Operation & Maintenance Vehicles and Machinery																															
Dragline		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	715	-	715	-	-	-	-	-	-	-	-	-	-	-
Floating grab dredger		-	-	-	-	-	-	-	-	-	-	-	-	-	-	870	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Split bottom barge		-	-	-	-	-	-	-	-	-	-	-	-	-	-	754	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Grader		-	-	-	-	-	-	671	-	-	-	-	671	-	-	-	-	671	-	-	-	-	671	-	-	-	-	-	671	-	-
Bulldozer (D6)		-	-	-	-	-	-	-	725	-	-	-	-	725	-	-	-	-	725	-	-	-	-	725	-	-	-	-	-	725	-
Low loader		-	-	-	-	-	-	-	-	-	-	-	390	-	-	-	-	-	-	-	390	-	-	-	-	-	-	-	-	390	-
12 ton truck		-	-	-	-	-	-	-	-	-	150	-	-	-	-	-	-	-	150	-	-	-	-	-	-	-	150	-	-	-	-
12 ton tipper truck		-	-	-	-	-	-	-	-	-	203	-	-	-	-	-	-	-	203	-	-	-	-	-	-	-	203	-	-	-	-
Tractor and trailer		-	-	-	-	-	-	-	-	-	247	124	-	-	-	-	-	-	247	124	-	-	-	-	-	-	247	124	-	-	-
Mobile workshop		-	-	-	-	-	-	-	-	-	208	-	-	-	-	-	-	-	208	-	-	-	-	-	-	-	208	-	-	-	-
Water bowser		-	-	-	-	-	-	-	-	-	137	-	-	-	-	-	-	-	137	-	-	-	-	-	-	-	137	-	-	-	-
Concrete mixer		-	-	-	-	-	-	-	-	-	-	-	-	13	-	-	-	-	-	-	-	13	-	-	-	-	-	-	-	13	-
Compressor and tools		-	-	-	-	-	-	-	-	-	-	-	-	-	260	-	-	-	-	-	-	-	-	-	260	-	-	-	-	-	-
Vibrator		-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
Water pump		-	-	-	-	-	-	-	4	-	-	-	-	4	-	-	-	-	4	-	-	-	-	4	-	-	-	-	4	-	-
Flail mower on hydraulic arm		-	-	-	-	-	-	-	13	-	-	-	-	13	-	-	-	-	13	-	-	-	-	13	-	-	-	-	13	-	-
Circular saw		-	-	-	-	-	-	-	3	-	-	-	-	3	-	-	-	-	3	-	-	-	-	3	-	-	-	-	3	-	-
FWD station wagon (LWB)		-	-	-	-	-	-	-	-	91	-	-	-	-	-	-	-	91	-	-	-	-	-	-	-	91	-	-	-	-	-
FWD pickup		-	-	-	-	-	-	-	-	-	77	77	-	-	-	-	-	-	77	77	-	-	-	-	-	-	77	77	-	-	-
Motorcycles		-	-	-	-	-	-	23	23	23	-	-	23	23	23	-	-	23	23	23	-	-	23	23	23	-	-	23	23	23	-
Bicycles		-	-	-	-	-	-	4	5	5	-	-	4	5	5	-	-	4	5	5	-	-	4	5	5	-	-	4	5	5	-
Sub-total(2)		-	-	-	-	-	-	698	773	119	1022	201	1088	786	288	1627	-	1504	1795	944	390	13	698	773	288	94	1022	899	1163	41	-
Total(1) & (2)		-	-	12	12	33	423	762	1478	227	1055	1884	2473	2675	321	1660	423	1943	2500	977	423	1696	2083	2662	321	202	1445	1263	1868	74	33

TABLE 4.37

Operation and Maintenance Cost Schedule - Alternative B

Item / Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Fuel and Oil	Annual costs (economic) '000 SoSh																													
Main irrigation pump station	-	95	290	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466
Sprinkler pump station	-	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128
Drainage pump station	-	-	-	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Generators for Project HQ	-	120	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240
Heavy machinery = (bulldozers, graders, etc.)	-	42	67	92	92	92	92	92	92	92	92	92	92	92	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103
Trucks, tractors and water bowser	-	36	49	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
4WD Land Rovers	4	8	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Motorcycles	-	15	30	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
Mobile workshop, compressor, drivers, etc.	-	4	5	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Sub-total(1)	4	452	829	1052	1053	1053	1053	1053	1053	1053	1053	1053	1053	1053	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064
Spare Parts and Materials																														
Canal, drain and in-field structures	-	24	48	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72
Primary road	-	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Vehicles and heavy machinery	-	157	258	457	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
Pumps, engines and generators	-	15	25	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Asbestos cement pipes (sprinkler mains)	-	-	6	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
Buildings	-	-	-	212	212	212	212	212	212	212	212	212	212	212	212	212	212	212	212	212	212	212	212	212	212	212	212	212	212	212
Sub-total(2)	-	205	346	783	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846
Total(1) & (2)	4	657	1175	1835	1899	1899	1899	1899	1899	1899	1899	1899	1899	1899	1910	1910	1910	1910	1910	1910	1910	1910	1910	1910	1910	1910	1910	1910	1910	1910

Note * Includes floating grab dredger and barge from year 15 onwards

TABLE 4.38

Total Engineering Cost Schedule (Economic) - Alternative B

Item	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Capital Costs															Annual costs '000 SoSh																
Major construction (Bills 1 to 8)		12695	26752	15215	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buildings (Bill 9)		5311	7449	2774	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Services and equipment (Bill 10)		1967	865	273	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Operation and maintenance vehicles and machinery		91	2467	1006	1425	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Engineering design and supervision (Bill 11)		1988	3505	1826	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sub-total (1)		22032	41018	21094	1425	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Recurrent Costs																															
Replacement of vehicles and machinery		-	-	-	-	-	-	698	773	119	1022	201	1088	786	288	1627	-	1504	1795	964	390	13	698	773	288	96	1022	899	1163	41	-
Fuel and oil		4	452	829	1052	1053	1053	1053	1053	1053	1053	1053	1053	1053	1053	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064
Spare parts and machinery		-	205	346	783	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846
Replacement of pumps, engines and miscellaneous items		-	-	12	12	33	423	364	705	108	33	1683	1385	1889	33	33	423	439	705	33	33	1683	1385	1889	33	108	423	364	705	33	33
Sub-total (2)		4	657	1287	1847	1932	2322	2961	3377	2126	2954	3783	4372	4574	2220	3570	2333	3853	4410	2887	2333	3606	3993	4572	2231	2112	3355	3173	3778	1984	1943
Total (1) & (2)		22036	41675	22381	3272	1948	2322	2961	3377	2126	2954	3783	4372	4574	2220	3570	2333	3853	4410	2887	2333	2606	3993	4572	2231	2112	3355	3173	3778	1904	1943

TABLE 4.39

Total Engineering Cost Schedule (Financial) - Alternative B

Item	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
Capital Costs																															
Major construction (Bills 1 to 8)		13537	29656	16826	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Buildings (Bill 9)		6347	8902	3315	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Services and equipment (Bill 10)		2385	1035	335	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Operation and maintenance vehicles and machinery		105	2837	1157	1639	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Engineering design and supervision (Bill 11)		2293	4029	2099	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Sub-total (1)		24667	46459	25730	1639	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Recurrent Costs																															
Replacement of vehicles and machinery		-	-	-	-	-	-	803	889	157	1175	251	1251	904	331	1871	-	1730	2864	1086	449	15	803	889	331	108	1175	1034	1330	47	
Fuel and oil		6	642	1177	1494	1495	1495	1495	1495	1495	1495	1495	1495	1495	1495	1511	1511	1511	1511	1511	1511	1511	1511	1511	1511	1511	1511	1511	1511	1511	15
Spare parts and machinery		-	226	381	861	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	9
Replacement of pumps, engines and miscellaneous items		-	-	14	14	38	486	419	811	124	38	1935	1593	2172	38	38	486	505	811	38	38	1935	1593	2172	38	124	486	419	811	38	
Sub-total (2)		6	868	1572	2369	2464	2912	3648	4126	2687	3639	4592	5270	5502	2795	4351	2928	4677	5317	3566	2929	4392	4838	5503	2811	2674	4103	3895	4591	2527	24
Total (1) & (2)		24673	47327	25302	4008	2482	2912	3648	4126	2687	3639	4592	5270	5502	2795	4351	2928	4677	5317	3566	2929	4392	4838	5503	2811	2674	4103	3895	4591	2527	24

4.7 Future Development

4.7.1 Alternative A

Alternative A is designed as the first phase of the development of the full scheme described in the Supplementary Study, and thus allows future expansion to the full scheme without requiring major changes to the engineering works. The layout for the future development is as shown on Plate Nr 26 in the Supplementary Study.

The main canal structures and earthworks have been sized as for the Supplementary Study and so no increase in size or alteration to these structures would be required. However, the pumps in the main pump station have been reduced for alternative A and so additional pumps and engines would be required for future expansion. In alternative A, the Mogambo outfall drain has been positioned to run down the southern boundary of the project; for future development, this drain would have to be re-aligned and the flood bund in the south-west corner removed.

4.7.2 Alternative B

The possible future development of the alternative B project area is shown on Plate Nr 8. This phase II development area of about 4 600 ha is independent of the phase I area and comprises two parts each fed by a separate pump station. One area lies to the north of the alternative B phase I area and the second area to the south of it. The two areas could easily be brought into operation independently and at different times.

The location of the northern pump station is the same as that of the main pump station in the Supplementary Study. The main canal from this pump station also follows the same line as the main canal in the Supplementary Study. The main pump station for the southern project has been located about 2 km south of Mana Moofi. The site is thought to be on a stable section of the river, however, this would have to be confirmed by a field survey. The main canal for the southern project has been aligned such that it passes through as small an area of banana plantation as possible. The canal and drain layouts are based on the layouts of the equivalent areas in the Supplementary Study.

The total developed area is approximately the same as that in the Supplementary Study with approximately equal areas of sprinkler and surface irrigation; however areas that have been allocated as villages in the Supplementary Study have been irrigated in this case. Very few alterations need to be made to the layout of alternative B. The western flood bund will need to be removed and rebuilt further west. However the fill from the removed flood bund can be used for the canal earthworks. The drains from the alternative B project area discharge into the area that will be used in the future development area. Although the area is largely for sprinkler, these drains will have to be linked into the drainage networks of the additional areas.

The areas identified for the future development schemes are listed below:

(1) Northern area project

Surface irrigation	=	243 ha net
Overhead irrigation	=	1 754 ha net

(2) Southern area project

Surface irrigation	=	1 350 ha net
Overhead irrigation	=	1 265 ha net

4.7.3 Cost Estimates for Future Development

The cost estimates for the future development of alternative A have been taken as the costs for the full scheme as given in the Supplementary Study less the costs for alternative A (Phase I).

It is difficult to make an accurate cost estimate for the future development of alternative B without doing a detailed analysis. However a cost estimate can be made by considering the costs of the alternative B project and producing a pro rata rate for surface irrigation and for infrastructural works. To produce a cost estimate for the overhead irrigation areas pro rata rates have been obtained from the costs for the overhead irrigation areas given in the Supplementary Study.

Table 4.40 gives a comparison of the costs for future development for both alternative A and B.

TABLE 4.40

Comparison of the Construction Costs for the Future Development of Alternative A and Alternative B. (SoSh '000)

		Alternative A	Alternative B
Phase I:	irrigation and drainage works	81 384	60 128
	buildings, services and equipment	20 519	20 458
	total	101 903	80 586
Phase II:	irrigation and drainage works	132 911	168 000
	buildings, services and equipment	50 177	52 166
	total	183 028	220 166
Total development: Phase I & II	irrigation and drainage works	214 295	228 128
	buildings, services and equipment	70 636	72 624
	total	284 931	300 752

As expected the costs for the future development of altenative B are greater than for alternative A. However it must be emphasised that no detailed design for the expansion areas for alternative B has been done and so cost estimates are indicative only.

4.8 Effect of Bardheere Dam

Bardheere dam is scheduled for construction in the upper reaches of the Juba river and provided that funds are available its earliest possible completion date is 1987. The advantages of the dam are as follows:

(i) There will be no problem of water shortage during the dry months (February and March).

(ii) The flows in the Juba river will be regulated to eliminate water shortage in the gilal season and greatly reduce the probability of flooding in the der season.

(iii) The profitability of development schemes will be increased because of the reduced need for flood protection and the wider range of crops that can be grown.

(iv) Allows for the installation of hydro-electric generation which could provide power for pumping plant along the river.

The greater water control provided by the dam ensures adequate water supply for the project throughout the year and so enables perennial crops to be grown. Annex 3 of the Supplementary study discussed the possible range of crops that could be grown once the dam was completed. The Supplementary Study concluded that the most suitable perennial crop was bananas. However, bananas should be grown on levee soils, of which the alternatives A and B have very little. Hence the dam would not have much effect until future development, when the levee soils would be included in the project area.

Alternatives A and B are predominently basin soils on which paddy rice is grown. Since paddy rice is a high value cash crop it would still be grown after the construction of the dam, but a longer maturity, higher yield variety could be used.

The most significant effect of the completion of the dam for alternatives A and B is likely to be due to the reduction in flood risks in the area. Smaller flood flows in the Juba river would reduce the rate of change of the river course. However, the reduction in the river silt load will tend to increase the scouring effect downstream of the dam. This is likely to be small at Mogambo due to the natural armouring of the river bed and the distance of the project from Bardheere. Any scouring that does occur at Mogambo can be mitigated by the addition of flexible protection at the pump station site and by lowering of the pump intakes by the addition of extra lengths of pump casing.

Once the dam is complete the flood protection works provided for in alternatives A and B are largely redundant. However, risk analysis (in Supplementary Study) has shown that it is unacceptable not to build these flood protection works due to possible damage caused by a 1 in 10 year flood. The works could be omitted if the project was delayed until the dam was complete. The reduction in flood levels also means that it will be easier to drain the western drains as there will be lower water levels to the west of the flood embankment.

CHAPTER 5

INFRASTRUCTURE

5.1 Project Headquarters and Village

The project headquarters and village are located about 1 km west of the village of Mogambo adjacent to the flood relief channel. They are sited on levee soils because special foundations are not required for buildings constructed on that type of soil. Expansive soils such as the basin clays in the project area are not so suitable for construction of buildings because piled foundations would be required. Good access is provided for the project headquarters by 0.5 km of surfaced primary road connecting it to the main Gelib-Kismayo road.

A suggested layout for the project headquarters and village is shown in Figure 5.1. It will be the centre for all administration and operation of the project and will house the senior and junior management staff. Four village wards housing 224 workers associated with the project will be located in the new village built at the project headquarters. The remainder of the workers will live in the existing villages of Mogambo, Bulo Yaag, Fagan and Mana Moofi.

The location and layout of the project headquarters and village will be the same for both alternatives A and B.

5.2 Buildings

The buildings to be constructed for the project have been kept to the minimum requirement so as to keep the costs as low as possible. No community facilities have been provided.

A list of the buildings to be constructed for both alternatives is given below in Table 5.1.

TABLE 5.1

Buildings Constructed in the Project

Building	Nr	Approximate unit floor area (m^2)
House Type AA	2	230
House Type A	7	200
House Type B	10	100
Office block	1	545
Workshop	1	900
Stores	1	360
Fuel station office	1	30
Training centre	1	200
Meteorological station	1	-
Security hut for stores	1	12
Operators' quarters(1)	5/4	20

Note: (1) All the buildings listed above, except the operators' quarters are situated in the project headquarters. The operators' quarters are located at pump stations and regulator groups. 5 Nr are required for alternative A and 4 Nr for alternative B.

The new village housing for the labourers will be constructed under a self help scheme with materials and assistance provided by the Contractor. It is intended that with this assistance and with guaranteed jobs at acceptable rates of pay, the labour required for the project will have sufficient incentive to construct their own houses in designated plots. Only about half the project work force will live in the new village housing at the project headquarters, the remainder will live in the existing villages of Mogambo, Bulo Yaag, Fagan and Mana Moofi.

No community buildings such as schools, clinics, shops and mosques will be constructed under the main civil works contract; these will be the responsibility of the relevant governmental agencies concerned or as in the case of shops will be undertaken by private enterprise.

A brief description of each type of building to be constructed by the project is given below :-

(a) Management Housing

Sketches of the 3 types of management staff houses are given in Chapter 6 of Annex 5 of the Supplementary Study. The general manager and the deputy general manager are to be accommodated in Type AA houses and the remainder of the senior executive management will have Type A houses. Junior executives will be accommodated in the Type B houses.

(b) Village Housing

A sketch of the proposed layout for the village houses is given in Chapter 6, Annex 5 of the Supplementary Study. The layouts and descriptions of the neighbourhood groups and village wards are as detailed in the Supplementary Study.

(c) Office Block

A sketch showing the layout of the office block is given in Figure 5.2. It has a floor area of 545 m^2 and comprises 16 rooms, a conference room and toilets.

(d) Workshop

The workshop is located adjacent to the surfaced road connecting the project headquarters to the main Gelib-Kismayo road. It has a floor area of 900 m^2 and a concrete hardstanding area of 200 m^2. The layout of the workshop is shown in Figure 5.3.

(e) Stores

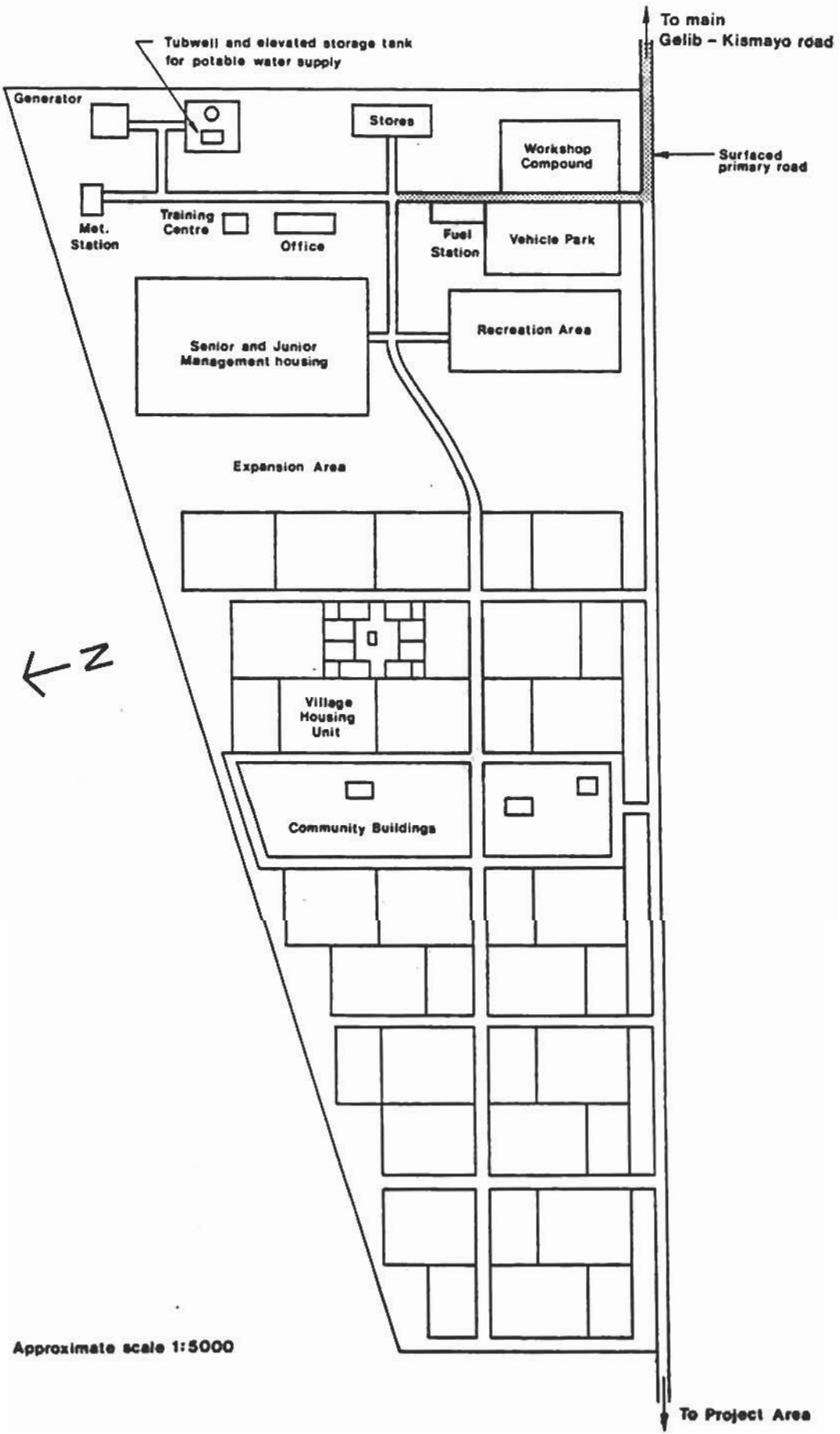
A storage building (size 12 m x 30 m) is required to store seeds, chemicals, timber and other building materials. There will be an office and toilet for the storekeeper and clerk.

(f) Fuel Station Office

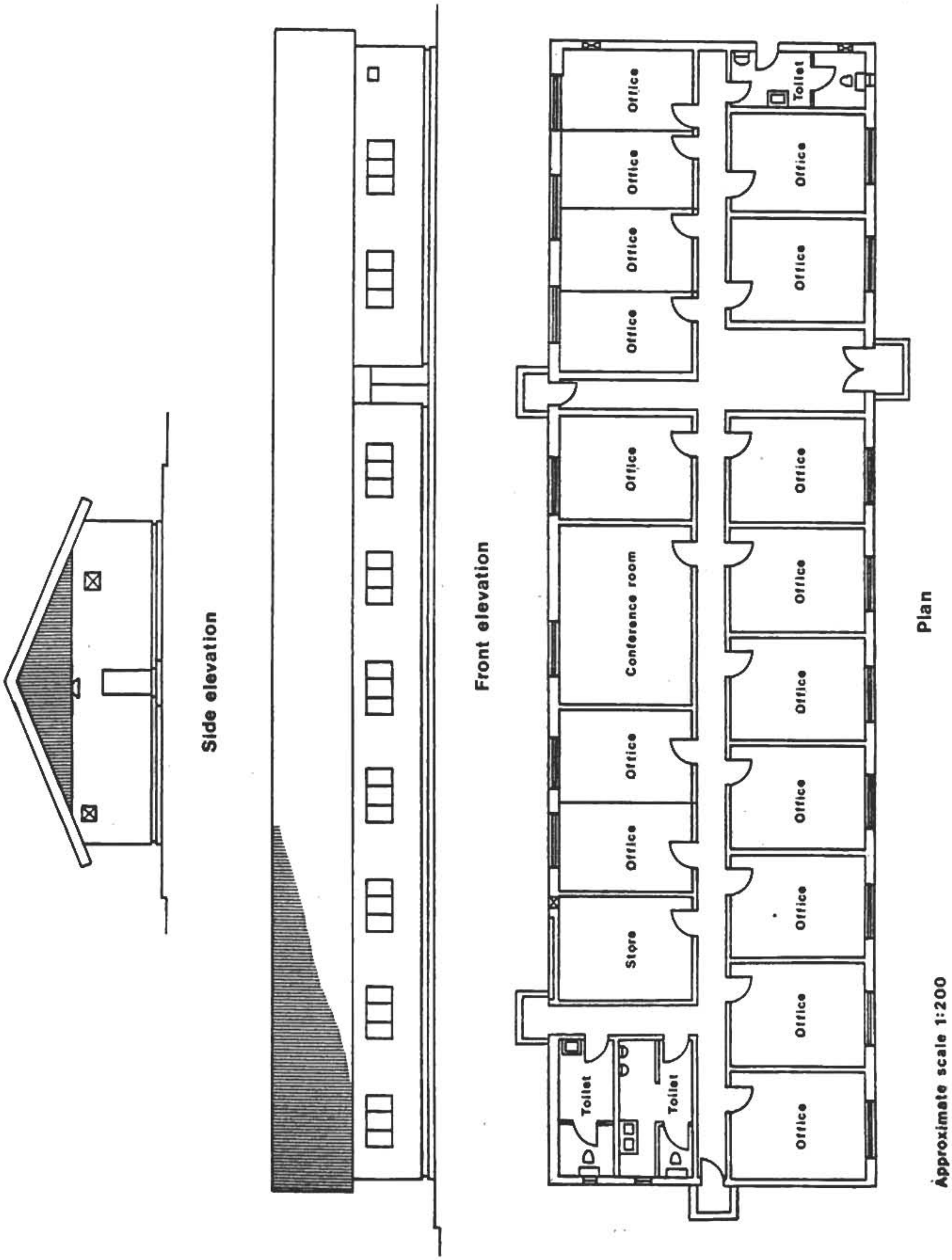
A small office of 30 m^2 floor area is required for the fuel station attendant and clerk. The fuel station yard comprises an area of 300 m^2 and should include a fenced area for storage of fuel and oil drums.

Project headquarters and village

5.1

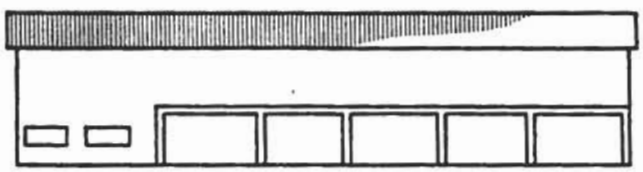


Project headquarters office block

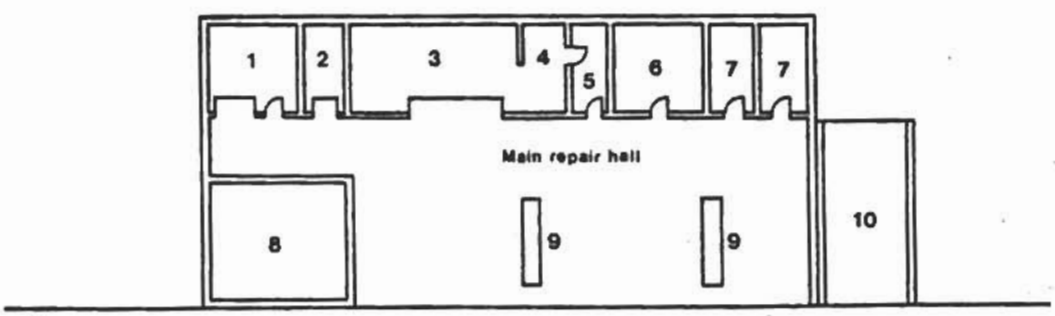


Project headquarters workshop

5.3



Front elevation



Plan

Approximate scale 1:500

Key

1 Tools room
2 Lubrication store
3 Spare parts
4 Storekeeper
5 Store
6 Workshop Managers Office
7 Toilets
8 Repair shop
9 Inspection pits
10 Vehicle washbay & ramp

(g) Training Centre

The proposed design for the training centre is as shown in Chapter 6, Annex 5 of the Supplementary Study. It has a floor area of 200 m^2.

(h) Meteorological Station

The meteorological station will include a rain gauge, anemometer, wet and dry bulb thermometer and an evaporation pan. It will be located in an open area and enclosed by a chain link fence.

(i) Vehicle Park

The vehicle park is situated adjacent to the workshop and has a total concrete hardstanding area of 2 000 m^2 of which 500 m^2 is covered.

5.3 Roads

A good quality bitumen surfaced road already exists on the eastern boundary of the project connecting Gelib to the port of Kismayo; a similar quality road connecting Gelib to Mogadishu is under construction and is due for completion in 1981. These roads will provide the necessary access for transportation of materials and machinery to the project area.

Access within the project area is provided by the following categories of road constructed for the project :-

(a) Surfaced Primary Road

The surfaced primary road is provided to connect the main Gelib-Kismayo road to the project headquarters. Details of its cross-section are as given in the album of drawings for the Supplementary Study. The length of surfaced road for both alternatives is 0.5 km.

(b) Primary Road

The primary road will be a graded earth road with a width of 6.0 m on a minimum embankment height of 0.15 m. It is required to provide access into the project area.

The primary road for alternative A runs from the project headquarters to the main canal and then runs adjacent to the west bank of the main canal. Its approximate length is 7.2 km.

The primary road for alternative B runs from the project headquarters to connect with the access roads which run parallel to the main collector drains. Another section of the primary road for alternative B runs parallel to the main canal to connect the main Gelib-Kismayo road to the access roads running adjacent to drain D1 (see Plate Nr 2). The approximate total length of both sections of primary road is 3.2 km.

(c) Access Roads

The access roads are generally provided on both sides of the drains and will be the main access routes within the project area. They will be formed from material excavated within the drains and will be on embankments with a bank top width of 6 m. The earthwork quantities for the access roads have been estimated from the computer printouts for the drains.

(d) Inspection Roads

The inspection roads are provided on top of main and distributary canal embankments. They are generally for inspection and operation and maintenance of the canals and will not be heavily trafficked. In fact, the use of these roads by general traffic should be discouraged to limit damage to canal banks. Both banks of the main canal have a bank top width of 5 m and thus there will be an inspection road along both banks. There will, however, only be an inspection road on one embankment of the distributary canals, the bank top widths being 4 m and 1 m, respectively.

(e) Unit Roads

The unit roads are graded earth roads at ground level which have a minimum width of 4.5 m.

5.4 Power and Water Supply

5.4.1 Power Supply

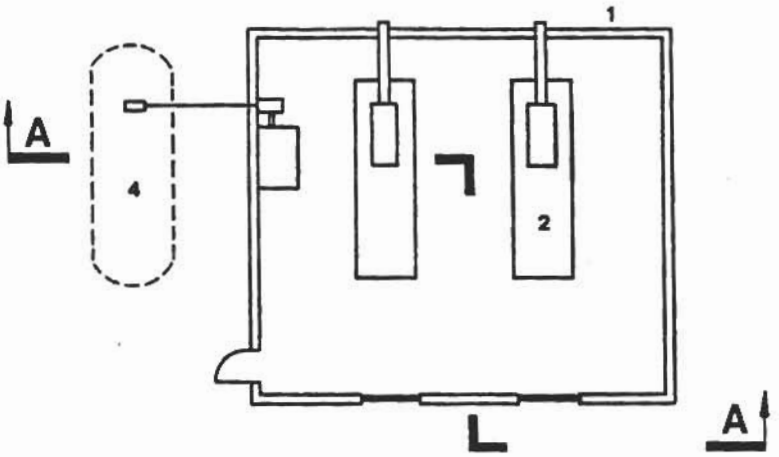
Electric power is required to supply the buildings and the electric pumps for the potable water supply in the project headquarters. Two 400 kVA generators were required for the project headquarters in the Supplementary Study, however the majority of this requirement was for the grain dryer and rice mill. No grain dryer or rice mill has been proposed for this Additional Study and so the power requirements can be greatly reduced. Figure 5.4 shows a suggested layout for the project headquarters generator house that is recommended for both alternatives. Two 100 kVA diesel driven generator sets are required.

5.4.2 Water Supply

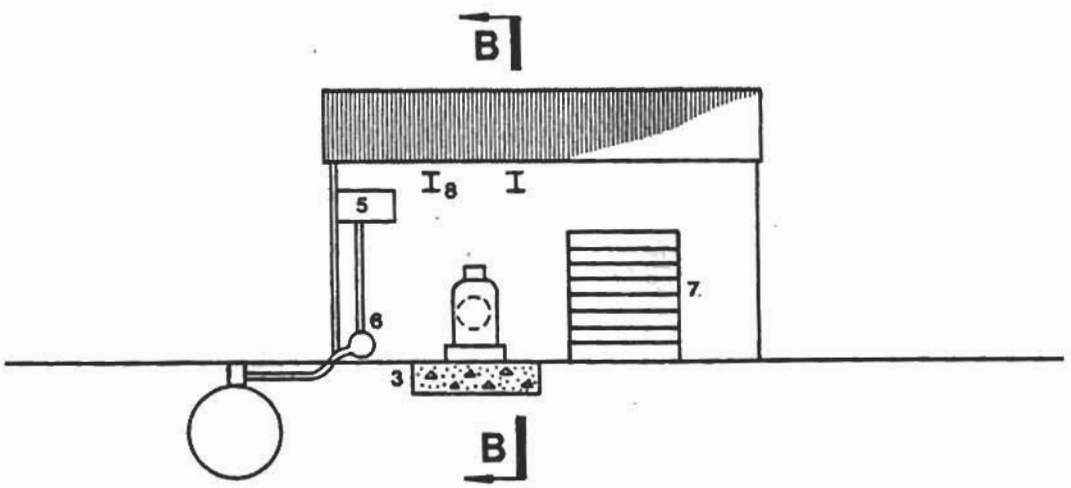
The potable water supply for the project headquarters is as proposed for the project headquarters for the Supplementary Study. The system should supply water to each management house and to each of the 56 neighbourhood groups of the village housing area as well as to all project buildings. One 10 l/s electric submersible pump and one 70 m^3 elevated storage tank are required. The cost estimates have been based on the costs for a system using groundwater, however, the availability of sufficient quantities of potable groundwater must be confirmed by further tests on site.

Project headquarters generator house

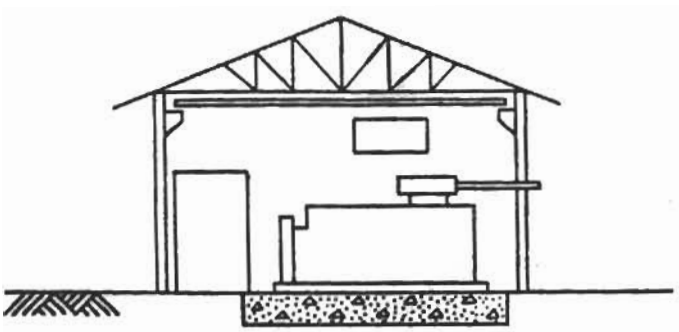
5.4



Plan



Section A-A



Section B-B

Approximate scale 1:150

Key

1 Concrete frame building
2 100 kVA diesel engine & generator
3 Concrete base
4 Fuel storage tank
5 Daily fuel tank
6 Fuel transfer pump
7 Roller shutter door
8 Steel lifting beam

CHAPTER 6

ORGANISATION AND MANAGEMENT

6.1 Form of the Project

Various forms that the project could take were discussed in the Supplementary Study namely :-

(a) A state farm
(b) A farm corporation
(c) A settlement scheme for smallholder tenants
(d) A group farm.

The recommendation for this Additional Study (as for the Supplementary Study) is to adopt a state farm incorporating a strong centralised management. This would have the advantage of providing strict control on the operation of the farm, the timing of agricultural operations, the organisation of agricultural machinery and the type of crops grown.

However, it must be emphasised that a settlement scheme for smallholder tenants provides a greater incentive to work because a farmer has a plot of land which is his by right instead of being part of a large paid labour force.

The engineering designs for this Additional Study have been based on the state farm concept but there is no major feature of the designs which would preclude the development of the project as a settlement scheme. Each farmer could be allocated an area of 2 to 4 ha and groups of farmers could work collectively within an irrigation field unit to perform such tasks as priming and supervising siphon pipes and moving laterals.

The settlement scheme option would still necessitate centralised control of the irrigation system and a pool of agricultural plant. The farmers would have to pay charges for water and for hire of machinery and equipment. They would also purchase the farm inputs (seed, fertiliser etc) from the farm management and market their produce through this management.

To summarise, it is considered that the project should start as a state farm but could change to a settlement scheme if desired at a later date when the organisation of the project had been established.

6.2 Labour Availability

The Supplementary Study discussed the problems of finding the required numbers (peak requirement 2 450) of labourers from the surrounding villages. The labour requirements for this smaller alternative development are much lower and no problems are envisaged. The recommended smaller development (alternative A/2) has an unskilled labour requirement of 420 and a semi-skilled labour requirement of 190. Most of these labourers should be available locally but some of the semi-skilled labourers such as machine operators and ditch riders will have to undergo some basic training.

6.3 Mogambo Farm Organisation

It is proposed that the Mogambo Farm Board be established as described in the Supplementary Study. The board members would represent the Ministries of National Planning, Agriculture, Livestock and Industry and the Juba Valley Development Authority (when established). The chairman of the board would be the General Manager of the Mogambo project (Figure 6.1).

The organisation of the Mogambo state farm at the operational stage once implementation has been completed would be as shown in Figure 6.2. Only one farm manager is required for the smaller alternative development as compared with the four farm managers proposed in the Supplementary Study for the full development.

The farm organisational structure is shown in Figure 6.3. Differences between the structure proposed for this Additional Study (both alternatives) and the structure proposed in the Supplementary Study are given below :-

(a) One farm manager as opposed to four.

(b) No crop processing or seed processing managers are required; this will be carried out by the Agricultural Development Corporation.

(c) No headquarters agriculturalist is required; only an agronomist and a field agriculturalist.

(d) No field inspectors are required.

6.4 Project Staffing

A full list of the project staff requirements is given in Table 6.1, showing the build-up through the implementation phase to the final operational requirements. A description of the key posts is given in Chapter 3, Annex 6 of the Supplementary Study.

It is proposed that some key posts are occupied by suitably qualified expatriates during the implementation stage because suitably experienced persons are unlikely to be available in Somalia at this time. It is intended that after 3 or 4 years these posts will be filled by Somali personnel who have been trained by the expatriate personnel.

Those posts which would initially be filled by expatriate staff are listed in Table 6.2.

TABLE 6.1

Project Staffing (alternatives A and B)

Designation	Grade	Year					Notes
		1	2	3	4	5	
General manager	SE	1	1	1	1	1	
Secretary to general manager	PA	1	1	1	1	1	
Internal auditor	JE	-	1	1	1	1	
Audit clerks	C	-	1	1	1	1	
Chief accountant	SE*	-	1	1	1	-	
Chief accountant	JE	-	-	-	-	1	(i)
Secretary	PA	-	1	1	1	1	
Assistant accountants	JE	-	1	1	1	1	
Accounts clerks	C	-	1	2	3	3	
Administrative manager	SE*	½	1	1	½	-	
Administrative manager	JE	-	-	-	½	1	(i)
Secretary	PA	-	1	1	1	1	
Clerks	C	-	1	1	1	1	
Training officer	JE	-	1	1	2	2	
Personnel manager	JE	½	1	1	1	1	
Secretary	PA	-	1	1	1	1	
Clerks	C	-	1	1	1	1	
Office manager	JE	-	1	1	1	1	
Clerks	C	1	1	2	2	2	
Watchmen	L	2	4	8	8	8	
Drivers	SL	5	8	8	8	8	
Building maintenance	SL	-	1	2	2	2	
Deputy general manager	SE*	½	1	1	1	-	
Deputy general manager	JE	-	-	-	-	1	(i)
Secretary	PA	-	1	1	1	1	
Agronomist	SE*	-	1	1	-	-	
Agronomist	JE	-	1	1	-	-	
Agriculturalist	JE	-	1	1	1	1	
Secretary	PA	-	1	1	1	1	
Stores	T	-	-	1	1	1	
Mechanisation specialist	SE*	-	1	1	-	-	(ii)
Workshop manager	T*	-	1	1	-	-	(iii)
Workshop mechanics/ tradesmen	T	-	5	10	10	10	
Mobile workshop mechanics	T	-	-	2	2	2	
Workshop labour	SL	-	5	10	10	10	
Storekeeper	T	-	1	1	1	1	
Fuel pump attendant	T	-	1	1	1	1	
Clerks	C	-	1	1	1	1	
Irrigation engineer	SE*	-	1	1	-	-	
Irrigation engineer	JE	-	-	-	1	1	(i)

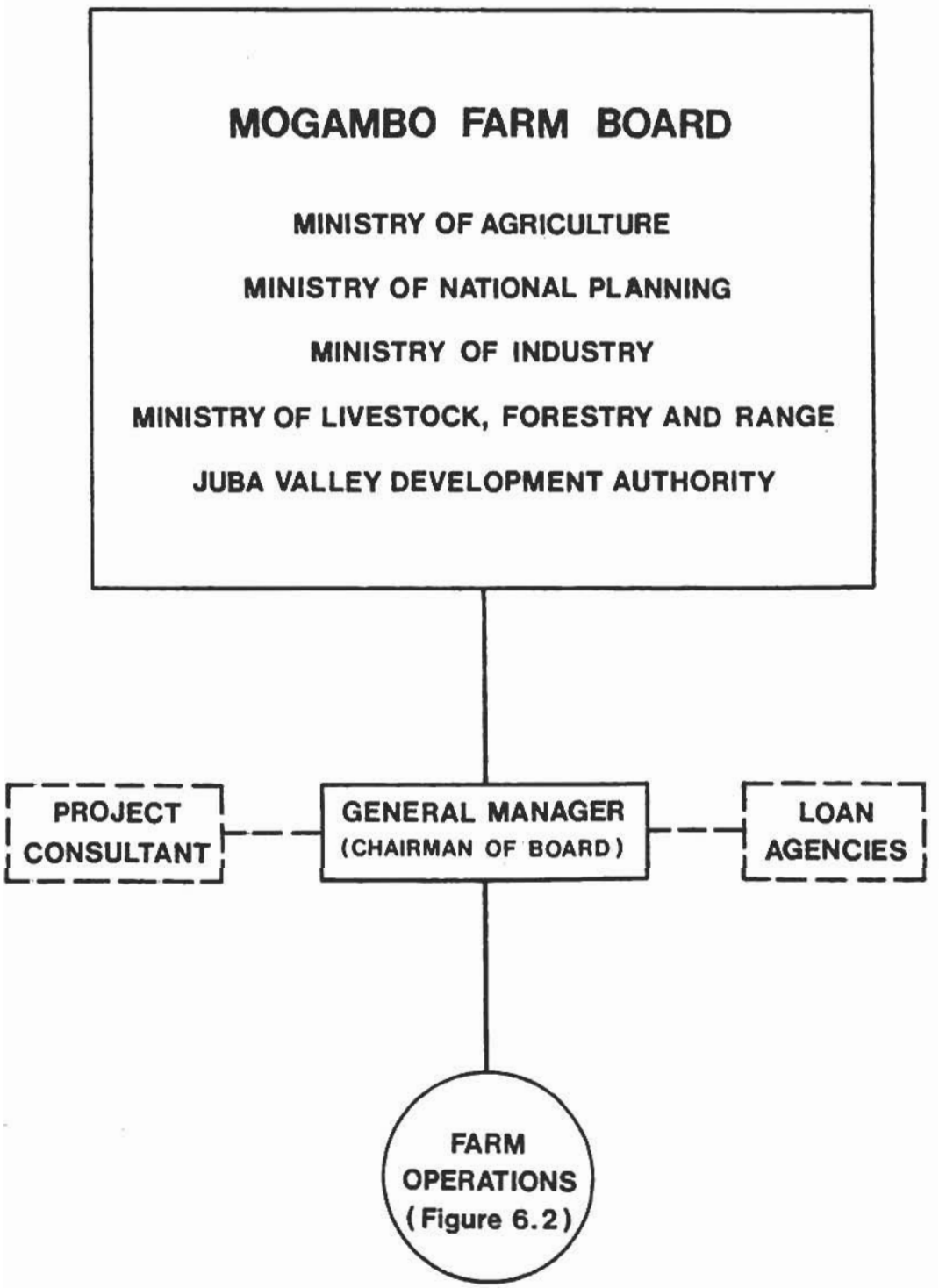
TABLE 6.1 (cont.)

Project Staffing (alternatives A and B)

Designation	Grade	Year					Notes
		1	2	3	4	5	
Surveyor	JE	-	1	1	1	1	
Pump operators	T	-	3	6	8	8	
Pump mechanics	T	-	1	2	2	2	
Canal maintenance foreman	S	-	1	1	1	1	
Canal maintenance labour	L	-	3	6	6	6	
Plant operators	T	-	1	2	3	5	
Assistant operators	T	-	1	2	3	5	
Drivers	SL	-	1	2	3	3	
Clerk	C	-	1	1	1	1	
Power station attendants	T	-	2	2	2	2	
Power station mechanics	T	-	1	2	2	2	
Water treatment works attendant	SL	-	1	1	1	1	
Farm manager	SE*	-	1	1	½	-	
Farm manager	JE	-	-	-	½	1	(i)
Mechanisation supervisor	JE	-	1	1	1	1	
Irrigation supervisor	JE	-	1	1	1	1	
Block supervisors	S	-	2	4	6	6	
Gate operators	SL	-	2	2	2	2	
Storekeeper	T	-	1	1	1	1	
Assistant storekeeper	T	-	1	1	1	1	
Clerks	C	-	2	2	2	2	
Watchmen	L	-	2	4	6	6	
Foreman irrigators	S	-	6	10	17	17	
Ditch riders	T	-	7	10	14	14	
Agricultural and irrigation labour	L	-	79	186	299	365	(iv)
Machinery operators	T	-	23	35	55	65	(iv)

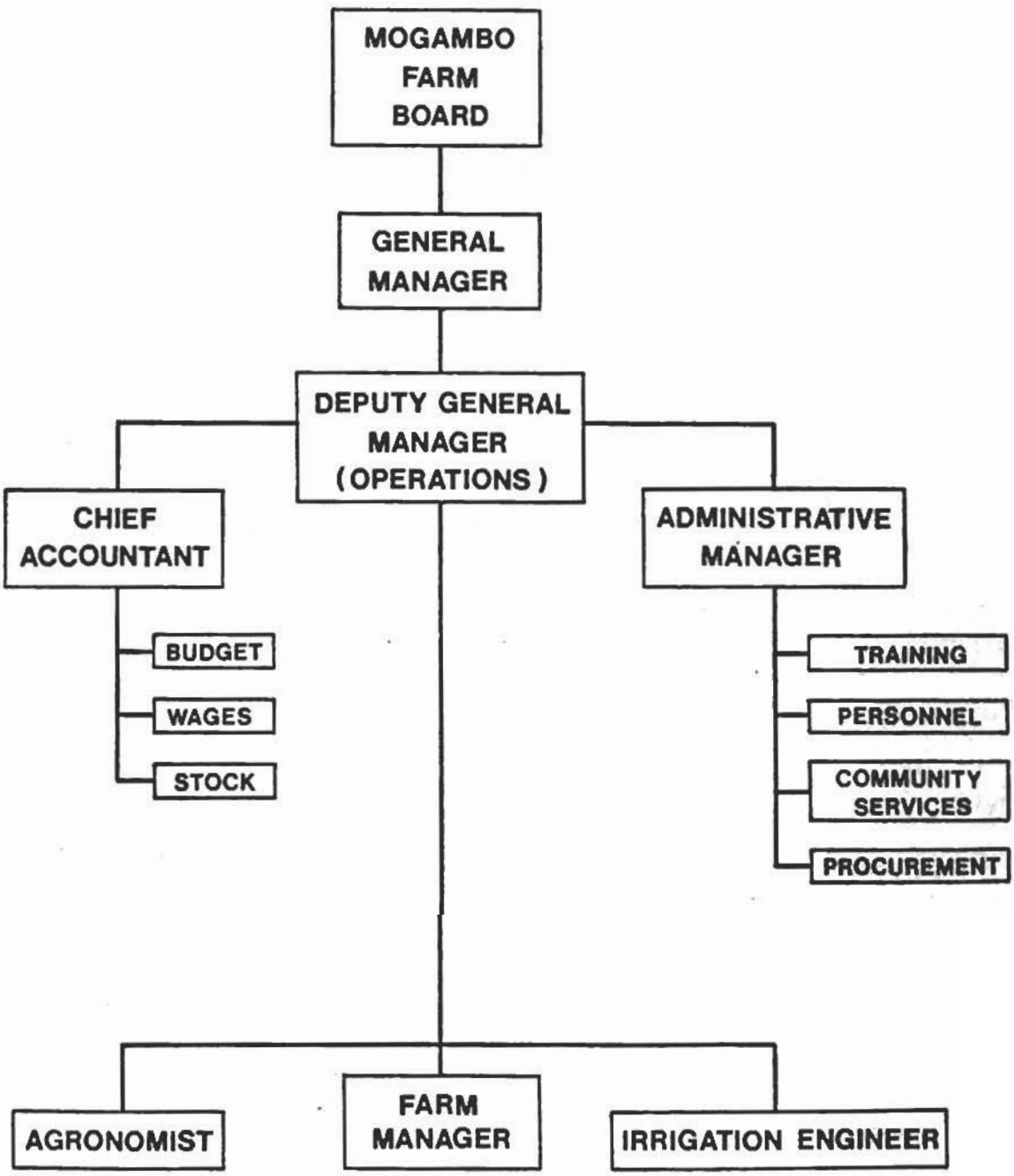
Notes:
- * Indicates expatriate
- (i) Somali replacement for expatriate
- (ii) Mechanisation specialist not replaced
- (iii) Workshop manager replaced by Somali mechanic
- (iv) These numbers are for case A/2
- SE - Senior executive
- JE - Junior executive
- PA - Personal assistant
- C - Clerk
- T - Technician
- S - Supervisor
- SL - Skilled labourer
- L - Labourer

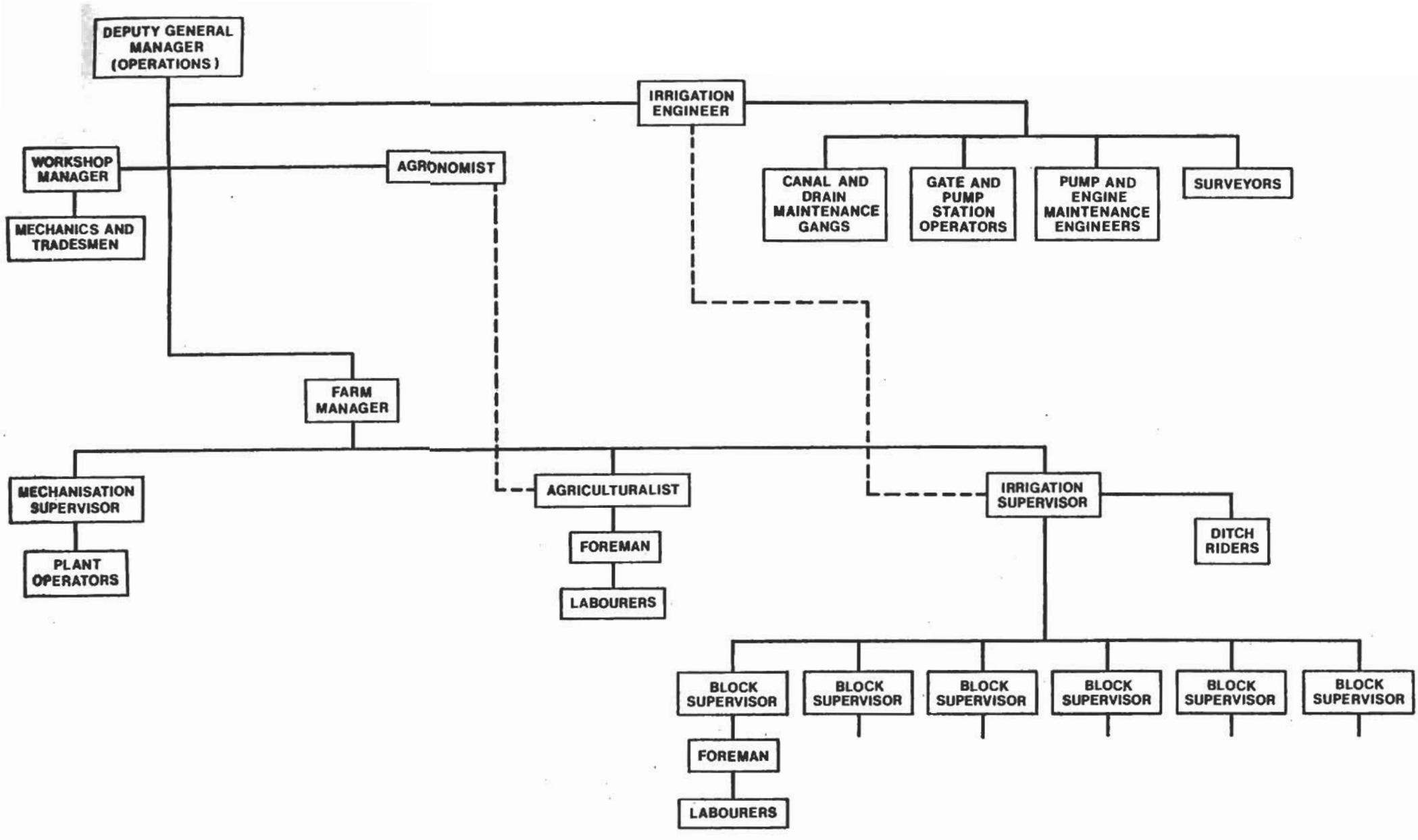
Mogambo Farm Board 6.1



Organisation of Mogambo Farm: Operational stage

6.2





Farm organisational structure

6.3

TABLE 6.2

Expatriate Staff Requirements

Designation	Year				
	1	2	3	4	5
Deputy general manager	½	1	1	1	-
Chief accountant	-	1	1	1	-
Administrative manager	½	1	1	½	-
Agronomist	-	1	1	-	-
Irrigation engineer	-	1	1	-	-
Farm manager	-	1	1	½	-
Mechanisation specialist	-	1	1	-	-
Workshop manager	-	1	1	-	-

6.5 Research

An important aspect of the organisation of the project is the need to set up a research programme to develop the best methods for operation of the overhead irrigation system. Overhead irrigation is fairly new to Somalia and by incorporating a small pilot area within the project area for both alternatives A and B it will be possible to develop the necessary expertise and improve the level and skills. Experiments with day and night irrigation and with different lateral spacings and sprinkler spacings can be carried out. This research will prove very useful when more extensive development of the levee soils occurs and sprinkler irrigation is required.

6.6 Implementation

It is proposed that expatriate management support be provided during the implementation stage and a Project Consultant should be appointed to provide:

(a) co-ordination and advice on all aspects of development of the project;

(b) a project co-ordinator based in Mogadishu who would initially head a small detailed planning team. This team would later move to Mogambo to form the basis of the Project Headquarters Management Team;

(c) a resident engineer and expatriate staff to supervise construction of the Works on site;

(d) expatriate project staff referred to in Section 6.4.

Figure 8.2 shows the relationship of the Project Consultant and expatriate staff to the project management structure during the implementation stage.

CHAPTER 7

ECONOMIC AND FINANCIAL ANALYSIS

7.1 Introduction and Bases for Analysis

The financial and economic analyses have been carried out using the same data and assumptions as in the Supplementary Feasibility Study with the exception of market prices for rice and maize which have been calculated as follows:

The price for rice and maize adopted in the Supplementary Study assumed that dried maize and hulled dried rice was collected by the Agricultural Development Corporation (ADC) at the project site. In this additional study it is assumed that because of the reduced scale of the enterprise, the project will not have any processing, drying or storage facilities, and these will be the responsibility of ADC. The storage and processing costs detailed in Appendix III of the Supplementary Study must therefore be deducted from the farmgate product prices; ADC will itself incur these costs and pass them on to the consumer. The cost adjustment is as follows:-

TABLE 7.1

Maize and Rice Values

		Costs in SoSh	
(a)	Maize	Financial	Economic
	Price per quintal dried and stored	97	120
	Drying and storage costs	0.88	0.73
	Net price (rounded)	96	119
(b)	Rice		
	Price of hulled dried rice per quintal	465	346
	Therefore value of 0.7 quintal hulled and dried (equivalent to 1 quintal of paddy)	325.5	242.2
	Processing costs for 1 quintal of paddy	8.2	6.8
	Therefore value of 1 quintal of paddy (rounded)	317	235

Otherwise the same production cost and price data and methodology have been employed.

7.2 Results of Analysis

Tables 7.2 to 7.5 show the 30 year cash flows, at economic prices, for the four alternatives studied (the supporting data are detailed in Appendices I to V). The IRR for each alternative has been calculated, and the results are as follows:-

Alternative	Cropped area* (ha)	Crops	IRR (economic) %
A/1	2 215	rice, maize, cotton	5.43
A/2	2 215	rice, cotton	8.94
B/1	1 931	rice, maize, cotton	5.27
B/2	1 931	rice, cotton	8.96

Note: * Includes overhead irrigation area

7.3 Selection of Best Alternative

Alternative B was examined in order to see whether a low cost scheme with no provision for further expansion would be significantly more attractive than alternative A. In the particular case of Mogambo, the upstream location of the pump station for alternative A allows some 300 extra hectares to be developed in comparison with alternative B. The additional production from this area offsets over a 30 year period, the additional capital costs of alternative A, with the result that the internal rates of return of alternatives A/1 and A/2 are practically identical to alternatives B/1 and B/2, respectively.

This result is demonstrated in the following table (economic values)

Alternatives	Capital costs (SoSh '000)	Gross margins(1) at full development (SoSh '000)
A/1	122 083	13 856
B/1	100 997	11 797
A/2	119 376	17 078
B/2	99 694	14 725

Note: (1) The value of incremental production less total operating costs.

The difference in capital costs between alternative A/1 and B/1 of some SoSh 21 million is offset in 10 years by the additional returns to A/1.

Thus, there is no economic advantage to be gained by choosing alternative B, and alternative A is recommended on the grounds that future development will be made easier.

Within alternative A, the rice-rice rotation offers clear economic advantages over the rice-maize rotation, and is therefore the recommended option.

Double cropping rice with a fallow period every fourth season should be possible technically. If for some unexpected reason, this rotation does not prove practicable over a period of years, the project can revert to the rice-maize rotation and still be profitable.

TABLE 7.2

Alternative A/1 : 30 Year Cash Flow at Economic Prices (SoSh '000)

Returns	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Value of future agricultural production		-	1261	6381	14747	21396	24546	26739	27517	27517	27517	27517	27517	27517	27517	27517	27517	27517	27517	27517	27517	27517	27517	27517	27517	27517	27517	27517	27517	27517	27517
Value of present production foregone		182	370	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552
Value of incremental production		(182)	891	5829	14195	20844	23994	26187	26965	26965	26965	26965	26965	26965	26965	26965	26965	26965	26965	26965	26965	26965	26965	26965	26965	26965	26965	26965	26965	26965	26965
Operating Costs																															
Agriculture - Inputs		-	447	1916	4082	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196	5196
- Labour		-	1517	2125	2181	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346
- Machinery		73	410	1082	2031	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482	2482
Engineering - Labour		-	536	625	316	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359
- Fuel & oil		4	497	937	1134	1165	1165	1165	1165	1165	1165	1165	1165	1165	1165	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176
- Spare parts & materials		-	134	362	597	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901
Administration - Labour		475	2182	2320	1532	649	649	649	649	649	649	646	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649
Total operating costs		552	5723	9367	11833	13098	13098	13098	13098	13098	13098	13098	13098	13098	13098	13109	13109	13109	13109	13109	13109	13109	13109	13109	13109	13109	13109	13109	13109	13109	13109
Capital & Replacement Costs																															
Agricultural machinery -																															
First purchase		466	4239	3288	4403	2779	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Replacements		-	-	-	-	-	-	1116	2459	4 510	3466	2036	2095	1518	3201	2513	2310	2785	2835	2616	2773	1142	2412	3171	2621	3239	2207	2358	2400	2459	2641
Engineering -																															
Major construction works		13272	32956	21967	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buildings		6196	8670	723	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Services and other		4387	7931	3575	1425	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Replacement items		-	19	36	42	42	93	1498	1303	236	1064	793	3757	2180	330	1669	93	2379	2325	986	432	605	3367	2167	330	211	1115	1699	1693	83	42
Total Capital Costs		24321	53815	29589	5870	2837	93	2614	3762	4746	4530	2829	5852	3698	3531	4182	2403	5164	5160	3602	3205	1747	5779	5338	2951	3450	3322	4057	4093	2542	2683
Total Annual Costs		24873	59538	38956	17703	15935	13191	15712	16860	17844	17628	15927	18950	16796	16629	17291	15512	18273	18269	16711	16314	14856	18888	18447	16060	16559	16431	17166	17202	15651	15792
Net Annual Cash Flow		(25055)	(58647)	(33127)	(5908)	4909	10803	10475	10105	9121	9337	11038	8015	10169	10336	9674	11453	8692	8696	10254	10651	12109	8077	8518	10905	10406	10534	9799	9763	11314	11173
Cumulative Cash Flow		(25055)	(83702)	(116827)	(120337)	(115428)	(104625)	(94150)	(84045)	(74924)	(65587)	(54549)	(46534)	(36365)	(26029)	(16355)	(4902)	3790	12486	22740	33391	45500	53577	62095	73000	83406	93940	103739	113502	124816	135989

TABLE 7.3

Alternative A/2 : 30 Year Cash Flow at Economic Prices (SoSh '000)

Returns	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Value of future agricultural production		-	1887	9168	19082	24796	28223	30285	30729	30729	30729	30729	30729	30729	30729	30729	30729	30729	30729	30729	30729	30729	30729	30729	30729	30729	30729	30729	30729	30729	30729
Value of present production foregone		182	370	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552
Value of incremental production		(182)	1517	8616	18530	24244	27671	29733	30177	30177	30177	30177	30177	30177	30177	30177	30177	30177	30177	30177	30177	30177	30177	30177	30177	30177	30177	30177	30177	30177	30177
Operating Costs																															
Agriculture -	Inputs	-	614	2626	5013	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668	5668
-	Labour	-	1633	1949	2009	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103	2103
-	Machinery	71	308	1136	2005	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243	2243
Engineering -	Labour	-	536	625	316	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359	359
-	Fuel & oil	4	497	937	1134	1165	1165	1165	1165	1165	1165	1165	1165	1165	1165	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176	1176
-	Spare parts & materials	-	134	362	597	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901	901
Administration -	Labour	475	2182	2320	1532	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649
Total operating costs		552	5784	9955	12606	13088	13088	13088	13088	13088	13088	13088	13088	13088	13088	13099	13099	13099	13099	13099	13099	13099	13099	13099	13099	13099	13099	13099	13099	13099	13099
Capital & Replacement Costs																															
Agricultural machinery -																															
First purchase		666	4136	2697	3604	1565	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Replacements		-	-	-	-	-	-	1038	2163	3230	2747	1931	2017	1206	2181	1161	2370	2566	2800	1756	1727	622	2436	2859	1683	2260	2224	1902	2531	1358	1678
Engineering -																															
Major construction works		13272	32956	21967	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buildings		6196	8670	723	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Services and other		4387	7931	3575	1425	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Replacement items		-	19	36	42	42	93	1498	1303	236	1064	793	3757	2180	330	1669	93	2379	2325	986	432	605	3367	2167	330	211	1115	1699	1693	83	42
Total Capital Costs		24321	53712	28998	5071	1623	93	2536	3466	3466	3811	2724	5774	3386	2511	2830	2463	4945	5125	2742	2159	1227	5803	5026	2013	2471	3339	3601	4026	1441	1720
Total Annual Costs		24873	59496	38953	17677	14711	13181	15624	16554	16554	16899	15812	18862	16474	15599	15929	15562	18044	18224	15841	15258	14326	18902	18125	15112	15570	16438	16700	17125	14540	14819
Net Annual Cash Flow		(25055)	(57979)	(30337)	853	9533	14490	14109	13623	13623	13278	14365	11315	13703	14578	14248	14615	12133	11953	14336	14919	15851	11275	12052	15065	14607	13739	13677	13054	15637	15358
Cumulative Cash Flow		(25055)	(83034)	(113371)	(112518)	(102985)	(88495)	(74386)	(60763)	(47140)	(33862)	(19497)	(8182)	5521	20099	34347	48962	61095	73048	87384	102303	118154	129429	141481	156546	171153	184892	198569	211623	227260	242618

TABLE 7.4

Alternative B/1 : 30 Year Cash Flow at Economic Prices (SoSh '000)

Returns	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Value of future agricultural production		-	1025	5756	11613	18510	21295	23186	24138	24138	24138	24138	24138	24138	24138	24138	24138	24138	24138	24138	24138	24138	24138	24138	24138	24138	24138	24138	24138	24138	24138
Value of present production foregone		158	322	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480
Value of incremental production		(158)	703	5276	11133	18030	20815	22706	23658	23658	23658	23658	23658	23658	23648	23658	23658	23658	23658	23658	23658	23658	23658	23658	23658	23658	23658	23658	23658	23658	23658
Operating Costs																															
Agriculture - Inputs		-	361	1727	3155	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559	4559
- Labour		-	1420	1984	1932	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058	2058
- Machinery		73	360	1099	1814	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326
Engineering - Labour		-	537	625	316	359	359	359	359	359	339	339	339	339	339	339	339	339	339	339	339	339	339	339	339	359	359	359	359	359	359
- Fuel & oil		4	452	829	1052	1053	1053	1053	1053	1053	1053	1053	1053	1053	1053	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064	1064
- Spare parts & materials		-	205	346	783	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846
Administration - Labour		475	2128	2320	1532	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649
Total operating costs		552	5517	8930	10584	11850	11850	11850	11850	11850	11850	11850	11850	11850	11850	11861	11861	11861	11861	11861	11861	11861	11861	11861	11861	11861	11861	11861	11861	11861	11861
Capital & Replacement Costs																															
Agricultural machinery -																															
First purchase		466	4036	3035	2941	2220	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Replacements		-	-	-	-	-	-	1116	2334	3724	2703	1546	2017	1482	2508	1836	2037	2686	2244	2048	2187	925	2031	3036	2052	2188	2082	2141	2097	1791	2181
Engineering -																															
Major construction works		11194	25252	15215	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buildings		5311	7649	2774	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Services and other		3951	6817	3105	1425	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Replacement items		-	-	12	12	33	423	1062	1478	227	1055	1884	2473	2675	321	1660	423	1943	2500	977	423	1696	2083	2662	321	202	1445	1263	1868	74	33
Total Capital Costs		20922	43554	24141	4378	2269	423	2178	3812	3951	3758	3230	4490	4157	2829	3496	2430	4629	4744	3025	2610	2621	4114	5698	2373	2390	3527	3404	3965	1865	2214
Total Annual Costs		21474	49071	33071	14962	14119	12273	14028	15662	15801	15608	15080	16340	16007	14679	15357	14291	16490	16605	14886	14471	14482	15975	17559	14234	14251	15388	15265	15826	13726	14075
Net Annual Cash Flow		(21632)	(48368)	(27795)	(3829)	3911	8542	8678	7996	7857	8050	8578	7318	7651	8979	8301	9367	7168	7053	8772	9187	9176	7683	6099	9424	9407	8270	8393	7832	9932	9583
Cumulative Cash Flow		(21632)	(69520)	(97315)	(101144)	(97233)	(88691)	(80013)	(72017)	(64160)	(56110)	(47532)	(40214)	(32563)	(23584)	(15283)	(5916)	1252	8305	17077	26264	35440	43123	49222	58646	68053	76323	84716	92548	102480	112063

TABLE 7.5

Alternative B/2 : 30 Year Cash Flow at Economic Prices (SoSh '000)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Returns																														
Value of fut-ure agricultural production	-	1573	9246	16792	21987	25075	26661	27105	27105	27105	27105	27105	27105	27105	27105	27105	27105	27105	27105	27105	27105	27105	27105	27105	27105	27105	27105	27105	27105	27105
Value of prevent production foregone	150	322	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480
Value of incremental production	(150)	1251	8766	16312	21507	24595	26181	26625	26625	26625	26625	26625	26625	26625	26625	26625	26625	26625	26625	26625	26625	26625	26625	26625	26625	26625	26625	26625	26625	26625
Operating Costs																														
Agriculture - Inputs	-	508	2680	4344	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999	4999
- Labour	-	1380	1924	1934	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961	1961
- Machinery	33	371	1170	1783	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022
Engineering - Labour	-	537	625	516	359	359	359	359	359	359	359	359	359	359	359	1086	1086	1086	1086	1086	1086	1086	1086	1086	1086	1086	1086	1086	1086	1086
- Fuel & oil	4	452	829	1052	1053	1053	1053	1053	1053	1053	1053	1053	1053	1053	1053	1086	1086	1086	1086	1086	1086	1086	1086	1086	1086	1086	1086	1086	1086	1086
- Spare parts & materials	-	205	346	383	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846	846
Administration - Labour	475	2182	2320	1532	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649	649
Total operating costs	552	5635	9874	11744	11889	11889	11889	11889	11889	11889	11889	11889	11889	11889	11900	11900	11900	11900	11900	11900	11900	11900	11900	11900	11900	11900	11900	11900	11900	11900
Capital & Replacement Costs																														
Agricultural machinery -																														
First purchase	466	4136	2697	3109	987	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Replacements	-	-	-	-	-	-	1038	2163	3230	2342	1955	1427	1206	2128	1135	1965	2605	2764	1165	1727	622	2032	2897	1630	2198	1633	1462	1927	1997	1628
Engineering -																														
Major construction works	11194	25252	15215	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buildings	5311	2469	2774	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Services and other	3951	6817	5105	1425	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Replacement items	-	-	12	12	33	423	1062	1478	227	1055	1884	2473	2675	321	1660	423	1943	2500	977	423	1696	2083	2662	321	202	1445	1263	1868	74	33
Total Capital Costs	20922	43650	23803	4546	1036	423	2100	3641	3457	3397	3817	3900	3881	2449	2795	2388	4548	5264	2142	2150	2318	4115	5559	1951	2400	3078	2725	3795	1671	1711
Total Annual Costs	21474	49289	33677	16290	12925	12312	13989	15530	15346	15286	15706	15789	15770	14338	14695	14288	16448	17164	14042	14050	14218	16015	17459	13851	14300	14978	14605	15695	13571	13611
Net Annual Cash Flow	(21632)	(68058)	(29911)	22	8582	12283	12192	11095	11279	11139	10919	10836	10855	12287	11930	12537	10177	9461	12583	12575	12607	10610	9164	12774	12325	11647	12020	10930	13254	13014
Cumulative Cash Flow	(21632)	(69670)	(99581)	(99559)	(89977)	(73694)	(61502)	(50407)	(39128)	(27989)	(16830)	(6034)	4821	17108	29038	41575	51752	61013	73596	86171	98578	109188	118354	131128	143453	155100	167120	178050	191304	204318

Section 4.7 discussed the possibilities for future expansion for both alternatives A and B. The estimated construction costs for the full development based on alternative A as the first phase are about SoSh 285 million, whereas those based on the designs for alternative B as the first phase are about SoSh 301 million. The latter costs are higher because three main pump stations are required as opposed to one. Alternative A is thus recommended as the preferred option.

Summaries of the capital costs and operating costs for the recommended alternative, A/2, are given in Tables 7.6 and 7.7, respectively.

TABLE 7.6

Summary of Capital Costs for Alternative A/2
(SoSh '000)

Item	Local currency	Foreign currency	Total	
Land preparation	6 415	6 414	12 829	(13 471)
Irrigation and drainage system	22 685	31 745	54 430	(60 525)
Buildings and services	5 598	11 360	16 958	(20 349)
Operation and maintenance vehicles and machinery	500	4 505	5 005	(5 756)
Agricultural machinery	1 247	11 221	12 468	(12 468)
Engineering design and supervision of construction	3 242	6 022	9 264	(10 653)
Physical contingencies	2 948	5 474	8 422	(9 431)
Total	42 635	76 741	119 376	(132 653)

Note: Costs are 1979 economic costs and do not include taxes or duties. Financial costs are shown in parenthesis.

TABLE 7.7

Summary of Operating Costs for Alternative A/2
(SoSh '000)

Item	Total cost for 30 years project life
Replacement of agricultural items	48 246
Replacement of engineering items	30 589
Agricultural inputs	155 621
Project staff	94 263
Fuel, oil and spares	119 477
Total	448 196

Note: Costs are 1979 economic costs.

TABLE 7.8

Alternative A/2 : 30 Year Cash Flow at Financial Prices (SoSh '000)

Returns	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Value of future agricultural production		-	2271	12001	25282	32876	37498	40280	40879	40879	40879	40879	40879	40879	40879	40879	40879	40879	40879	40879	40879	40879	40879	40879	40879	40879	40879	40879	40879	40879	40879
Value of present production foregone		146	297	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443
Value of incremental production		(146)	1974	11558	24839	32433	37055	39837	40436	40436	40436	40436	40436	40436	40436	40436	40436	40436	40436	40436	40436	40436	40436	40436	40436	40436	40436	40436	40436	40436	40436
Operating Costs																															
Agriculture - Inputs		-	641	2718	5182	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858	5858
- Labour		-	1531	2182	2382	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559	2559
- Machinery		88	437	1256	2206	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467	2467
Engineering - Labour		-	540	633	324	367	367	367	367	367	367	367	367	367	367	367	367	367	367	367	367	367	367	367	367	367	367	367	367	367	367
- Fuel & oil		6	706	1331	1610	1654	1654	1654	1654	1654	1654	1654	1654	1654	1654	1670	1670	1670	1670	1670	1670	1670	1670	1670	1670	1670	1670	1670	1670	1670	1670
- Spare parts & materials		-	147	398	657	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991	991
Administration - Labour		478	2187	2330	1542	659	659	659	659	659	659	659	659	659	659	659	659	659	659	659	659	659	659	659	659	659	659	659	659	659	659
Total operating costs		572	6189	10848	13703	14555	14555	14555	14555	14555	14555	14555	14555	14555	14555	14571	14571	14571	14571	14571	14571	14571	14571	14571	14571	14571	14571	14571	14571	14571	14571
Capital & Replacement Costs																															
Agricultural machinery - First purchase		466	4136	2697	3604	1565	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Replacements		-	-	-	-	-	-	1038	2163	3230	2767	1931	2017	1206	2181	1161	2370	2566	2800	1756	1727	622	2636	2859	1685	2260	2224	1902	2531	1358	1678
Engineering - Major construction works		14866	36094	24108	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buildings		2604	10361	864	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Services and other		5191	9184	4132	1639	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Replacement items		-	22	41	48	48	107	1723	3499	272	1223	912	4320	2507	379	1919	107	2776	2674	1134	497	696	3872	2692	579	143	1282	1954	1968	95	48
Total Capital Costs		27927	59797	31842	5291	1631	107	2761	5662	3502	3990	2843	6336	3713	2560	3080	2477	5302	5474	2890	2224	1318	6508	5551	2262	2403	3506	3856	4279	1453	1726
Total Annual Costs		28499	65986	42690	19194	16186	14662	17316	18217	18057	18525	17398	20891	18268	17115	17651	17048	19873	20045	17461	16795	15889	20879	19922	16633	16974	18077	18427	18850	16026	16297
Net Annual Cash Flow		(28868)	(65440)	(32060)	5645	16247	22393	22521	22219	22379	21911	23038	19545	22168	23321	22785	23388	20563	20391	22975	23641	24547	19557	20514	23803	23462	22359	22009	21586	24412	24139
Cumulative Cash Flow		(28868)	(94308)	(126368)	(120723)	(104476)	(82083)	(59562)	(37343)	(14964)	6947	29985	49530	71698	95019	117804	141192	161755	182146	205121	228762	253309	272866	293380	317183	340645	363004	385013	406599	431011	455150

TABLE 7.9

Alternative A/2 : 30 Year Foreign Exchange Cash Flows (SoSh '000)

Returns	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Value of future agricultural production		-	1824	8291	13078	22178	25196	27013	27404	27404	27404	27404	27404	27404	27404	27404	27404	27404	27404	27404	27404	27404	27404	27404	27404	27404	27404	27404	27404	27404	27404
Value of present production foregone		176	358	534	534	534	534	534	534	534	534	534	534	534	534	534	534	534	534	534	534	534	534	534	534	534	534	534	534	534	534
Value of incremental production		(176)	1466	7757	16544	21644	24662	26479	26870	26870	26870	26870	26870	26870	26870	26870	26870	26870	26870	26870	26870	26870	26870	26870	26870	26870	26870	26870	26870	26870	26870
Operating Costs																															
Agriculture	- Inputs	-	450	1695	3171	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577	3577
	- Labour	-	532	532	133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Machinery	66	349	1022	1805	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019
Engineering	- Labour	-	266	266	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- Fuel & oil	4	667	863	1021	1049	1049	1049	1049	1049	1049	1049	1049	1049	1049	1058	1058	1058	1058	1058	1058	1058	1058	1058	1058	1058	1058	1058	1058	1058	1058
	- Spare parts & materials	-	121	326	537	811	811	811	811	811	811	811	811	811	811	811	811	811	811	811	811	811	811	811	811	811	811	811	811	811	811
Administration	- Labour	266	1239	1239	665	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total operating costs		336	3604	5923	7332	7456	7456	7456	7456	7456	7456	7456	7456	7456	7456	7467	7467	7467	7467	7467	7467	7467	7467	7467	7467	7467	7467	7467	7467	7467	7467
Capital & Replacement Costs																															
Agricultural machinery -																															
First purchase		419	3722	2427	3244	1409	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Replacements		-	-	-	-	-	-	934	1947	2907	2672	1738	1815	1085	1963	1045	2133	2309	2520	1580	1554	560	2192	2573	1515	2034	2002	1712	2098	1222	1510
Engineering -																															
Major construction works		9256	20614	12105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buildings		4027	5636	470	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Services and other		2987	3636	1697	1283	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Replacement items		-	17	32	38	38	84	1348	1173	212	958	714	3381	1962	297	1502	84	2141	2093	887	384	565	3030	1950	297	190	1004	1529	1524	75	38
Total Capital Costs		16689	33625	16731	4565	1461	84	2282	3120	3119	3630	2452	5196	3047	2260	2547	2217	4450	4613	2467	1938	1105	5222	4523	1812	2224	3006	3241	3622	1297	1548
Total Annual Costs		17025	37029	22654	11897	8917	7540	9738	10576	10575	10886	9908	12652	10503	9716	10014	9684	11917	12080	9934	9405	8572	12689	11990	9279	9691	10473	10708	11089	8764	9015
Net Annual FE Flow		(17201)	(35563)	(14897)	4647	12727	17122	16741	16294	16295	15984	16962	14218	16367	17154	16856	17186	14953	14790	16936	17465	18298	14181	14880	17591	17179	16197	16162	15781	18106	17855

7.4 Financial Results and Foreign Exchange Flows

Table 7.8 presents the projected 30 year cash flow for alternative A/2 assuming financial values derived as detailed in Appendix VI. The internal financial rate of return has been calculated at 13.45%. This substantial increase over the economic return is due to the higher financial price for rice. (Financial = SoSh 317 per quintal, economic = SoSh 235 per quintal.)

The foreign exchange flows are listed in Table 7.9. Considering these flows only, the project has an economic rate of return of 17.41%, i.e. considerably more foreign exchange is saved by agricultural production than is spent in capital and operating costs.

7.5 Economic Indicators

Table 7.10 lists the results for the calculation of various economic indicators, as defined in Chapter 8, Annex 7 of the Supplementary Study. The Somali Development Bank charges 6% interest on long term loans to agriculture, therefore this rate has been used to calculate the economic indicators.

TABLE 7.10

Economic Indicators for Alternative A/2, Assuming Economic Values

Break even point	Year 13
Benefit stream discounted at 6% (SoSh '000)	327 391
Cost stream discounted at 6% (SoSh '000)	288 846
Benefit/cost ratio	1.15
Net present worth at 6% interest (SoSh '000)	38 545
30 year non-discounted value added (SoSh '000)	242 418
30 year non-discounted foreign exchange savings (SoSh '000)	361 466

7.6 Sensitivity Analyses

Table 7.11 presents a range of sensitivity analyses similar to those in the Supplementary Study.

TABLE 7.11

IRR of Alternative A/2 under Various Assumptions

	IRR %
1. Economic values - Table 7.3	8.94
2. Financial values - Table 7.8	13.45
3. Foreign exchange flows - Table 7.9	17.41
4. As 1, but foreign exchange upvalued by 50%	11.17
5. As 1, but capital costs increased by 20%	6.00
6. As 1, but operating costs increased by 20%	6.54
7. As 1, but output decreased by 20%	3.50
8. As 1, but output delayed 2 years	5.50
9. As 1, but all costs up 20% and output decreased by 10%	1.94
10. As 1, but all costs decreased by 10%	11.45
11. As 1, but output increased by 10%	11.22
12. As 1, but all costs decreased by 10% and output increased 10%	13.74

7.7 Conclusions

The selected alternative, A/2, can be considered both economically and financially viable. The respective IRR's are 8.94% and 13.45% and with the Somali Shilling priced at its true open market value the economic IRR rises to 11.17%.

Increasing either capital or operating costs in real terms by 20% drops the economic IRR to around 6% and a 20% reduction in output reduces it to 3.5%. Thus, the economic viability of the project is reasonably resilient to adverse circumstances; even the worst case considered likely, in which all costs rise by 20% and returns drop by 10%, still results in a positive economic IRR of some 2%.

Cost decreases or output increases of 10% raise the economic IRR to over 11%, and a combination of the two circumstances lifts it to 13.74%.

The project generates substantially more foreign exchange than it costs, which is an important consideration in view of the national balance of payments situation.

CHAPTER 8

IMPLEMENTATION

8.1 Introduction

The recommended smaller project development is alternative A/2 comprising of 2 052 ha of surface irrigated rice with an annual intensity of 150% and 163 ha of overhead irrigated cotton. This is the recommended alternative because of its high internal rate of return and minimum cost for future expansion.

The implementation of a complete project such as the Mogambo irrigation project normally involves three separate parties:-

(a) the Project Authority

(b) the Project Consultant

(c) the Contractor executing the works.

The Project Consultant may be assisted by sub-consultants and other specialists. There may well be more than one contractor as well as others participating in the execution of the works.

Implementation concerns the organisation of three basic activities:-

(a) Setting up the Project Authority's organisation which will ultimately operate and maintain the project.

(b) The engineering construction

(c) The agricultural planning and execution.

The project objective is a fully operational state farm and in order to achieve this it is essential that all three organisational activities grow together. This requires the development and bringing into production of part of the area as soon as possible so that early opportunities for training staff and operational experience are provided. Thereafter, there must be progressive development to ensure that shortly after completion of the engineering works, the whole project area is under production and taken over by the Authority's organisation. Adopting this procedure will help to ensure an early return on the large capital investment.

8.2 Programme

A complete programme for the implementation of the works is shown in Figure 8.1. This incorporates the following activities:-

(a) Establishment of the Project Authority.

(b) Design and construction of the civil engineering, building and infrastructure works.

(c) Procurement of:-

(i) maintenance plant, equipment and materials

(ii) farm machinery and equipment

(iii) seed, fertiliser, spray chemicals, etc.

(d) Agricultural planning and execution, and training of personnel.

Tables 8.1, 8.2, 8.3, and 8.4 show a provisional programme for the progressive agricultural development of the project area.

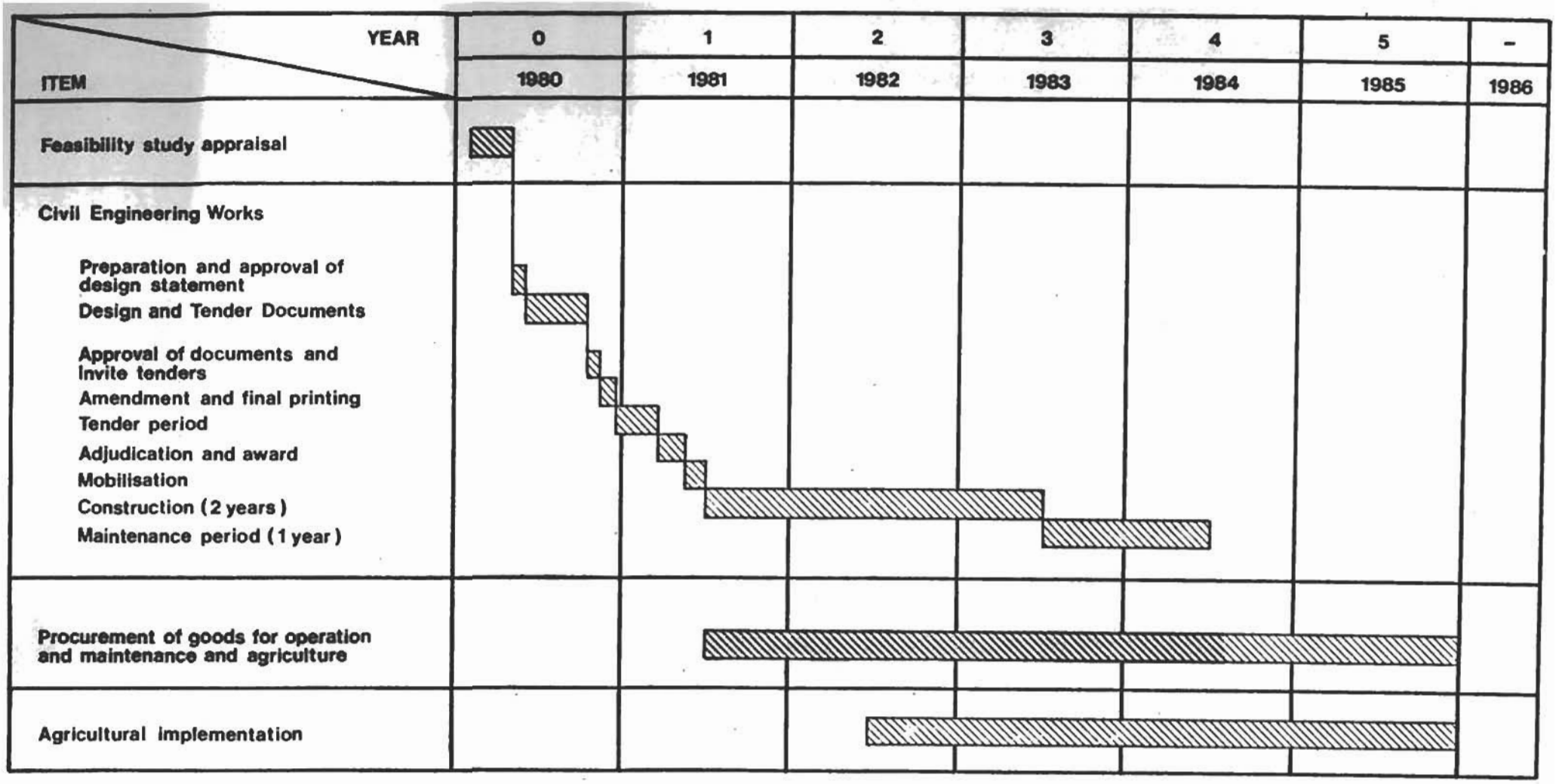
8.3 Method of Implementation

The method of implementation discussed in the Supplementary Study report generally applies to this smaller development.

The chief difference in undertaking the smaller development is the shorter construction period which will require a high standard of construction management.

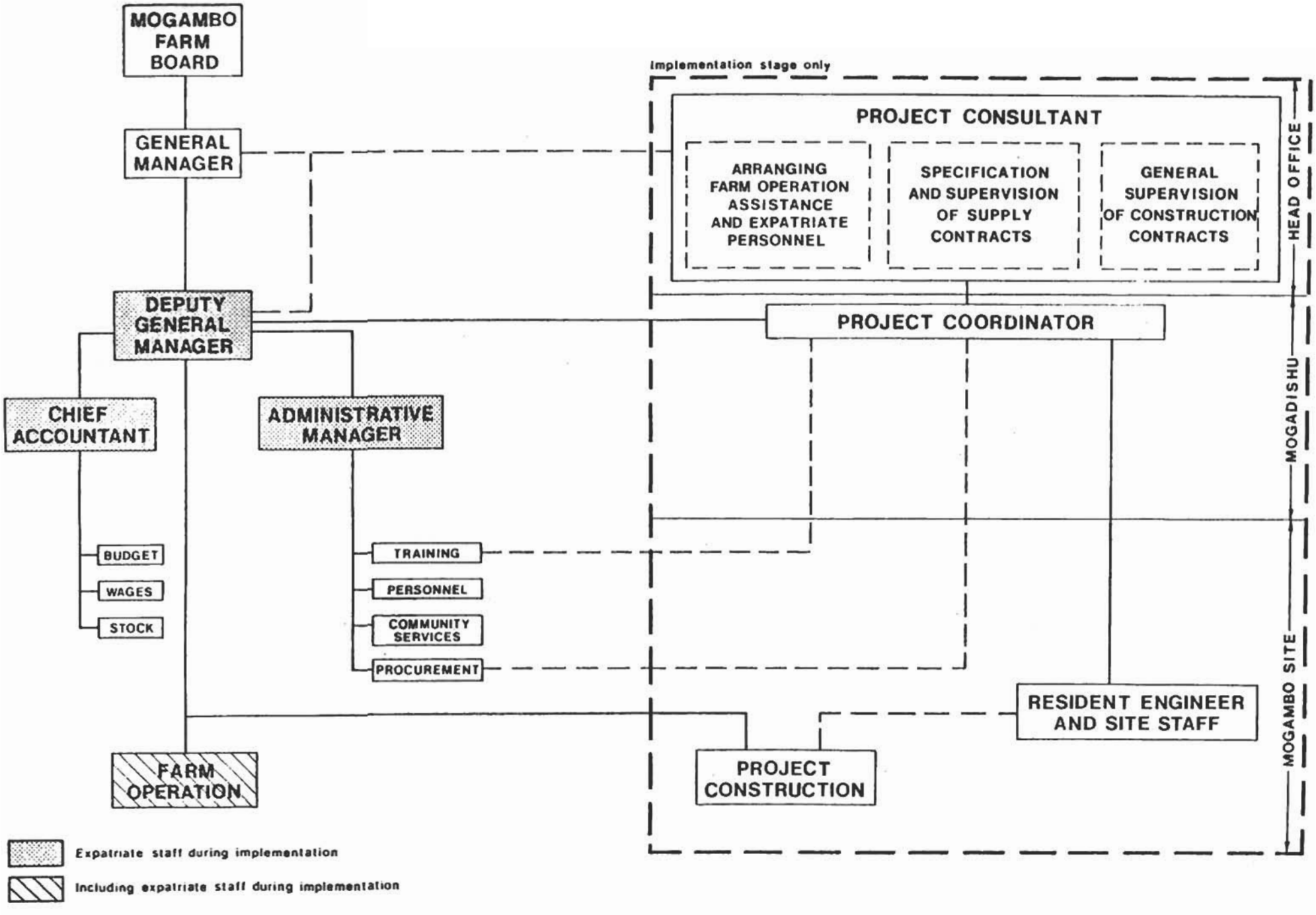
The works should be undertaken either by an International contractor or by a Somali contractor in association with an expatriate management construction team provided by an International contractor or similar organisation.

The organisation structure during the implementation stage is shown in Figure 8.2.



Project implementation programme

8.1



Mogambo state farm organisation : Implementation stage 8.2

TABLE 8.1

Alternative A - Crop Rotation 1

Command	Net area (ha)	1981			1982		1983		1984		1985
		Construction					Maintenance Period				
M1/C1	216	-	-	-	maize	rice	maize	rice	fallow	rice	maize
M1/C3	243	-	-	-	-	rice	maize	rice	maize	rice	fallow
M1/C4	459	-	-	-	-	-	maize	rice	fallow	rice	maize
M1/C6	243	-	-	-	-	-	-	rice	maize	rice	maize
M2/C1	270	-	-	-	-	-	-	rice	maize	rice	maize
M2/C2	270	-	-	-	-	-	-	-	maize	rice	maize
M2/C4	351	-	-	-	-	-	-	-	maize	rice	fallow
P1	163	-	-	-	cotton	-	cotton	-	cotton	-	cotton
Rice		-	-	-	-	459	-	1 431	-	2 052	-
Maize		-	-	-	216	-	918	-	1 377	-	1 458
Cotton		-	-	-	163	-	163	-	163	-	163

In subsequent years, 2 052 ha rice in the gu season and 1 485 ha maize in the der season plus 163 ha cotton in the der season

TABLE 8.2

Alternative A - Crop Rotation 2

Command	Net area (ha)	1981			1982		1983		1984		1985
		Construction					Maintenance Period				
M1/C1	216	-	-	-	rice	rice	rice	fallow	rice	rice	rice
M1/C3	243	-	-	-	-	rice	rice	rice	fallow	rice	rice
M1/C4	459	-	-	-	-	-	rice	rice	rice	fallow	rice
M1/C6	243	-	-	-	-	-	-	rice	rice	rice	fallow
M2/C1	270	-	-	-	-	-	-	rice	fallow	rice	rice
M2/C2	270	-	-	-	-	-	-	-	rice	rice	fallow
M2/C4	351	-	-	-	-	-	-	-	rice	rice	rice
P1	163	-	-	-	cotton	-	cotton	-	cotton	-	cotton
Rice		-	-	-	216	459	918	1 215	1 539	1 593	1 539
Cotton		-	-	-	163	-	163	-	163	-	163

In subsequent years assume average of 75% surface area cropped in any season = 1 539 ha rice plus 163 ha cotton in der season.

TABLE 8.3

Alternative B - Crop Rotation 1

Command	Net area (ha)	1981		1982		1983		1984		1985	
		Construction				Maintenance Period					
C1 u/s end	270	-	-	-	-	rice	maize	rice	fallow	rice	maize
C1 d/s end	324	-	-	-	-	-	maize	rice	maize	rice	fallow
C2	189	-	-	-	maize	rice	maize	fallow	maize	rice	fallow
C3 (excl.C3/2)	405	-	-	-	-	-	-	rice	maize	rice	maize
C3/2	243	-	-	-	-	-	-	-	-	rice	maize
C4	378	-	-	-	-	-	-	-	maize	rice	maize
P1	122	-	-	-	cotton	-	cotton	-	cotton	-	cotton
Rice		-	-	-	-	459	-	999	-	1 809	-
Maize		-	-	-	189	-	783	-	1 296	-	1 296
Cotton		-	-	-	122	-	122	-	122	-	122

In subsequent years 1 809 ha rice in the gu season and 1 296 ha maize in the der season plus 122 ha cotton in the der season.

TABLE 8.4

Alternative B - Crop Rotation 2

Command	Net area (ha)	1981			1982		1983		1984		1985
		Construction					Maintenance Period				
C1 u/s end	270	-	-	-	-	rice	rice	rice	fallow	rice	rice
C1 d/s end	324	-	-	-	-	-	rice	rice	fallow	rice	rice
C2	189	-	-	-	ri ce	rice	fallow	rice	rice	rice	fallow
C3 (excl.C3/2)	405	-	-	-	-	-	-	rice	rice	fallow	rice
C3/2	243	-	-	-	-	-	-	-	rice	rice	fallow
C4	378	-	-	-	-	-	rice	fallow	rice	rice	rice
P1	122	-	-	-	cotton	-	cotton	-	cotton	-	cotton
Rice		-	-	-	189	459	972	1 188	1 215	1 404	1 377
Cotton		-	-	-	122	-	122	-	122	-	122

In subsequent years 1 377 ha rice each season; 122 ha cotton in der season

APPENDIX I

DATA COMMON TO ALL ALTERNATIVES

APPENDIX I

DATA COMMON TO ALL ALTERNATIVES

1. Value of Present Production

The gross area of 2 700 ha in alternative A contains approximately half of the farms located within the 7 500 ha gross of the Supplementary Study. The value of present production for alternative A has been taken as half that in the Supplementary Study. The value for alternative B (gross area 2 350 ha) has been reduced in proportion, as follows:-

Alternative	Gross area (ha)	Value foregone (SoSh '000)		
		Yr 1	Yr 2	Yr 3 onwards
A	2 700	182	370	552
B	2 350	158	322	480

2. Engineering Labour

The engineering and irrigation labour costs have been recalculated and have proven to be very similar for all cases (irrigation casual labour is included in the agricultural costs, not in this section). For simplicity all cases use the same values.

Table I-1 shows the cost details.

3. Administration and Overhead Labour Costs

These have been recalculated and are shown in Table I-2.

4. Non-attributable Capital Costs

As in the Supplementary Study, the capital cost of the flood relief channel and associated siphon has been excluded from the analyses since this structure will benefit other downstream farmers.

TABLE I - 1

Engineering/Irrigation Labour Costs

Rate (SoSh/Year)	Grade	Numbers/year				
		Year 1	2	3	4	5 onwards
380 000	Senior executive (expatriate)	-	1	1	-	-
21 600	Junior executive (Somali)	-	1	1	2	2
10 800	Technician/personal assistant	-	9	16	20	24
9 600	Supervisor	-	1	1	1	1
8 400	Clerical	-	1	1	1	1
6 000	Skilled labour	-	2	3	4	4
	Total cost, excluding unskilled labour (SoSh '000)	-	529	610	301	344
	Numbers of unskilled labour	-	3	6	6	6
3 750(1)	Total financial cost (SoSh '000)	-	540	633	324	367
2 500(1)	Total economic cost (SoSh '000)	-	536	625	316	359

Note: (1) Unskilled labour rate at financial and economic prices.

Source Table 6.1

TABLE I - 2

Administration/Overhead Labour Costs

Rate (SoSh/year)	Grade	Year	Numbers/year 1	2	3	4	5 onwards
380 000	Senior executive (expatriate)		1	4	4	2½	-
250 000	Junior executive (expatriate)		-	1	1	-	-
30 000	Senior executive (Somali)		1	1	1	1½	3
21 600	Junior executive (Somali)		½	5	5	5	6
10 800	Technician/ personal assistant		1	12	19	19	19
8 400	Clerical		1	6	8	10	10
6 000	Skilled labour		5	14	20	20	20
	Total cost excluding unskilled labour (SoSh '000)		470	2 172	2 300	1 512	629
	Numbers of unskilled labour		2	4	8	8	8
3 750(1)	Total financial cost (SoSh '000)		478	2 187	2 330	1 542	659
2 500(1)	Total economic cost (SoSh '000)		475	2 182	2 320	1 532	649

Note: (1) Unskilled labour rate at financial and economic prices.

Source: Table 6.1.

APPENDIX II

SUPPORTING DATA FOR ALTERNATIVE A/1

TABLE II - 1

Agricultural Implementation Schedule (ha)

Year	2		3		4		5 onwards	
Crop	Gu	Der	Gu	Der	Gu	Der	Gu	Der
Paddy rice	-	-	459	-	1 431	-	2 052	-
Maize (surface)	-	216	-	918	-	1 377	-	1 458
Cotton	-	163	-	163	-	163	-	163

TABLE II - 2

Volume of Agricultural Production

Crop	Yield level (q/ha)	Year 2	3	4	5	6	7	8 onwards
(a) Hectares at each yield level								
Paddy rice	25	-	459	972	621	-	-	-
	30	-	-	459	972	621	-	-
	35	-	-	-	459	972	621	-
	40	-	-	-	-	459	1 431	2 052
Maize-surface	25	216	702	459	81	-	-	-
	30	-	216	702	459	81	-	-
	35	-	-	216	702	459	81	-
	40	-	-	-	216	918	1 377	1 458
Cotton-hand	12	163	-	-	-	-	-	-
	16	-	163	-	-	-	-	-
	20	-	-	163	-	-	-	-
	25	-	-	-	163	163	163	163
(b) Volume of production (quintal)								
Unmilled rice		-	11 475	38 070	60 750	71 010	78 975	82 080
Maize		5 400	24 030	40 095	49 005	55 215	57 915	58 320
Seed cotton		1 956	2 608	3 260	4 075	4 075	4 075	4 075

TABLE II - 3

Value of Agricultural Production (SoSh '000)

Crop	Price SoSh (q/year)	Year 2	3	4	5	6	7	8 onwards
(a) Economic								
Paddy rice	317	-	3 638	12 068	19 258	22 510	25 035	26 019
Maize	96	518	2 307	3 849	4 704	5 301	5 560	5 599
Seed cotton	286	559	746	932	1 165	1 165	1 165	1 165
Total		1 077	6 691	16 849	25 127	28 976	31 760	32 783
(b) Economic								
Paddy rice	235	-	2 697	8 946	14 276	16 687	18 559	19 289
Maize	119	643	2 860	4 771	5 832	6 571	6 892	6 940
Seed cotton	316	618	1 824	1 030	1 288	1 288	1 288	1 288
Total		1 261	6 381	14 747	21 396	24 546	26 739	27 517

TABLE II - 4

Agricultural Direct Input Costs Including Aerial Sprays (SoSh '000)

Crop	Cost/ha	Year 2	3	4	5 onwards
(1) Financial					
Rice-paddy	1 789	-	821	2 560	3 671
Maize-surface	1 009	218	926	1 389	1 471
Cotton-hand	1 563	255	255	255	255
Total		473	2 002	4 204	5 397
(2) Economic					
Rice paddy	1 733	-	795	2 480	3 556
Maize-surface	960	207	881	1 322	1 400
Cotton-hand	1 474	240	240	240	240
Total		447	1 916	4 042	5 196

TABLE II - 5

Agricultural Labour Costs

Rate SoSh/yr	Grade	Year 1	2	Numbers/year 3	4	5 onwards
380 000	Senior executive (expat)	-	2	2	½	-
21 600	Junior executive	-	3	3	4½	5
10 800	Technician/personal assistant	-	32	53	77	92
9 600	Supervisor	-	6	15	23	23
8 400	Clerical	-	2	2	2	2
6 000	Skilled labour	-	2	2	2	2
	Total cost excluding unskilled labour (SoSh '000)	-	1 257	1 570	1 368	1 351
	Numbers of unskilled labour	-	104	222	325	398
3 750(1)	Total financial cost (SoSh '000)	-	1 647	2 403	2 587	2 844
2 500(1)	Total economic cost (SoSh '000)	-	1 517	2 125	2 181	2 346

Note: (1) Unskilled labour rate at financial and economic prices.

TABLE II - 6

Calculation of Agricultural Unskilled Labour Requirements

	Crop	J	F	M	A	M	J	J	A	S	O	N	D
(a)	Man days per ha												
	Paddy rice	-	-	-	2	5	5	5	4	1	-	-	-
	Surface maize	3	-	-	-	-	-	-	-	4	6	6	3
	Cotton-hand	35	23	7	-	-	-	-	3	5	6	4	15
(b)	Men required per month (assuming 24 days/month)												
Year	ha												
2	Rice 0	-	-	-	-	-	-	-	-	-	-	-	-
	Maize 216	-	-	-	-	-	-	-	-	36	54	54	27
	Cotton 163	-	-	-	-	-	-	-	20	34	40	27	102
	Total	-	-	-	-	-	-	-	20	70	94	81	129
3	Rice 459	-	-	-	38	96	96	96	77	19	-	-	-
	Maize 918	27	-	-	-	-	-	-	-	153	230	230	115
	Cotton 163	238	156	48	-	-	-	-	20	34	40	27	102
	Total	265	156	48	38	96	96	96	97	206	270	257	217
4	Rice 1 431	-	-	-	119	298	298	298	239	60	-	-	-
	Maize 1 377	115	-	-	-	-	-	-	-	230	344	344	172
	Cotton 163	238	156	48	-	-	-	-	20	34	40	27	102
	Total	353	156	48	119	298	298	298	259	324	384	371	284
5	Rice 2 052	-	-	-	171	428	428	428	342	86	-	-	-
	Maize 1 458	172	-	-	-	-	-	-	-	243	365	365	182
	Cotton 163	238	156	48	-	-	-	-	20	34	40	27	102
	Total	410	156	48	171	428	428	428	362	363	405	392	284
6	Rice 2 052	-	-	-	171	428	428	428	342	86	-	-	-
	Maize 1 458	182	-	-	-	-	-	-	-	243	365	365	182
	Cotton 163	238	156	48	-	-	-	-	20	34	40	27	102
	Total	420	156	48	171	428	428	428	362	363	405	392	284

(c) *Annual labour requirements in excess of basic labour force assumed*

Year	Basic labour force assumed (men/year)	Extra man months required	Extra man months required	Total man years required
2	100	29	2	102
3	200	215	18	218
4	300	232	19	319
5	370	271	22	392
6	370	281	23	393

TABLE II - 7

Agricultural Machinery Operating Costs

Crop	Cost per ha[1] (SoSh)		Hectares/year				
	Financial	Economic	Year 1	2	3	4	5 onwards
Paddy rice	690	631	-	-	459	1 431	2 052
Surface maize	798	731	-	216	918	1 377	1 458
Cotton	797	743	-	163	163	163	163
Unit	Cost per year		Nr per year				
Land Rover-LWB	18 320	15 260	3	5	6	6	6
Land Rover-SWB	16 620	13 560	2	4	4	4	4
Total Costs (financial)		(SoSh '000)	88	460	1 356	2 393	2 886
Total Costs (economic)		(SoSh '000)	73	410	1 082	2 031	2 482

Note: (1) Excludes depreciation or operators' labour

TABLE II - 8

Mechanised Field Operations, by Crop

Operation	Paddy rice	Maize	Cotton	Year 1	2	3	4	5
				Hectares per year				
Chisel ripper	x		x		163	622	1 594	2 215
Soil saver		x			216	918	1 377	1 458
Heavy discing	x		x		163	622	1 594	2 215
Land planing	x				0	459	1 431	2 052
Fertiliser application	x	x	x		379	1 540	2 971	3 673
Light harrowing	x	x	x		379	1 540	2 971	3 673
Planting/drilling	x	x	x		379	1 540	2 971	3 673
Inter-row cultivation		x	x		379	1 081	1 540	1 621
Ridging	x	x			216	1 377	2 808	3 510
Combine harvesting	x	x			216	1 377	2 808	3 510
Crop transport	x	x	x		379	1 540	2 971	3 673
Flail (post harvest)	x	x	x		379	1 540	2 971	3 673

TABLE II - 9

Number of Tractors and Machinery Required at Full Development

Operation	Class of tractor (hp)	Output (h/ha)	Area to work/year (ha)	Time worked (h)	Days in season	Hours/ day	Requirements theory	Requirements actual
Chisel rip	150	0.77	2 215	1 706	90	12	1.6	3
Soil saver	150	1.11	1 458	1 618	65	12	2.1	3
Disc harrow	150	0.56	5 888	3 297	120	12	2.3	3
Land plane	110	0.56	2 052	1 149	50	10	2.3	3
Fertilise	110	0.24	3 673	882	80	10	1.1	2
Combine drill	110	0.48	3 673	1 763	70	10	2.5	4
Inter-row cultivator	75	0.83	1 621	1 345	80	10	1.7	3
Border disc	75	0.18	3 510	632	40	10	1.6	3
Flail	110	0.69	3 673	2 534	100	10	2.5	4
Trailers								
10 tonne	110	1.0	3 673	3 673	-	-	7.3	9
5 tonne	75	0.5	3 673	1 837	-	-	3.7	5
Combine-rice	-	0.91	2 052	1 867	25	10	7.5	10
Combine-maize	-	1.25	1 458	1 823	45	10	4.1	6

Class of tractor	Hours available per tractor	Total hours worked per year	Total tractor requirements theory	Total tractor requirements actual
150 hp	1 500	6 621	4.4	6
110 hp	1 200	10 001	8.3	11
75 hp	1 200	3 807	3.2	5

TABLE II - 10

Machinery Requirements to Project Maturity

	Year			
	2	3	4	5
Tractors				
150 hp crawler	2	3	5	6
110 hp 4 wheel drive	3	6	9	11
75 hp 2 wheel drive	3	4	5	5
Implements				
Chisel ripper	1	2	3	3
Soil saver plough	1	2	3	3
Disc harrow	1	2	3	3
Land plane	0	1	2	3
Fertiliser broadcaster	1	1	2	2
Combine drill	1	2	3	4
Inter-row cultivator	1	2	3	3
Border disc	1	2	3	3
Flail	1	2	4	4
Trailer - 10 tonne	3	5	7	9
Trailer - 5 tonne	2	3	4	5
Harvesters				
Combine harvester units	2	4	7	10
Maize headers	2	4	6	6
Rice headers and threshing mechanisms	-	3	7	10
Operators	25	43	65	80

TABLE II - 11

Agricultural Machinery Capital and Replacement Costs (SoSh '000) Case A/1

Item	Unit price (SoSh '000)	Number purchased per year																													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
150 hp crawler	590.9	0	2	1	2	1	0	0	0	2	1	2	1	0	0	0	2	1	2	1	0	0	0	2	1	2	1	0	0	0	2
110 hp 4 WD	217.3	0	3	3	3	2	0	0	3	3	3	2	0	0	3	3	3	2	0	0	3	3	3	2	0	0	3	3	3	2	0
75 hp 2 WD	125	0	3	1	1	0	0	0	3	1	1	0	0	0	3	1	1	0	0	0	3	1	1	0	0	0	3	1	1	0	0
Chisel ripper	36.4	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1
Soil saver	42.3	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1
Disc harrow	38.6	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	0	0	1	1	0
Land plane	141.8	0	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1	0
Fert. spinner	114.5	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0
Combine drill	99.2	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1	1	1	0
I-R cultivator	36	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0
Border disc	35.7	0	1	1	1	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
Flail	49.5	0	1	1	2	0	0	0	1	1	2	0	0	0	1	1	2	0	0	0	1	1	2	0	0	0	1	1	2	0	0
10-T trailer	53.3	0	3	2	2	2	0	0	0	0	0	0	3	2	2	2	0	0	0	0	0	0	3	2	2	2	0	0	0	*0	0
5-T trailer	25.6	0	2	1	1	1	0	0	0	0	0	0	2	1	1	1	0	0	0	0	0	0	2	1	1	1	0	0	0	0	0
Base harvester	391.2	0	2	2	3	3	0	2	2	3	3	0	2	2	3	3	0	2	2	3	3	0	2	2	3	3	0	2	2	3	3
Maize header	108	0	2	2	2	0	0	2	2	2	0	0	2	2	2	0	0	2	2	2	0	0	2	2	2	0	0	2	2	2	0
Rice header	69	0	0	3	4	3	0	0	3	4	3	0	0	3	4	3	0	0	3	4	3	0	0	3	4	3	0	0	3	4	3
L/Rover LWB	100.1	3	2	1	0	0	0	0	0	3	2	1	0	0	0	0	0	3	2	1	0	0	0	0	0	3	2	1	0	0	0
L/Rover SWB	82.9	2	2	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2	2	0	0	0	0
Hand sprayers	0.6	0	5	5	5	0	0	5	5	5	0	0	5	5	5	0	0	5	5	5	0	0	5	5	5	0	0	5	5	5	0
TOTAL		466	4 239	3 288	4 403	2 779	0	1 116	2 459	4 510	3 466	2 036	2 095	1 518	3 201	2 513	2 310	2 785	2 835	2 616	2 773	1 142	2 412	3 171	2 621	3 239	2 207	2 358	2 400	2 459	2 641

APPENDIX III

SUPPORTING DATA FOR ALTERNATIVE A/2

TABLE III - 1

Agricultural Implementation Schedule (ha)

Year	2		3		4		5 onwards	
Crop	Gu	Der	Gu	Der	Gu	Der	Gu	Der
Paddy rice	-	216	459	918	1 215	1 539	1 593	1 539
Cotton	-	163	-	163	-	163	-	163

TABLE III - 2

Volume of Agricultural Production

Crop	Yield level (q/ha)	Year 2	3	4	5	6	7	8 onwards
(a) Hectares at each yield level								
Paddy rice	25	216	1 161	1 377	378	-	-	-
	30	-	216	1 161	1 377	378	-	-
	35	-	-	216	1 161	1 377	378	-
	40	-	-	-	216	1 377	2 754	3 132
Cotton-hand	12	163	-	-	-	-	-	-
	16	-	163	-	-	-	-	-
	20	-	-	163	-	-	-	-
	25	-	-	-	163	163	163	163
(b) Volume of production (quintal)								
Unmilled rice.		5 400	35 505	76 815	100 035	114 615	123 390	125 280
Seed cotton		1 956	2 608	3 260	4 075	4 075	4 075	4 075

TABLE III - 3

Value of Agricultural Production (SoSh '000)

Crop	Price SoSh (q/year)	Year 2	3	4	5	6	7	8 onwards
(a) Financial								
Paddy rice	317	1 712	11 255	25 350	31 711	36 333	39 115	39 714
Seed cotton	286	559	746	932	1 165	1 165	1 165	1 165
Total		2 271	12 001	25 282	32 876	37 498	40 280	40 879
(b) Economic								
Paddy rice	235	1 269	8 344	18 052	23 508	26 935	28 997	29 441
Seed cotton	316	618	824	1 030	1 288	1 288	1 288	1 288
Total		1 887	9 168	19 082	24 796	28 223	30 285	30 729

TABLE III - 4

Agricultural Direct Input Costs Including Aerial Spraying (SoSh '000)

Crop	Cost/ha	Year			
		2	3	4	5 onwards
(1) Financial					
Paddy rice	1 789	386	2 463	4 927	5 603
Cotton-hand	1 563	255	255	255	255
Total		641	2 718	5 182	5 858
(2) Economic					
Paddy rice	1 733	374	2 386	4 773	5 428
Cotton-hand	1 474	240	240	240	240
Total		614	2 626	5 013	5 668

TABLE III - 5

Agricultural Labour Costs

Rate SoSh/yr	Grade	Year 1	2	Numbers/year 3	4	5 onwards
380 000	Senior executive (expat)	-	2	2	½	-
21 600	Junior executive	-	3	3	4½	5
10 800	Technician/personal assistant	-	30	45	67	77
9 600	Supervisor	-	6	15	23	23
8 400	Clerical	-	2	2	2	2
6 000	Skilled labour	-	2	2	2	2
	Total cost excluding unskilled labour (SoSh '000)	-	1 235	1 484	1 261	1 190
	Numbers of unskilled labour	-	79	186	299	365
3 750(1)	Total financial cost (SoSh '000)	-	1 531	2 182	2 382	2 559
2 500(1)	Total economic cost (SoSh '000)	-	1 433	1 949	2 009	2 103

Note: (1) Unskilled labour rate at financial and economic prices.

TABLE III - 6

Calculation of Agricultural Unskilled Labour Requirements

	Crop	J	F	M	A	M	J	J	A	S	O	N	D
(a)	Man days per ha												
	Rice-Gu	-	-	-	2	5	5	5	4	1	-	-	-
	Rice-Der	5	4	1	-	-	-	-	-	-	2	5	5
	Cotton	35	23	7	-	-	-	-	3	5	6	4	15
(b)	Men required per month (assuming 24 days/month)												
Year		ha											
2	Rice-Gu	0	-	-	-	-	-	-	-	-	-	-	-
	Rice-Der	216	-	-	-	-	-	-	-	-	18	45	45
	Cotton	163	-	-	-	-	-	-	20	34	41	27	102
	Total		-	-	-	-	-	-	20	34	59	72	147
3	Rice-Gu	459	-	-	-	38	96	96	96	77	19	-	-	-
	Rice-Der	918	45	36	9	-	-	-	-	-	-	77	191	191
	Cotton	238	156	48	-	-	-	-	-	20	34	41	27	102
	Total		283	192	57	38	96	96	96	97	53	118	218	293
4	Rice-Gu	1 215	-	-	-	101	253	253	253	203	51	-	-	-
	Rice-Der	1 539	191	153	38	-	-	-	-	-	-	128	321	321
	Cotton	163	238	156	48	-	-	-	-	20	34	41	27	102
	Total		429	309	86	101	253	253	253	223	85	169	348	423
5	Rice-Gu	1 593	-	-	-	133	332	332	332	266	66	-	-	-
	Rice-Der	1 539	321	257	64	-	-	-	-	-	-	128	321	321
	Cotton	163	238	156	48	-	-	-	-	20	34	41	27	102
	Total		559	413	112	133	332	332	332	286	100	169	348	423

(c) Annual Labour Requirements in Excess of Base Labour Force Assumed

Year	Base force (men/yr)	Extra man months	Extra man years	Total man years
2	70	79	7	77
3	150	386	32	182
4	250	518	43	293
5	330	346	29	359

TABLE III - 7

Agricultural Machinery Operating Costs

Crop	Cost per ha(1) (SoSh)		Hectares/year				
	Financial	Economic	Year 1	2	3	4	5 onwards
Paddy rice	690	631	-	216	1 377	2 754	3 132
Cotton	797	743	-	163	163	163	163
Unit	**Cost per year**		**Nr per year**				
Land Rover-LWB	18 320	15 260	3	5	6	6	6
Land Rover-SWB	16 620	13 560	2	4	4	4	4
Total Costs (financial)		(SoSh '000)	88	437	1 256	2 206	2 467
Total Costs (economic)		(SoSh '000)	73	388	1 136	2 005	2 243

Note: (1) Excludes depreciation or operators' labour

TABLE III - 8

Mechanised Field Operations, by Crop

Operation	Paddy rice	Cotton-hand	Year	Hectares per year 2	3	4	5
Chisel ripper	x	x		379	1 540	2 917	3 295
Heavy discing	x	x		379	1 540	2 917	3 295
Land planing	x			216	1 377	2 754	3 132
Fertiliser application	x	x		379	1 540	2 917	3 295
Light harrowing	x	x		379	1 540	2 917	3 295
Planting/drilling	x	x		379	1 540	2 917	3 295
Inter-row cultivation		x		163	163	163	163
Ridging	x			216	1 377	2 754	3 132
Combine harvesting	x			216	1 377	2 754	3 132
Crop transport	x	x		379	1 540	2 917	3 295
Flail (post harvest)	x	x		379	1 540	2 917	3 295

TABLE III - 9

Number of Tractors and Machinery Required at Full Development

Operation	Class of tractor (hp)	Output (h/ha)	Area to work/year (ha)	Time worked (h)	Days in season	Hours/ day	Requirements theory	Requirements actual
Chisel rip	150	0.77	3 295	2 537	90	12	2.4	4
Disc harrow	150	0.56	6 590	3 690	120	12	2.6	4
Land plane	110	0.56	3 132	1 754	100	10	1.8	3
Fertilise	110	0.24	3 295	791	80	10	1.0	2
Combine drill	110	0.48	3 295	1 582	70	10	2.3	4
Inter-row cultivator	75	0.83	163	135	80	10	0.2	1
Border disc	75	0.18	3 132	564	40	10	1.4	2
Flail	110	0.69	3 295	2 274	100	10	2.3	4
Trailers								
10 tonne	110	1.0	3 295	3 295	-	-	6.6	8
5 tonne	75	0.5	3 295	1 648	-	-	3.3	5
Rice-combine	-	0.91	3 132	2 850	50	10	5.7	7

Class of tractor	Hours available per tractor	Total hours worked per year	Total tractor requirements theory	Total tractor requirements actual
150 hp	1 500	6 227	4.2	6
110 hp	1 200	9 696	8.1	10
75 hp	1 200	2 333	2.0	3

TABLE III - 10

Machinery Requirements to Project Maturity

	Year			
	2	3	4	5
Tractors				
150 hp crawler	2	3	5	6
110 hp 4 wheel drive	3	5	8	10
75 hp 2 wheel drive	2	2	3	3
Implements				
Chisel ripper	1	2	4	4
Soil saver plough	1	2	4	4
Disc harrow	1	2	3	3
Land plane	-	1	2	3
Fertiliser broadcaster	1	2	2	2
Combine drill	1	2	4	4
Inter-row cultivator	1	1	1	1
Border disc	1	2	2	2
Flail	1	2	4	4
Trailer - 10 tonne	3	5	7	8
Trailer - 5 tonne	2	3	4	5
Harvesters				
Rice combine	2	4	6	7
Operators	23	35	55	65

TABLE III - 11

Agricultural Machinery Capital and Replacement Costs (SoSh '000) Case A/2

Item	Unit price (SoSh '000)	Number purchased per year																												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
150 hp crawler	590.9	0	2	1	2	1	0	0	0	2	1	2	1	0	0	0	2	1	2	1	0	0	0	2	1	2	1	0	0	0	2
110 hp 4 WD	217.3	0	3	2	3	2	0	0	3	2	3	2	0	0	3	2	3	2	0	0	3	2	3	2	0	0	3	2	3	0	0
75 hp 2 WD	125	0	2	0	1	0	0	0	2	0	1	0	0	0	2	0	1	0	0	0	2	0	1	0	0	0	2	0	1	0	0
Chisel ripper	36.4	0	1	1	2	0	0	0	0	1	1	2	0	0	0	0	1	1	2	0	0	0	0	1	1	2	0	0	0	0	1
Soil saver	42.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Disc harrow	38.6	0	1	1	2	0	0	0	1	1	2	0	0	0	1	1	2	0	0	0	1	1	2	0	0	0	1	1	1	2	0
Land plane	141.8	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	1	1	0
Fert. spinner	114.5	0	1	1	0	0	0	1	1	0	0	0	0	1	0	0	0	1	1	0	1	0	1	1	0	0	0	1	1	1	0
Combine drill	99.2	0	1	1	2	0	0	0	1	1	2	0	0	0	1	1	2	0	0	0	1	1	2	0	0	0	0	1	1	2	0
I-R cultivator	36	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0
Border disc	35.7	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Flail	49.5	0	1	1	2	0	0	0	1	1	2	0	0	0	1	1	2	0	0	0	1	1	2	0	0	0	0	1	1	2	0
10-T trailer	53.3	0	3	2	2	1	0	0	0	0	0	0	3	2	2	1	0	0	0	0	0	0	3	2	2	1	0	0	0	0	0
5-T trailer	25.6	0	2	1	1	1	0	0	0	0	0	0	2	1	1	1	0	0	0	0	0	0	2	1	1	1	0	0	0	0	0
Base harvester	391.2	0	2	2	2	1	0	2	2	2	1	0	2	2	2	1	0	2	2	2	1	0	2	2	2	1	0	2	2	2	1
Rice header	69	0	2	2	2	1	0	2	2	2	1	0	2	2	2	1	0	2	2	2	1	0	2	2	2	1	0	2	2	2	1
L/Rover LWB	100.1	3	2	1	0	0	0	0	0	3	2	1	0	0	0	0	0	3	2	1	0	0	0	0	0	3	2	1	0	0	0
L/Rover SWB	82.9	2	2	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2	2	0	0	0	0
Hand sprayers	0.6	0	5	5	5	0	0	5	5	5	0	0	5	5	5	0	0	5	5	5	0	0	5	5	5	0	0	5	5	5	0
TOTAL		466	4 136	2 697	3 604	1 565	0	1 038	2 163	3 230	2 747	1 931	2 017	1 206	2 181	1 161	2 370	2 566	2 800	1 756	1 727	622	2 436	2 859	1 683	2 260	2 224	1 902	2 351	1 350	1 678

APPENDIX IV

SUPPORTING DATA FOR ALTERNATIVE B/1

TABLE IV - 1

Agricultural Implementation Schedule (ha)

Year	2		3		4		5	
Crop	Gu	Der	Gu	Der	Gu	Der	Gu	Der
Paddy rice	-	-	459	-	999	-	1 809	-
Maize (surface)	-	189	-	783	-	1 296	-	1 296
Cotton	-	122	-	122	-	122	-	122

TABLE IV - 2

Volume of Agricultural Production

Crop	Yield level (q/ha)	Year 2	3	4	5	6	7	8 onwards
(a) Hectares at each yield level								
Paddy rice	25	-	459	540	810	-	-	-
	30	-	-	459	540	810	-	-
	35	-	-	-	459	540	810	-
	40	-	-	-	-	459	999	1 809
Maize-surface	25	189	594	513	-	-	-	-
	30	-	189	594	513	-	-	-
	35	-	-	189	594	513	-	-
	40	-	-	-	189	783	1 296	1 296
Cotton-hand	12	122	-	-	-	-	-	-
	16	-	122	-	-	-	-	-
	20	-	-	122	-	-	-	-
	25	-	-	-	122	122	122	122
(b) Volume of production (quintal)								
Unmilled rice		-	11 475	27 270	52 515	61 560	68 310	72 360
Maize		4 725	20 520	37 260	43 740	49 275	51 840	51 840
Seed cotton		1 464	1 952	2 440	3 050	3 050	3 050	3 050

TABLE IV - 3

Value of Agricultural Production (SoSh '000)

Crop	Price SoSh (q/year)	Year 2	3	4	5	6	7	8 onwards
(a) Financial								
Paddy rice	317	-	3 638	8 645	16 647	19 515	21 654	22 938
Maize	96	454	1 970	3 577	4 199	4 730	4 977	4 977
Seed cotton	286	419	558	698	872	872	872	872
Total		873	6 166	12 920	21 718	25 117	27 503	28 787
(b) Economic								
Paddy rice	235	-	2 697	6 408	12 341	14 467	16 053	17 005
Maize	119	526	2 442	4 434	5 205	5 864	6 169	6 169
Seed cotton	316	463	617	771	964	964	964	964
Total		1 025	5 756	11 613	18 510	21 295	23 186	24 138

TABLE IV - 4

Agricultural Direct Input Costs Including Aerial Spraying (SoSh '000)

Crop	Cost/ha	Year			
		2	3	4	5 onwards
(1) Financial					
Paddy rice	1 789	-	821	1 787	3 236
Maize	1 009	191	790	1 308	1 308
Cotton-hand	1 563	191	191	191	191
Total		382	1 802	3 286	4 735
(2) Economic					
Paddy rice	1 733	-	795	1 731	3 135
Maize	960	181	752	1 244	1 244
Cotton-hand	1 474	180	180	180	180
Total		381	1 727	3 155	4 559

TABLE IV - 5

Agricultural Labour Costs

Rate SoSh/yr	Grade	Year 1	2	Numbers/year 3	4	5 onwards
380 000	Senior executive (expat)	-	2	2	½	-
21 600	Junior executive	-	3	3	4½	5
10 800	Technician/personal assistant	-	30	48	65	77
9 600	Supervisor	-	6	15	23	23
8 400	Clerical	-	2	2	2	2
6 000	Skilled labour	-	2	2	2	2
	Total cost excluding unskilled labour (SoSh '000)	-	1 235	1 516	1 239	1 190
	Numbers of unskilled labour	-	74	187	277	347
3 750(1)	Total financial cost (SoSh '000)	-	1 513	2 217	2 278	2 491
2 500(1)	Total economic cost (SoSh '000)	-	1 420	1 984	1 932	2 058

Note: (1) Unskilled labour rate at financial and economic prices.

TABLE IV - 6

Calculation of Agricultural Unskilled Labour Requirements

	Crop	J	F	M	A	M	J	J	A	S	O	N	D
(a)	Man days per ha												
	Paddy rice	-	-	-	2	5	5	5	4	1	-	-	-
	Maize-surface	3	-	-	-	-	-	-	-	4	6	6	3
	Cotton-hand	35	23	7	-	-	-	-	3	5	6	4	15
(b)	Men required per month (assuming 24 days/month)												
Year	ha												
2	Rice 0	-	-	-	-	-	-	-	-	-	-	-	-
	Maize 189	-	-	-	-	-	-	-	-	32	47	47	24
	Cotton 122	-	-	-	-	-	-	-	15	25	30	20	76
	Total	-	-	-	-	-	-	-	15	57	77	67	100
3	Rice 459	-	-	-	38	96	96	96	77	19	-	-	-
	Maize 783	24	-	-	-	-	-	-	-	131	196	196	98
	Cotton 122	178	117	36	-	-	-	-	15	25	30	20	76
	Total	202	117	36	38	96	96	96	92	175	226	216	174
4	Rice 999	-	-	-	83	208	208	208	167	42	-	-	-
	Maize 1 296	98	-	-	-	-	-	-	-	216	324	324	162
	Cotton 122	178	117	36	-	-	-	-	15	25	30	20	76
	Total	276	117	36	83	208	208	208	182	283	354	344	238
5	Rice 1 809	-	-	-	151	377	377	377	302	75	-	-	-
	Maize 1 296	162	-	-	-	-	-	-	-	216	324	324	162
	Cotton 122	178	117	36	-	-	-	-	15	25	30	20	76
	Total	340	117	36	151	377	377	377	317	316	354	344	238

(c) Annual Labour Requirements in Excess of Based Labour Force Assumed

Year	Base Force (men/yr)	Extra man months	Extra man years	Total man years
2	70	20	2	72
3	170	153	13	183
4	250	257	21	271
5	320	249	21	341

TABLE IV - 7

Agricultural Machinery Operating Costs

Crop	Cost per ha[1] (SoSh)		Hectares/year				
	Financial	Economic	Year 1	2	3	4	5 onwards
Paddy rice	690	631	-	-	459	999	1 809
Surface maize	798	731	-	189	783	1 296	1 296
Cotton (hand)	797	743	-	122	122	122	122
Unit	Cost per year		Nr per year				
Land Rover-LWB	18 320	15 260	3	5	6	6	6
Land Rover-SWB	16 620	13 560	2	4	4	4	4
Total Costs (financial)		(SoSh '000)	88	406	1 215	1 997	2 556
Total Costs (economic)		(SoSh '000)	73	360	1 099	1 814	2 362

Note: (1) Excludes depreciation or operators' labour

TABLE IV - 8

Mechanised Field Operations, by Crop

Operation	Paddy rice	Basin maize	Cotton-hand	Hectares per year Year 2	3	4	5 onwards
Chisel ripper	x		x	122	581	1 121	1 931
Soil saver		x		189	783	1 296	1 296
Heavy discing	x		x	122	581	1 121	1 931
Land planing	x			-	459	999	1 809
Fertiliser application	x	x	x	311	1 364	2 417	3 227
Light harrowing	x	x	x	311	1 364	2 417	3 227
Planting/drilling	x	x	x	311	1 364	2 417	3 227
Inter-row cultivation		x	x	311	905	1 418	1 418
Ridging	x	x		189	1 242	2 295	3 105
Combine harvesting	x	x		189	1 242	2 295	3 105
Crop transport	x	x	x	311	1 364	2 417	3 227
Flail (post harvest)	x	x	x	311	1 364	2 417	3 227

Number of Tractors and Machinery Required at Full Development

Operation	Class of tractor (hp)	Output (h/ha)	Area to work/year (ha)	Time worked (h)	Days in season	Hours/ day	Requirements theory	Requirements actual
Chisel rip	150	0.77	1 931	1 487	90	12	1.4	3
Soil saver plough	150	1.11	1 296	1 439	65	12	1.8	3
Disc harrow	150	0.56	5 158	2 888	120	12	2.0	3
Land plane	110	0.56	1 809	1 013	50	10	2.0	3
Fertiliser spreader	110	0.24	3 227	774	80	10	1.0	2
Combine drill	110	0.48	3 227	1 549	70	10	2.2	3
Inter-row cultivator	75	0.83	1 418	1 177	80	10	1.4	2
Border disc	75	0.18	3 105	559	40	10	1.4	2
Flail	110	0.69	3 227	2 227	100	10	2.2	3
Trailers								
10 tonne	110	1.0	3 227	3 227	-	-	6.5	8
5 tonne	75	0.5	3 227	1 614	-	-	3.2	4
Combine-rice	-	0.91	1 809	1 646	25	10	6.6	8
Combine-maize	-	1.25	1 296	1 620	45	10	3.6	5

Class of tractor	Hours available per tractor	Total hours worked per year	Total tractor requirements theory	Total tractor requirements actual
150 hp	1 500	5 814	3.9	5
110 hp	1 200	8 790	7.3	9
75 hp	1 200	3 350	2.8	4

TABLE IV - 10

Machinery Requirements to Project Maturity

	Year			
	2	3	4	5
Tractors				
150 hp crawler	2	3	4	5
110 hp 4 wheel drive	3	5	7	9
75 hp 2 wheel drive	2	3	4	4
Implements				
Chisel ripper	1	2	3	3
Soil saver plough	1	2	3	3
Disc harrow	1	2	3	3
Land plane	-	1	2	3
Fertiliser broadcaster	1	1	2	2
Combine drill	1	2	3	3
Inter-row cultivator	1	2	2	2
Border disc	1	1	2	2
Flail	1	2	3	3
Trailer - 10 tonne	2	4	6	8
Trailer - 5 tonne	1	2	3	4
Harvesters				
Combine harvester units	2	4	6	8
Maize headers	2	4	5	5
Rice headers and threshing mechanisms	-	3	6	8
Operators	23	38	53	65

TABLE IV - 11

Agricultural Machinery Capital and Replacement Costs (SoSh '000) Case B/1

Item	Unit price (SoSh '000)	Number purchased per year																														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
150 hp crawler	590.9	0	2	1	1	1	0	0	0	2	1	1	1	0	0	0	2	1	1	1	0	0	0	2	1	1	1	0	0	0	2
110 hp 4 WD	217.3	0	3	2	2	2	0	0	3	2	2	2	0	0	3	2	2	2	0	0	3	2	2	2	0	0	3	2	2	2	0
75 hp 2 WD	125	0	2	1	1	0	0	0	2	1	1	0	0	0	2	1	1	0	0	0	2	1	1	0	0	0	2	1	1	0	0
Chisel ripper	36.4	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1
Soil saver	42.3	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1
Disc harrow	38.6	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0
Land plane	141.8	0	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1	0
Fert. spinner	114.5	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0
Combine drill	99.2	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0
I-R cultivator	36	0	1	1	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0
Border disc	35.7	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Flail	49.5	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0
10-T trailer	53.3	0	2	2	2	2	0	0	1	0	0	0	2	2	2	2	0	0	0	0	0	0	2	2	2	2	0	0	0	0	0
5-T trailer	25.6	0	1	1	1	1	0	0	0	1	0	0	1	1	1	1	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0
Base harvester	391.2	0	2	2	2	2	0	2	2	2	2	0	2	2	2	2	0	2	2	2	2	0	2	2	2	2	0	2	2	2	2
Maize header	108	0	2	2	1	0	0	2	2	1	0	0	2	2	1	0	0	2	2	1	0	0	2	2	1	0	0	2	2	1	0
Rice header	69	0	0	3	3	2	0	0	3	3	2	0	0	3	3	2	0	0	3	3	2	0	0	3	3	2	0	0	3	3	2
L/Rover LWB	101.1	3	2	1	0	0	0	0	0	3	2	1	0	0	0	0	0	3	2	1	0	0	0	0	0	3	2	1	0	0	0
L/Rover SWB	82.9	2	2	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2	2	0	0	0	0
Hand sprayers	0.6	0	5	5	5	0	0	5	5	5	0	0	5	5	5	0	0	5	5	5	0	0	5	5	5	0	0	5	5	5	0
TOTAL		466	4 036	3 035	2 941	2 120	0	1 116	2 334	3 724	2 703	1 346	2 017	1 482	2 508	1 836	2 007	2 686	2 244	2 048	2 187	924	2 031	3 036	2 052	2 188	2 082	2 141	2 097	1 791	2 181

APPENDIX V

SUPPORTING DATA FOR ALTERNATIVE B/2

TABLE V - 1

Agricultural Implementation Schedule (ha)

Year	2		3		4		5	
Crop	Gu	Der	Gu	Der	Gu	Der	Gu	Der
Paddy rice	-	189	459	972	1 188	1 215	1 404	1 377
Cotton	-	122	-	122	-	122	-	122

TABLE V - 2

Volume of Agricultural Production

Crop	Yield level (q/ha)	Year 2	3	4	5	6	7	8 onwards
(a) Hectares at each yield level								
Paddy rice	25	189	1 242	972	378	-	-	-
	30	-	189	1 242	972	378	-	-
	35	-	-	189	1242	972	378	-
	40	-	-	-	189	1 431	2 403	2 781
Cotton	12	122	-	-	-	-	-	-
	16	-	122	-	-	-	-	-
	20	-	-	122	-	-	-	-
	25	-	-	-	122	122	122	122
(b) Volume of production (quintal)								
Unmilled rice		4 725	36 720	68 175	89 640	102 600	109 350	111 240
Seed cotton		1 464	1 952	2 440	3 050	3 050	3 050	3 050

TABLE V - 3

Value of Agricultural Production (SoSh '000)

Crop	Price SoSh (q/year)	Year 2	3	4	5	6	7	8 onwards
(a) Financial								
Paddy rice	317	1 498	11 640	21 611	28 416	32 524	34 664	35 263
Seed cotton	286	419	558	698	872	872	872	872
Total		1 917	12 198	22 309	29 288	33 396	35 536	36 135
(b) Economic								
Paddy rice	235	1 110	8 629	16 021	21 023	24 111	25 697	26 141
Seed cotton	316	463	617	771	964	964	964	964
Total		1 573	9 246	16 792	21 987	25 075	26 661	27 105

TABLE V - 4

Agricultural Direct Input Costs Including Aerial Spraying (SoSh '000)

Crop	Cost/ha	Year 2	3	4	5 onwards
(1) Financial					
Paddy rice	1 789	338	2 560	4 299	4 975
Cotton-hand	1 563	191	191	191	191
Total		529	2 751	4 490	5 166
(2) Economic					
Paddy rice	1 733	328	2 480	4 164	4 819
Cotton-hand	1 474	180	180	180	180
Total		508	2 660	4 344	4 999

TABLE V - 5

Agricultural Labour Costs

Rate SoSh/yr	Grade	Numbers/year Year 1	2	3	4	5 onwards
380 000	Senior executive (expat)	-	2	2	1½	-
21 600	Junior executive	-	3	3	4½	5
10 800	Technician/personal assistant	-	30	45	65	72
9 600	Supervisor	-	6	15	23	23
8 400	Clerical	-	2	2	2	2
6 000	Skilled labour	-	2	2	2	2
	Total cost excluding unskilled labour (SoSh '000)	-	1 235	1 484	1 239	1 136
	Numbers of unskilled labour	-	58	176	278	330
3 750(1)	Total financial cost (SoSh '000)	-	1 453	2 144	2 282	2 374
2 500(1)	Total economic cost (SoSh '000)	-	1 380	1 924	1 934	1 961

Note: (1) Unskilled labour rate at financial and economic prices.

TABLE V - 6

Calculation of Agricultural Unskilled Labour Requirements

	Crop		J	F	M	A	M	J	J	A	S	O	N	D
(a)	Man days per ha													
	Rice-Gu		-	-	-	2	5	5	5	4	1	-	-	-
	Rice-Der		5	4	1	-	-	-	-	-	-	2	5	5
	Cotton		35	23	7	-	-	-	-	3	5	6	4	15
(b)	Men required per month (assuming 24 days/month)													
Year		ha												
2	Rice-Gu	0	-	-	-	-	-	-	-	-	-	-	-	-
	Rice-Der	189	-	-	-	-	-	-	-	-	-	16	39	39
	Cotton	122	-	-	-	-	-	-	-	15	25	30	20	76
	Total		-	-	-	-	-	-	-	15	25	46	59	115
3	Rice-Gu	459	-	-	-	38	96	96	96	77	19	-	-	-
	Rice-Der	972	39	32	8	-	-	-	-	-	-	81	203	203
	Cotton	122	178	117	36	-	-	-	-	15	25	30	20	76
	Total		217	149	44	38	96	96	96	92	43	111	223	279
4	Rice-Gu	1 188	-	-	-	99	248	248	248	198	50	-	-	-
	Rice-Der	1 215	203	162	41	-	-	-	-	-	-	101	253	253
	Cotton	122	178	117	36	-	-	-	-	15	25	30	20	76
	Total		381	279	77	99	248	248	248	213	75	131	273	329
5	Rice-Gu	1 404	-	-	-	117	293	293	293	234	59	-	-	-
	Rice-Der	1 377	253	203	51	-	-	-	-	-	-	115	287	287
	Cotton	122	178	117	36	-	-	-	-	15	25	30	20	76
	Total		431	320	87	117	293	293	293	249	84	145	307	363
6	Rice-Gu	1 404	-	-	-	117	293	293	293	234	59	-	-	-
	Rice-Der	1 377	287	230	57	-	-	-	-	-	-	115	287	287
	Cotton	122	178	117	36	-	-	-	-	15	25	30	20	76
	Total		465	347	93	117	293	293	293	249	84	145	307	363

(c) Annual Labour Requirements in Excess of Based Labour Force Assumed

Year	Base force (men/yr)	Extra man months	Extra man years	Total man years
2	50	74	6	56
3	150	269	22	172
4	250	262	22	272
5	300	221	18	318
6	300	282	24	324

TABLE V - 7

Agricultural Machinery Operating Costs

Crop	Cost per ha[1] (SoSh)		Hectares/year				
	Financial	Economic	Year 1	2	3	4	5 onwards
Paddy rice	690	631	-	189	1 431	2 403	2 781
Cotton	797	743	-	163	163	163	163
Unit	Cost per year		Nr per year				
Land Rover-LWB	18 320	15 260	3	5	6	6	6
Land Rover-SWB	16 620	13 560	2	4	4	4	4
Total Costs (financial)		(SoSh '000)	88	418	1 293	1 964	2 225
Total Costs (economic)		(SoSh '000)	73	371	1 170	1 783	2 022

Note: (1) Excludes depreciation or operators' labour

TABLE V - 8

Mechanised Field Operations, by Crop

Operation	Paddy rice	Cotton-hand	Year 2	Hectares per year 3	4	5 onwards
Chisel ripper	x	x	311	1 553	2 525	2 903
Heavy discing	x	x	311	1 553	2 525	2 903
Land planing	x		189	1 431	2 403	2 781
Fertiliser application	x	x	311	1 553	2 525	2 903
Light harrowing	x	x	311	1 553	2 525	2 903
Planting/drilling	x	x	311	1 553	2 525	2 903
Inter-row cultivation		x	122	122	122	122
Ridging	x		189	1 431	2 403	2 781
Combine harvesting	x		189	1 431	2 403	2 781
Crop transport	x	x	311	1 553	2 525	2 903
Flail (post harvest)	x	x	311	1 553	2 525	2 903

TABLE V - 9

Number of Tractors and Machinery Required at Full Development

Operation	Class of tractor (hp)	Output (h/ha)	Area to work/year (ha)	Time worked (h)	Days in season	Hours/ day	Requirements theory	Requirements actual
Chisel rip	150	0.77	2 903	2 235	90	12	2.1	3
Disc harrow	150	0.56	5 806	3 251	120	12	2.3	4
Land plane	110	0.56	2 781	1 557	100	10	1.6	3
Fertiliser spreader	110	0.24	2 903	697	80	10	0.9	2
Combine drill	110	0.48	2 903	1 393	70	10	2.0	3
Inter-row cultivator	75	0.83	122	101	80	10	0.1	1
Border disc	75	0.18	2 781	501	40	10	1.3	2
Flail	110	0.69	2 903	2 003	100	10	2.0	3
Trailers								
10 tonne	110	1.0	2 903	2 903	-	-	5.8	7
5 tonne	75	0.5	2 903	1 452	-	-	2.9	4
Rice combine	-	0.91	2 781	2 531	50	10	5.1	7

Class of tractor	Hours available per tractor	Total hours worked per year	Total tractor requirements theory	Total tractor requirements actual
150 hp	1 500	5 486	3.7	5
110 hp	1 200	8 553	7.1	9
75 hp	1 200	2 054	1.7	3

TABLE V - 10

Machinery Requirements to Project Maturity

	Year			
	2	3	4	5
Tractors				
150 hp crawler	2	3	5	5
110 hp 4 wheel drive	3	5	7	9
75 hp 2 wheel drive	2	2	3	3
Implements				
Chisel ripper	1	2	3	3
Disc harrow	1	2	3	4
Land plane	1	2	3	3
Fertiliser broadcaster	1	2	2	2
Combine drill	1	2	3	3
Inter-row cultivator	1	1	1	1
Border disc	1	2	2	2
Flail	1	2	3	3
Trailer - 10 tonne	3	5	6	7
Trailer - 5 tonne	2	3	4	4
Harvesters				
Rice combine	2	4	6	7
Operators	23	35	53	60

TABLE V - 11

Agricultural Machinery Capital and Replacement Costs (SoSh '000) Case B/2

Item	Unit price (SoSh '000)	Number purchased per year																												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
150 hp crawler	590.9	0	2	1	2	0	0	0	0	2	1	2	0	0	0	0	2	1	2	0	0	0	0	2	1	2	0	0	0	0	2
110 hp 4 WD	217.3	0	3	2	2	2	0	0	3	2	2	2	0	0	3	2	2	2	0	0	3	2	2	2	0	0	3	2	2	2	0
75 hp 2 WD	125	0	2	0	1	0	0	0	2	0	1	0	0	0	2	0	1	0	0	0	2	0	1	0	0	0	2	0	1	0	0
Chisel ripper	36.4	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1
Disc harrow	38.6	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1	1	1	1
Land plane	141.8	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1	1	0
Fert. spinner	114.5	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1	1	0
Combine drill	99.2	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0
I-R cultivator	36	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Border disc	35.7	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0
Flail	49.5	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	1	1	0	0	0
10-T trailer	53.3	0	3	2	1	1	0	0	0	0	0	0	3	2	1	1	0	0	0	0	0	0	3	2	1	1	0	0	0	0	0
5-T trailer	25.6	0	2	1	1	0	0	0	0	0	0	0	2	1	1	0	0	0	0	0	0	0	2	1	1	0	0	0	0	0	0
Base harvester	391.2	0	2	2	2	1	0	2	2	2	1	0	2	2	2	1	0	2	2	2	1	0	2	2	2	1	0	2	2	2	1
Rice header	69	0	2	2	2	1	0	2	2	2	1	0	2	2	2	1	0	2	2	2	1	0	2	2	2	1	0	2	2	2	1
L/Rover LWB	100.1	3	2	1	0	0	0	0	0	3	2	1	0	0	0	0	0	3	2	1	0	0	0	0	0	3	2	1	0	0	0
L/Rover SWB	82.9	2	2	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2	2	0	0	0	0
Hand sprayers	0.6	0	5	5	5	0	0	5	5	5	0	0	5	5	5	0	0	5	5	5	0	0	5	5	5	0	0	5	5	5	0
TOTAL		466	4 136	2 697	3 109	987	0	1 038	2 163	3 230	2 342	1 933	1 427	1 206	2 128	1 135	1 965	2 605	2 734	1 165	1 727	622	2 032	2 897	1 630	2 198	1 633	1 442	1 927	1 397	1 678

APPENDIX VI

FINANCIAL AND FOREIGN EXCHANGE VALUES FOR ALTERNATIVE A/2

APPENDIX VI

FINANCIAL AND FOREIGN EXCHANGE VALUES FOR ALTERNATIVE A/2

1. Financial Cash Flow

(a) Value of Present Production

As in Cases A/1 and A/2 (Economic) the value in each year is taken as 50% of the level in the Supplementary Study. Thus,

Year	1	2	3
Value (SoSh '000)	146	297	443

(b) Other Values

Otherwise, the agricultural financial values have been calculated as shown in Appendices I and III. Agricultural machinery financial capital costs are the same as the economic values, as in the Supplementary Study. The derivation of engineering values is detailed in Section 4.6.

2. Foreign Exchange Costs

(a) Crop Prices

The foreign exchange crop prices derived from the Supplementary Study are used as follows:-

FE price of milled rice = SoSh 296 per quintal
FE price of paddy rice = SoSh 207 per quintal
FE price of seed cotton = SoSh 361 per quintal

(b) Value of Proposed Agricultural Production (SoSh '000)

Crop Year	2	3	4	5	6	7	8 onwards
Paddy rice	1 118	7 350	15 901	20 707	23 725	25 542	25 933
Seed cotton	706	941	1 177	1 471	1 471	1 471	1 471
Total	1 824	8 291	17 078	22 178	25 196	27 013	27 404

(c) Value of Present Production

As in Cases A/1 and A/2 (Economic), the value in each year is taken as 50% of the foreign exchange level in the Supplementary Study. Thus,

Year	1	2	3
Value (SoSh '000)	176	358	534

(d) Agricultural Inputs

The FE cost per hectare is taken from the Supplementary Study, Section IV - 12.

Crop	FE Cost/ha (SoSh)	Year	2	3 (SoSh '000)	4	5 onwards
Paddy rice	1 072		231	1 476	2 952	3 358
Cotton-hand	1 346		219	219	219	219
Total			450	1 695	3 171	3 577

(e) Agricultural, Engineering and Administration Labour Costs

The foreign exchange element is 70% of expatriates' salaries, assuming 30% is paid in local currency.

(f) Other Costs

As detailed in the Supplementary Study, Section IV-12 all other costs are taken as 90% foreign exchange except the Engineering Capital works in years 1 to 3 which are detailed in Chapter 4.

APPENDIX VII

COMPUTER ANALYSES FOR ALTERNATIVE B

APPENDIX VII

Computer Analyses for Alternative B

CANAL DESIGN DATA AND EARTHWORK QUANTITIES

A. Canal Design Data and Earthwork Quantities

Introduction

1. The design data give values for the design discharge, water level, bed level, bed width and water surface slope at different chainages along the canal.

2. All chainages, dimensions and levels are given in metres, all earthwork volumes in cubic metres and all discharges in cubic metres per second.

3. The earthwork quantities are based on existing ground levels taken from contours (0.25 m intervals). Computations of cut and fill areas are performed at appropriate intervals along the canal and at canal structures. No deduction has been made for lengths of canal occupied by structures.

4. The canals are referenced in accordance with the following system :-

   The head of the main canal is referred to as 'S. BASIN' (settling basin) and the tail as 'S. RESERVOIR' (storage reservoir).

   The distributary canals have a reference made up of the letter C and a sequence number.

Design Criteria

1. All canals were designed using the following Lacey regime equations :

$$Dm = 2.46\, V^2/f$$

$$Ws = 4.83\, e\, Q^{\frac{1}{2}}$$

$$S = \frac{0.003\, e^{1/3}\, f^{5/3}\, E}{Q^{1/6}}$$

where Ws = water surface width (m)

Dm = mean depth = $\frac{\text{water area}}{Ws}$ (m)

V = mean velocity (m/s)

Q = design discharge (m^3s)

S = water surface slope

e = width factor

f = Lacey silt factor

E = $\frac{\text{wetted perimeter}}{Ws}$

2. Freeboard :-

0.5 m in main canal

0.4 m in all distributaries

3. Lacey silt factor :-

0.4 in main canal

0.5 in all distributaries

4. Lacey width factor :-

0.83 in all canals

5. Typical cross sections of the main canal are as shown on Plate Nr 42 in the Supplementary Study. A typical cross section of the distributary canals is shown in Figure 4.1. Both banks of the main canal have a bank top width of 5 m. One bank of the distributary canals has a bank top width of 4 m and the other 1 m.

CANAL DESIGN DATA FOR MAIN CANAL

CHAINAGE	STRUCTURE NAME	DESIGN DISCHARGE U/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH U/S (M)	WATER SURFACE SLOPE U/S (M/M)
200	S.BASIN	****	******	12.22	******	11.82	****	********
520	SIPHON	3.26	12.20	12.00	11.00	10.80	5.80	0.000060
1850	S.RESEVOIR	3.26	11.92	******	10.72	******	5.80	0.000060

EARTHWORK QUANTITIES FOR MAIN CANAL

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF IMPORTED FILL (CU.M.)
200	S.BASIN	10.00					
			2.71	0.00	0	19746	19746
520	SIPHON	10.00					
			2.46	0.00	0	66855	66855
1850	S.RESEVOIR	10.00					
TOTAL QUANTITIES OF EARTHWORKS FOR CANAL					0	86601	86601

CANAL DESIGN DATA FOR DISTRIBUTARY C1

CHAINAGE	STRUCTURE NAME	DESIGN DISCHARGE U/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH U/S (M)	WATER SURFACE SLOPE U/S (M/M)
0	HEAD	****	******	10.30	******	9.42	****	********
570	C1/3&4,X REG	1.61	10.24	10.14	9.37	9.30	4.10	0.000099
1140	C1/5&9	1.45	10.09	10.09	9.24	9.27	3.90	0.000102
1710	C1/6&8,X REG	1.29	10.03	9.93	9.21	9.15	3.60	0.000104
2280	C1/11&10	1.13	9.87	9.87	9.09	9.12	3.40	0.000107
2850	C1/13&12,X RE	0.97	9.80	9.70	9.06	9.00	3.20	0.000110
3420	C1/5&14	0.81	9.64	9.64	8.94	8.99	2.90	0.000115
3990	C1/16,X REG	0.64	9.57	9.47	8.92	8.85	2.60	0.000121
4560	C1/17,18&20	0.56	9.40	9.40	8.78	8.88	2.40	0.000124
4960	C1/22	0.32	9.34	9.34	8.83	8.88	1.80	0.000140
5110	C1/19,X REG	0.24	9.32	9.22	8.85	8.81	1.60	0.000150
5360	C1/24&26,ES	0.16	9.18	******	8.77	******	1.30	0.000164

EARTHWORK QUANTITIES FOR DISTRIBUTARY C1

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF IMPORTED FILL (CU.M.)
0	HEAD	9.50					
			1.57	0.00	0	3282	3282
180		8.75					
			1.79	0.00	0	8825	8825
570	C1/3&4,X REG	9.00					

980		8.40	1.82	0.00	0	9577	9577
1140	C1/5&9	8.75	1.92	0.00	0	4069	4069
1450		9.00	1.59	0.00	0	5819	5819
1710	C1/6&8,X REG	8.75	1.56	0.00	0	4735	4735
2000		8.75	1.56	0.00	0	5259	5259
2280	C1/11&10	8.75	1.53	0.00	0	4918	4918
2850	C1/13&12,X RE	8.50	1.61	0.00	0	10856	10856
3300		8.25	1.70	0.00	0	9389	9389
3420	C1/5&14	8.00	1.92	0.00	0	3052	3052
3750		8.00	2.02	0.00	0	9749	9749
3990	C1/16,X REG	7.50	2.23	0.00	0	8431	8431
4320		8.00	2.10	0.00	0	10421	10421
4560	C1/17,18&20	8.00	1.81	0.00	0	5553	5553
4700		7.50	2.04	0.00	0	4208	4208
4960	C1/22	7.50	2.26	0.00	0	9323	9323
5110	C1/19,X REG	7.75	2.10	0.00	0	4765	4765
5320		8.00	1.73	0.00	0	4487	4487
5360	C1/24&26,ESCA	7.75	1.71	0.00	0	838	838
					---	---	---
TOTAL QUANTITIES OF EARTHWORKS FOR CANAL					0	127555	127555

CANAL DESIGN DATA FOR DISTRIBUTARY C2

CHAINAGE	STRUCTURE NAME	DESIGN DISCHARGE U/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH U/S (M)	WATER SURFACE SLOPE U/S (M/M)
0	HEAD	****	******	10.82	******	10.27	****	********
570	C2/5&C2/6	0.41	10.74	10.74	10.19	10.28	2.00	0.000133
1140	C2/7&8,X REG	0.24	10.66	10.56	10.19	10.11	1.60	0.000149
1710	C2/9,ESCAPE	0.21	10.47	******	10.02	******	1.50	0.000154

EARTHWORK QUANTITIES FOR DISTRIBUTARY C2

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF IMPORTED FILL (CU.M.)
0	HEAD	9.50					
			1.58	0.00	0	5521	5521
300		9.75					
			1.66	0.00	0	5422	5422
570	C2/5&C2/6	9.25					
			2.12	0.00	0	9027	9027
850		8.75					
			2.47	0.00	0	6256	6256
1000		8.50					
			2.32	0.00	0	5252	5252
1140	C2/7&8,X REG	9.00					
			1.69	0.00	0	5361	5361
1400		9.50					
			1.40	0.00	0	4551	4551
1710	C2/9,ESCAPE	9.50					
TOTAL QUANTITIES OF EARTHWORKS FOR CANAL					0	41391	41391

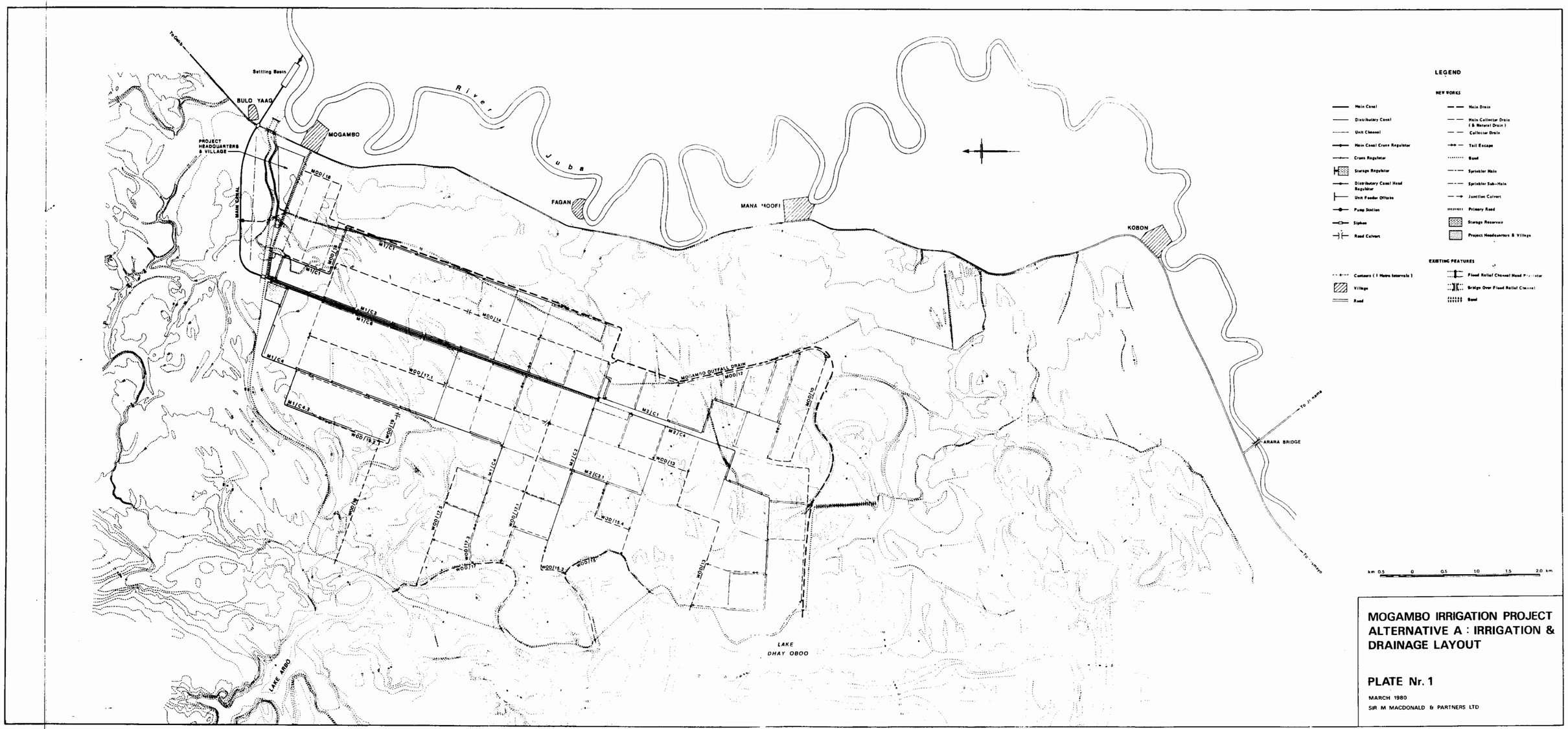
CANAL DESIGN DATA FOR DISTRIBUTAY C3

STRUCTURE CHAINAGE	NAME	DESIGN DISCHARGE U/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH U/S (M)	WATER SURFACE SLOPE U/S (M/M)
0	HEAD	****	******	10.75	******	9.82	****	********
570	C3/1	1.94	10.70	10.70	9.76	9.78	4.50	0.000096
1710	C3/3,X REG	1.86	10.59	10.49	9.67	9.71	4.40	0.000096
2280	C3/5,X REG	1.13	10.42	10.22	9.64	9.46	3.40	0.000107
2850	C3/7&2	1.05	10.16	10.16	9.40	9.44	3.30	0.000109
3420	C3/9,4&3,X RE	0.89	10.10	10.00	9.38	9.35	3.00	0.000113
3990	C3/11&6	0.65	9.93	9.93	9.28	9.34	2.60	0.000120
4560	C3/13,10,12&8	0.49	9.86	9.76	9.27	9.35	2.20	0.000128
5130	C3/15&14,ES	0.16	9.66	******	9.26	******	1.30	0.000164

EARTHWORK QUANTITIES FOR DISTRIBUTAY C3

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF IMPORTED FILL (CU.M.)
0	HEAD	9.50					
			1.88	0.00	0	12251	12251
500		9.00					
			2.00	0.00	0	1906	1906
570	C3/1	9.20					
			1.83	0.00	0	5430	5430
800		9.30					
			1.65	0.00	0	9528	9528
1280		9.50					
			1.77	0.00	0	3559	3559
1440		9.00					
			2.25	0.00	0	9603	9603
1710	C3/3,X REG	8.50					
			2.11	0.00	0	12803	12803
2110		9.00					
			1.68	0.00	0	3487	3487
2280	C3/5,X REG	9.30					
			1.45	0.00	0	8081	8081
2800		9.00					
			1.69	0.00	0	1032	1032

2850	C3/7&2	8.75	1.68	0.00	0	2048	2048
2950		9.00	1.40	0.00	0	6937	6937
3420	C3/9,4&3,X RE	9.25	0.86	0.19	129	1573	1444
3650		9.80	1.11	0.00	0	2485	2485
3900		8.70	1.74	0.00	0	1939	1939
3990	C3/11&6	8.50	1.92	0.00	0	5330	5330
4200		8.30	1.64	0.00	0	4318	4318
4420		9.00	1.62	0.00	0	2685	2685
4560	C3/13,10,12&8	8.30	1.75	0.00	0	3045	3045
4700		8.50	1.47	0.00	0	6885	6885
5130	C3/15&14,ESCA	8.75					
					------	-------	-------
TOTAL QUANTITIES OF EARTHWORKS FOR CANAL					129	104924	104795

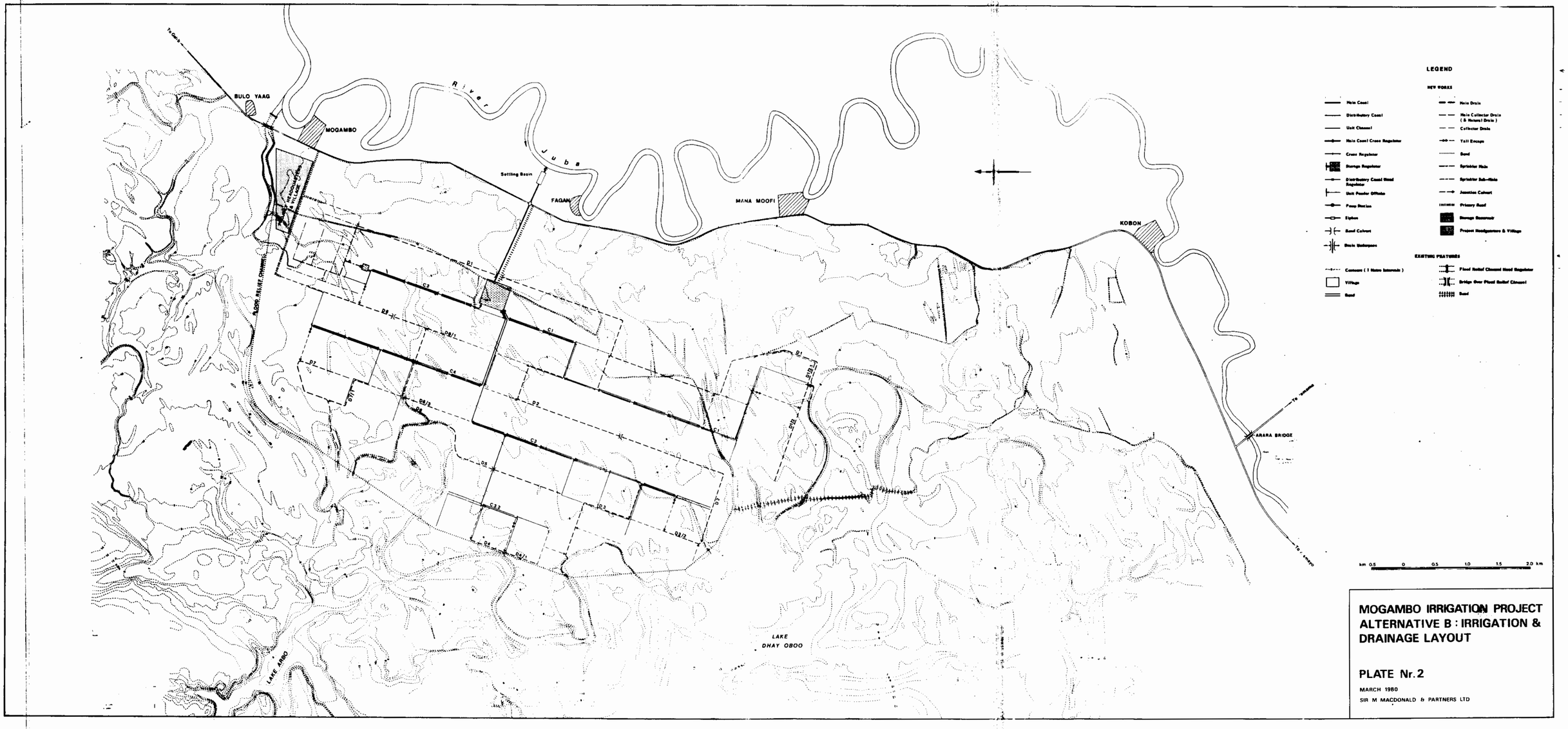


MOGAMBO IRRIGATION PROJECT
ALTERNATIVE A : IRRIGATION & DRAINAGE LAYOUT

PLATE Nr. 1

MARCH 1980

SIR M MACDONALD & PARTNERS LTD


To Dolo
BULO YAAG
MOGAMBO
River Juba
Settling Basin
FAQAM
MANA MOOFI
KOBON
ARARA BRIDGE
To Luuq
LAKE DHAY OBOO
LAKE ARDO
LEGEND
NEW WORKS
Main Canal
Distributary Canal
Unit Channel
Main Canal Cross Regulator
Cross Regulator
Storage Regulator
Distributary Canal Head Regulator
Unit Powder Offtake
Pump Station
Siphon
Road Culvert
Drain Underpass
Main Drain
Main Collector Drain (& Pumped Drain)
Collector Drain
Tail Escape
Road
Sprinkler Main
Sprinkler Sub-Main
Junction Culvert
Primary Road
Storage Reservoir
Project Headquarters & Village
EXISTING FEATURES
Contours (1 Metre Intervals)
Village
Road
Flood Relief Channel Head Regulator
Bridge Over Flood Relief Channel
Road
km 0.5 0 0.5 1.0 1.5 2.0 km
MOGAMBO IRRIGATION PROJECT
ALTERNATIVE B : IRRIGATION & DRAINAGE LAYOUT
PLATE Nr. 2
MARCH 1980
SIR M MACDONALD & PARTNERS LTD

CANAL DESIGN DATA FOR C3.2

CHAINAGE	STRUCTURE NAME	DESIGN DISCHARGE U/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH U/S (M)	WATER SURFACE SLOPE U/S (M/M)
0	HEAD	****	******	10.36	******	9.77	****	********
1140	C3.2/3,4,6&8,	0.49	10.21	10.11	9.63	9.71	2.20	0.000128
1710	C3.2/5&10,E	0.16	10.02	******	9.61	******	1.30	0.000164

EARTHWORK QUANTITIES FOR C3.2

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF IMPORTED FILL (CU.M.)
0	HEAD	9.25					
			1.63	0.00	0	1943	1943
100		9.00					
			1.85	0.00	0	10013	10013
520		8.75					
			1.80	0.00	0	8203	8203
880		9.00					
			1.63	0.00	0	5062	5062
1140	C3.2/3,4,6&8,	9.00					
			1.57	0.00	0	10408	10408
1710	C3.2/5&10,ESC	8.80					
TOTAL QUANTITIES OF EARTHWORKS FOR CANAL					0	35628	35628

CANAL DESIGN DATA FOR DISTRIBUTARY C4

STRUCTURE CHAINAGE	NAME	DESIGN DISCHARGE U/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH U/S (M)	WATER SURFACE SLOPE U/S (M/M)
0	HEAD	****	******	11.07	******	10.31	****	********
1140	C4/1&2,X REG	1.06	10.95	10.85	10.18	10.13	3.30	0.000108
1710	C4/3&6	0.89	10.78	10.78	10.06	10.11	3.00	0.000112
2280	C4/5,7&8,X RE	0.73	10.72	10.62	10.04	10.03	2.70	0.000117
2850	C4/9,10&11	0.49	10.54	10.54	9.95	10.08	2.20	0.000128
3420	C4/12&13,X RE	0.24	10.46	10.36	9.99	10.03	1.60	0.000149
3990	C4/14&ESCAP	0.08	10.25	******	9.92	******	1.00	0.000191

EARTHWORK QUANTITIES FOR DISTRIBUTARY C4

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF IMPORTED FILL (CU.M.)
0	HEAD	9.50					
			2.19	0.00	0	17035	17035
500		9.00					
			2.28	0.00	0	7284	7284
700		9.25					
			2.00	0.00	0	11942	11942
1140	C4/1&2,X REG	9.50					
			1.60	0.00	0	6804	6804
1500		9.75					
			1.44	0.00	0	3256	3256
1710	C4/3&6	9.75					
			1.30	0.00	0	2408	2408
1900		10.00					
			1.51	0.00	0	6553	6553
2280	C4/5,7&8,X RE	9.25					
			1.88	0.00	0	2957	2957
2400		9.00					
			1.87	0.00	0	10978	10978
2850	C4/9,10&11	9.20					
			1.83	0.00	0	3531	3531
3000		9.00					
			1.78	0.00	0	4494	4494
3200		9.25					
			1.85	0.00	0	5261	5261
3420	C4/12&13,X RE	8.80					
			1.84	0.00	0	4272	4272
3600		9.00					
			1.44	0.00	0	5990	5990
3990	C4/14&ESCAPE	9.50					
					------	-------	-------
TOTAL QUANTITIES OF EARTHWORKS FOR CANAL					0	92766	92766

DRAIN DESIGN DATA AND EARTHWORK QUANTITIES

B. Drain Design Data and Earthwork Quantities

Introduction

1. The design data give values for the design discharge, design water level, bed level and bed width at different chainages along the drain.

2. All chainages, dimensions and levels are given in metres, all earthwork volumes in cubic metres, and all discharges in cubic metres per second.

3. The earthwork quantities are based on existing ground levels taken from contours (0.25 m intervals). Computations of cut and fill areas are performed at appropriate intervals along the drain and at drain structures. No deduction has been made for lengths of drain occupied by structures.

4. The drains have a reference made up of the letter D and a sequence number.

5. The earthwork quantities include the fill for the 6 m wide access roads on either side of the drains.

Design Criteria

1. All drains were designed using the Manning equation:

$$V = \frac{R^{\frac{2}{3}} S^{\frac{1}{2}}}{n}$$

where V = mean velocity (m/s)

n = Manning's roughness coefficient = 0.033

R = hydraulic radius (m) = $\frac{\text{water area}}{\text{wetted perimeter}}$

S = water surface slope

2. Zero freeboard for all drains

3. A typical cross section of the drains is as shown on Plate Nr 42 in the Supplementary Study.

DRAIN DESIGN DATA FOR D1

CHAINAGE	STRUCTURE NAME	DESIGN DISCHARGE D/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH D/S (M)
9040	END	.25	******	9.14	******	8.70	1.32
8640	INTAKE	.30	8.94	8.94	8.50	8.48	1.36
8070	INTAKE	.34	8.66	8.66	8.20	8.10	1.68
7500	INTAKE	.39	8.54	8.54	7.98	7.95	1.77
6750	U/PASS	.39	8.37	8.27	7.78	7.68	1.77
5790	INTAKE	.43	8.06	8.06	7.47	7.44	1.86
5220	INTAKE	.48	7.93	7.93	7.31	7.19	2.23
4650	INTAKE	.53	7.87	7.87	7.13	7.10	2.31
4080	COLLECTOR	.57	7.82	7.82	7.05	7.03	2.38
3510	INTAKE	.62	7.76	7.76	6.97	6.94	2.45
2940	INTAKE	.66	7.70	7.70	6.88	6.86	2.52
2370	INTAKE	.76	7.65	7.65	6.81	6.90	3.75
1740	INTAKE	.80	7.59	7.59	6.84	6.82	3.83
0	OUTFALL	****	7.41	******	6.64	******	****

EARTHWORK QUANTITIES FOR D1

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF EXCESS CUT (CU.M.)
9040	END	10.00					
			.00	1.40	1915	1170	745
8640	INTAKE	10.00					
			.00	1.45	1750	994	755
8300		9.70					
			.00	1.34	1043	673	370
8070	INTAKE	9.50					

7800		9.20	.00	1.28	1242	790	452
7500	INTAKE	9.00	.00	1.09	1082	877	204
7350		9.25	.00	1.19	636	439	197
7000		9.75	.00	1.62	2390	024	366
6750	U/PASS	10.00	.00	2.07	2516	731	1785
6500		9.80	.00	2.25	2888	731	2157
6200		9.50	.00	2.06	2998	877	2120
5900		9.00	.00	1.72	2251	877	1374
5790	INTAKE	9.00	.00	1.52	676	322	354
5650		9.00	.00	1.58	932	409	522
5350		9.00	.00	1.63	2097	877	1220
5220	INTAKE	9.00	.00	1.68	952	380	572
5050		9.50	.00	2.07	1876	497	1379
4780		9.50	.00	2.34	3632	790	2842
4650	INTAKE	9.00	.00	2.11	1483	380	1103
4500		9.25	.00	2.03	1633	439	1194
4220		9.00	.00	2.05	3092	819	2273
4080	COLLECTOR	8.50	.00	1.69	1150	409	741
3950		8.80	.00	1.63	1019	380	639
3740		8.75	.00	1.77	1871	614	1257

			.00	1.64	1831	673	1158
3510	INTAKE	8.50					
			.00	1.45	1403	614	788
3300		8.25					
			.00	1.22	779	439	340
3150		8.00					
			.00	1.36	1281	614	667
2940	INTAKE	8.50					
			.00	1.55	1047	409	638
2800		8.30					
			.00	1.56	1901	731	1170
2550		8.50					
			.00	1.43	1203	526	677
2370	INTAKE	8.00					
			.00	1.10	597	292	305
2270		8.00					
			.00	1.37	1750	643	1106
2050		8.50					
			.00	1.77	3515	907	2608
1740	INTAKE	8.75					
			.00	1.82	3704	907	2797
1430		8.50					
			.00	1.49	4787	1550	3237
900		8.00					
			.00	1.17	3595	1609	1987
350		7.75					
			.00	.72	1231	1024	207
0	OUTFALL	7.00					
					-------	-------	-------
TOTAL QUANTITIES OF EARTHWORKS FOR DRAIN					69749	26442	43307
					=======	=======	=======

DRAIN DESIGN DATA FOR D1/2

CHAINAGE	STRUCTURE NAME	DESIGN DISCHARGE D/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH D/S (M)
1580	END	.05	******	6.99	******	6.69	1.00
790	INTAKE	.09	6.91	6.91	6.61	6.51	1.20
390	ESCAPE	.30	6.87	6.87	6.47	6.23	1.91
0	OUTFALL	****	6.83	******	6.19	******	****

EARTHWORK QUANTITIES FOR D1/2

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF EXCESS CUT (CU.M.)
1580	END	8.00					
			.00	1.19	600	518	82
1400		7.75					
			.00	.97	958	1152	0
1000		7.50					
			.00	.75	338	605	0
790	INTAKE	7.25					
			.00	.82	179	259	0
700		7.40					
			.00	1.21	729	576	153
500		8.00					
			.00	1.65	667	317	350
390	ESCAPE	8.25					
			.00	1.78	1220	432	788
240		7.75					
			.00	1.17	1033	691	341
0	OUTFALL	7.00					
					-------	-------	-------
TOTAL QUANTITIES OF EARTHWORKS FOR DRAIN					5723	4550	1714
					=======	=======	=======

DRAIN DESIGN DATA FOR D1/2.1

CHAINAGE	STRUCTURE NAME	DESIGN DISCHARGE D/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH D/S (M)
380	END	.05	******	7.42	******	7.12	1.00
0	OUTFALL	****	7.38	******	7.08	******	****

EARTHWORK QUANTITIES FOR D1/2.1

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF EXCESS CUT (CU.M.)
380	END	7.75	.00	.28	148	1094	0
0	OUTFALL	7.00					
					-------	-------	-------
	TOTAL QUANTITIES OF EARTHWORKS FOR DRAIN				148	1094	0
					=======	=======	=======

DRAIN DESIGN DATA FOR D2

CHAINAGE	STRUCTURE NAME	DESIGN DISCHARGE D/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH D/S (M)
5600	END	.05	******	8.68	******	8.48	1.00
5030	INTAKE	.09	8.44	8.44	8.24	8.11	1.00
4460	INTAKE	.23	8.19	8.19	7.86	7.65	1.61
3890	INTAKE	.28	8.11	8.11	7.57	7.53	1.73
3320	INTAKE	.37	8.04	8.04	7.46	7.40	1.92
2750	CULVERT	.46	7.96	7.86	7.32	7.16	2.09
2180	INTAKE	.55	7.79	7.79	7.09	7.04	2.24
1610	INTAKE	.64	7.71	7.71	6.96	6.92	2.37
1040	INTAKE	.74	7.64	7.64	6.85	6.81	2.50
0	OUTFALL	****	7.50	******	6.67	******	****

EARTHWORK QUANTITIES FOR D2

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF EXCESS CUT (CU.M.)
5600	END	8.75					
			.00	.48	329	1152	0
5200		9.00					
			.00	.47	138	490	0
5030	INTAKE	8.50					
			.00	.70	403	806	0

4750		9.00	.00	1.20	976	835	141
4460	INTAKE	9.25	.00	1.37	1303	749	554
4200		8.75	.00	1.03	1012	893	119
3890	INTAKE	8.50	.00	.86	491	547	0
3700		8.25	.00	1.02	1258	1094	163
3320	INTAKE	8.75	.00	1.25	1513	922	592
3000		8.50	.00	1.04	902	720	182
2750	CULVERT	8.25	.00	1.29	1810	1008	802
2400		8.60	.00	1.32	1184	634	550
2180	INTAKE	8.25	.00	1.11	1427	950	477
1850		8.00	.00	.77	443	490	0
1680		7.50	.00	.66	149	202	0
1610	INTAKE	7.75	.00	.98	1543	1181	362
1200		8.00	.00	1.39	991	461	530
1040	INTAKE	8.50	.00	1.72	4293	1411	2881
550		8.50	.00	2.03	3938	1008	2930
200		9.00	.00	2.43	1047	202	846
130		9.25	.00	1.95	1371	374	997
0	OUTFALL	8.00					
					26522	16128	12127

TOTAL QUANTITIES OF EARTHWORKS FOR DRAIN

DRAIN DESIGN DATA FOR D2/2

CHAINAGE	STRUCTURE NAME	DESIGN DISCHARGE D/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH D/S (M)
670	ESCAPE	.21	******	7.91	******	7.35	1.69
100	COLLECTOR	.30	7.85	7.85	7.29	7.21	1.91
0	OUTFALL	****	7.84	******	7.20	******	****

EARTHWORK QUANTITIES FOR D2/2

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF EXCESS CUT (CU.M.)
670	ESCAPE	8.50					
			.00	1.29	1739	1066	674
300		8.75					
			.00	1.20	837	576	261
100	COLLECTOR	8.25					
			.00	.80	247	288	0
0	OUTFALL	7.75					
TOTAL QUANTITIES OF EARTHWORKS FOR DRAIN					2823	1930	935

DRAIN DESIGN DATA FOR D3

STRUCTURE CHAINAGE	STRUCTURE NAME	DESIGN DISCHARGE D/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH D/S (M)
1620	END	.05	******	7.92	******	7.62	1.00
1080	INTAKE	.09	7.84	7.84	7.54	7.44	1.20
450	INTAKE	.14	7.80	7.80	7.40	7.33	1.40
0	OUTFALL	****	7.75	******	7.28	******	****

EARTHWORK QUANTITIES FOR D3

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF EXCESS CUT (CU.M.)
1620	END	8.25					
			.00	.64	215	490	0
1450		8.25					
			.00	1.04	455	490	0
1280		9.00					
			.00	1.45	916	576	340
1080	INTAKE	9.00					
			.00	1.57	1000	518	482
900		9.00					
			.00	1.58	1012	518	494
720		9.00					
			.00	1.46	446	259	187
630		8.75					
			.00	1.22	665	518	146
450	INTAKE	8.50					
			.00	1.18	635	490	146
280		8.50					
			.00	1.20	1081	806	275
0	OUTFALL	8.50					
					-------	-------	-------
TOTAL QUANTITIES OF EARTHWORKS FOR DRAIN					6424	4666	2069
					=======	=======	=======

DRAIN DESIGN DATA FOR D4

CHAINAGE	STRUCTURE NAME	DESIGN DISCHARGE D/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH D/S (M)
570	END	.05	******	8.35	******	8.11	1.00
0	OUTFALL	****	8.24	******	8.00	******	****

EARTHWORK QUANTITIES FOR D4

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF EXCESS CUT (CU.M.)
570	END	9.25					
			.00	1.07	1589	1642	0
0	OUTFALL	9.00					
	TOTAL QUANTITIES OF EARTHWORKS FOR DRAIN .				1589	1642	0

DRAIN DESIGN DATA FOR D4/1

CHAINAGE	STRUCTURE NAME	DESIGN DISCHARGE D/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH D/S (M)
570	END	.05	******	8.35	******	8.05	1.00
0	OUTFALL	****	8.34	******	8.04	******	****

EARTHWORK QUANTITIES FOR D4/1

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF EXCESS CUT (CU.M.)
570	END	8.75					
			.00	.83	1062	1642	0
0	OUTFALL	9.00					
	TOTAL QUANTITIES OF EARTHWORKS FOR DRAIN				1062	1642	0

DRAIN DESIGN DATA FOR D5

STRUCTURE CHAINAGE	NAME	DESIGN DISCHARGE D/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH D/S (M)
1710	END	.09	******	7.92	******	7.52	1.20
1140	INTAKE	.18	7.86	7.86	7.46	7.34	1.56
570	U/PASS	.18	7.80	7.70	7.28	7.18	1.81
0	OUTFALL	****	7.65	******	7.13	******	****

EARTHWORK QUANTITIES FOR D5

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF EXCESS CUT (CU.M.)
1710	END	9.25					
			.00	1.37	932	605	327
1500		8.50					
			.00	1.26	584	432	152
1350		9.00					
			.00	1.28	838	605	233
1140	INTAKE	8.50					
			.00	1.17	934	691	243
900		8.50					
			.00	1.33	1556	950	606
570	U/PASS	8.75					
			.00	1.70	1638	634	1004
350		9.00					
			.00	1.85	2981	1008	1973
0	OUTFALL	9.00					
					-------	-------	-------
TOTAL QUANTITIES OF EARTHWORKS FOR DRAIN					9462	4925	4537
					=======	=======	=======

DRAIN DESIGN DATA FOR D6

CHAINAGE	STRUCTURE NAME	DESIGN DISCHARGE D/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH D/S (M)
2850	END	.25	******	8.89	******	8.31	1.75
2280	INTAKE	.50	8.83	8.83	8.25	8.06	2.30
1710	INTAKE	.59	8.78	8.68	8.01	7.86	2.45
1140	INTAKE	.78	8.62	8.62	7.80	7.72	2.70
570	U/PASS	.78	8.46	8.46	7.66	7.56	2.70
0	OUTFALL	****	8.41	******	7.51	******	****

EARTHWORK QUANTITIES FOR D6

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF EXCESS CUT (CU.M.)
2850	END	9.75					
			.00	1.46	2304	1152	1152
2450		9.75					
			.00	1.49	1011	490	521
2280	INTAKE	9.75					
			.00	1.57	1319	518	801
2100		9.50					
			.00	1.35	2272	1123	1149
1710	INTAKE	9.25					
			.00	1.40	1339	605	734
1500		9.25					
			.00	1.31	2073	1037	1036
1140	INTAKE	9.00					
			.00	1.60	3601	1267	2334
700		9.60					
			.00	1.76	1220	374	845
570	U/PASS	9.25					
			.00	1.58	3375	1210	2166
150		9.00					
			.00	.98	409	288	121
50		8.00					
			.00	.74	140	144	0
0	OUTFALL	8.50					
					-------	-------	-------
TOTAL QUANTITIES OF EARTHWORKS FOR DRAIN					19063	8208	10859
					=======	=======	=======

DRAIN DESIGN DATA FOR D6/1

CHAINAGE	STRUCTURE NAME	DESIGN DISCHARGE D/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH D/S (M)
570	END	.09	******	8.91	******	8.51	1.20
0	OUTFALL	****	8.85	******	8.45	******	****

EARTHWORK QUANTITIES FOR D6/1

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF EXCESS CUT (CU.M.)
570	END	9.25					
			.00	.63	434	922	0
250		9.00					
			.00	.54	269	720	0
0	OUTFALL	9.00					
					-------	-------	-------
TOTAL QUANTITIES OF EARTHWORKS FOR DRAIN .					703	1642	0
					=======	=======	=======

DRAIN DESIGN DATA FOR D6/3

STRUCTURE CHAINAGE	STRUCTURE NAME	DESIGN DISCHARGE D/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH D/S (M)
570	END	.05	******	8.92	******	8.62	1.00
0	OUTFALL	****	8.86	******	8.56	******	****

EARTHWORK QUANTITIES FOR D6/3

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF EXCESS CUT (CU.M.)
570	END	9.25					
			.00	.53	396	1210	0
150		9.00					
			.00	.18	35	432	0
0	OUTFALL	8.50					
TOTAL QUANTITIES OF EARTHWORKS FOR DRAIN					431	1642	0

DRAIN DESIGN DATA FOR D7

STRUCTURE CHAINAGE	NAME	DESIGN DISCHARGE D/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH D/S (M)
1470	END	.05	******	8.46	******	8.13	1.00
900	ESCAPE	.25	8.40	8.40	8.10	7.80	1.80
800	INTAKE	.30	8.39	8.39	7.98	7.75	1.91
400	INTAKE	.34	8.35	8.35	7.71	7.68	2.01
0	OUTFALL	****	8.31	******	7.64	******	****

EARTHWORK QUANTITIES FOR D7

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF EXCESS CUT (CU.M.)
1470	END	9.25					
			.00	1.20	740	634	106
1250		9.40					
			.00	1.22	1202	1008	194
900	ESCAPE	9.25					
			.00	1.49	598	288	310
800	INTAKE	9.50					
			.00	1.76	1602	576	1026
600		9.50					
			.00	1.91	1816	576	1240
400	INTAKE	9.75					
			.00	2.09	4301	1152	3149
0	OUTFALL	9.75					
TOTAL QUANTITIES OF EARTHWORKS FOR DRAIN					10259	4234	6026

DRAIN DESIGN DATA FOR D7/1

CHAINAGE	STRUCTURE NAME	DESIGN DISCHARGE D/S (CU.M/S)	DESIGN WATER LEVEL U/S	DESIGN WATER LEVEL D/S	BED LEVEL U/S	BED LEVEL D/S	BED WIDTH D/S (M)
950	END	.05	******	8.66	******	8.36	1.00
280	INTAKE	.09	8.59	8.59	8.17	8.07	1.20
0	OUTFALL	****	8.57	******	8.17	******	****

EARTHWORK QUANTITIES FOR D7/1

CHAINAGE (M)	STRUCTURE NAME	GROUND LEVEL	AVERAGE BANK HEIGHT (M)	AVERAGE CUT DEPTH (M)	VOLUME OF CUT (CU.M.)	VOLUME OF FILL (CU.M.)	VOLUME OF EXCESS CUT (CU.M.)
950	END	9.25					
			.00	1.17	744	662	81
720		9.50					
			.00	1.58	4077	2074	2003
0	OUTFALL	9.75					
					-------	-------	-------
TOTAL QUANTITIES OF EARTHWORKS FOR DRAIN . .					4820	2736	2084
					=======	=======	=======

SPRINKLER PIPEWORK DESIGN DATA, QUANTITIES AND COSTS

C. Sprinkler Pipework Design Data, Quantities and Costs

Introduction

1. The digital profile lists for each node, the length, discharge, pipe diameter, velocity and flow, fittings used, ground level, total head in the main and pressure head (called residual head).

2. The network is described as having a node at any point where there is a fitting, or valve, or change of diameter, or a lateral off the main.

3. All lengths, levels and dimensions are in metres, pressures are in metres head of water.

4. Fittings and valves are abbreviated as below:-

Gate Valve	G VALVE
Tee junction	TEE
90% bend	ELBOW

5. The pipe material and roughness, the interest rate, the economic life and the price of fuel are given on the printout.

6. The minimum head at sprinkler nozzles is required to be 30 m. Allowing for losses in the riser and lateral, the minimum pressure head allowed in the mains is 34 m.

INPUT DATA

PROJECT: MOGAMBO

PIPE MATERIAL: ASBESTOS CEMENT PIPE ROUGHNESS IN METRES: 0.0000250

INTEREST RATE: 10 % ECONOMIC LIFE: 30 YEARS

COST OF FUEL: 1·160 SOMALI SHIL PER LITRE

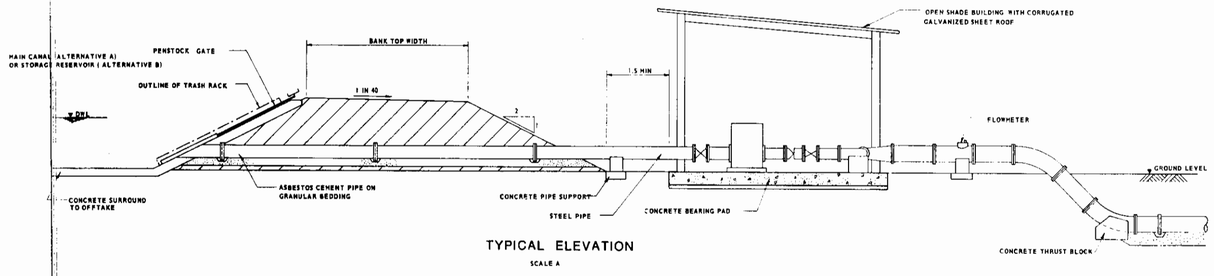
PIPE DIAMETER METRES	COST PER METRE SOMALI S
0.100	89.800
0.150	128.800
0.200	197.100
0.225	229.100
0.250	253.800
0.300	319.500
0.350	417.800
0.400	505.200
0.450	604.700
0.500	754.600
0.600	949.500
0.700	1219.600
0.750	1356.300

DIGITAL PROFILE OF PIPE NETWORK

REACH D/S	REACH U/S	LENGTH	DISCHARGE	PIPE DIAMETER	FLOW VELOCITY	D/S VALVE OR FITTING	D/S GROUND LEVEL	D/S HEAD	U/S HEAD	D/S RESIDUAL
9	8	325	0.017	0.150	0.97		10.25	44.25	46.13	34.00
8	7	325	0.034	0.200	1.09	G-VALVE	10.25	46.14	47.79	35.89
7	6	310	0.034	0.200	1.09	ELBOW	10.25	47.83	49.40	37.58
6	5	230	0.068	0.250	1.39	TEE	10.25	49.58	50.99	39.33
5	4	80	0.137	0.300	1.94	TEE	10.00	51.33	52.05	41.33
4	3	155	0.171	0.350	1.78	TEE	10.00	52.34	53.33	42.34
3	2	250	0.171	0.350	1.78	ELBOW	10.00	53.45	55.05	43.45
2	1	420	0.205	0.400	1.63	TEE	10.00	55.30	57.26	45.30
12	11	325	0.017	0.150	0.97		10.00	48.56	50.44	38.56
11	10	325	0.034	0.200	1.09	G-VALVE	10.00	50.45	52.09	40.45
10	2	580	0.034	0.200	1.09	ELBOW	10.00	52.13	55.05	42.13
14	13	325	0.017	0.150	0.97		10.00	48.51	50.39	38.51
13	4	325	0.034	0.200	1.09	G-VALVE	10.00	50.40	52.05	40.40
16	15	325	0.017	0.150	0.96		10.00	45.89	47.75	35.89
15	6	325	0.034	0.200	1.09	G-VALVE	10.25	47.76	49.40	37.51
19	18	325	0.017	0.150	0.97		9.75	45.43	47.31	35.68
18	17	325	0.034	0.200	1.09	G-VALVE	10.00	47.32	48.97	37.32
17	5	170	0.068	0.225	1.72	TEE	10.00	49.24	50.99	39.24
21	20	325	u.u17	0.150	0.97		10.25	45.43	47.31	35.18
20	17	325	0.034	0.200	1.09	G-VALVE	0.20	47.32	48.97	47.12

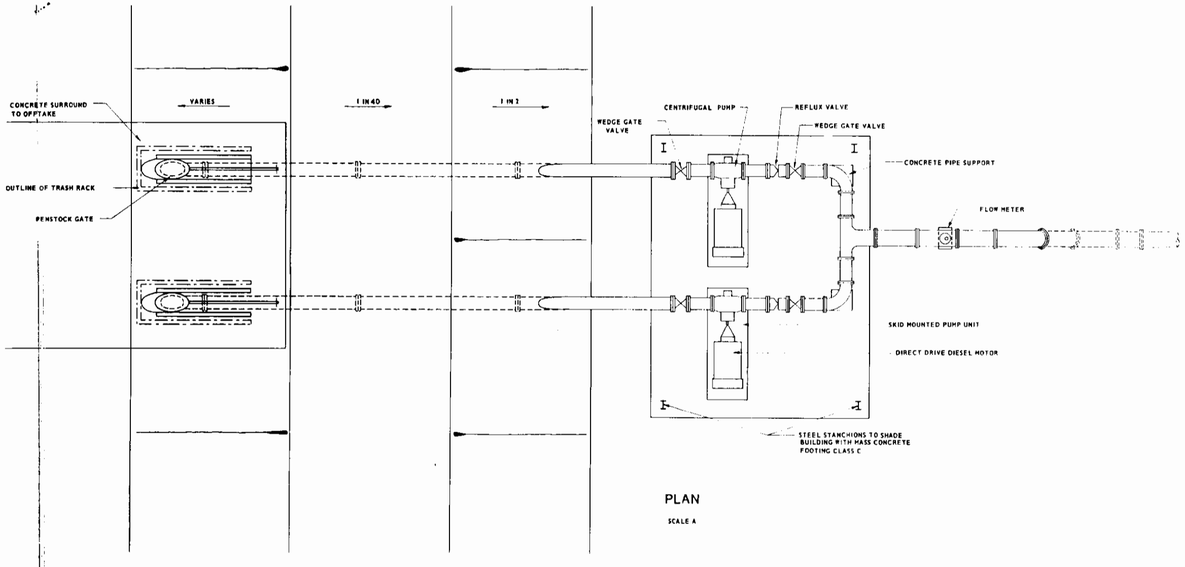
SUMMARY OF SYSTEM

PIPE DIAMETER	TOTAL LENGTH METRES	TOTAL COST SOMALI S
0.100	0	0
0.150	1950	251160
0.200	2840	559763
0.225	170	38947
0.250	230	58374
0.300	80	25560
0.350	405	169209
0.400	420	212184
0.450	0	0
0.500	0	0
0.600	0	0
0.700	0	0
0.750	0	0
TOTALS	6095	1315200



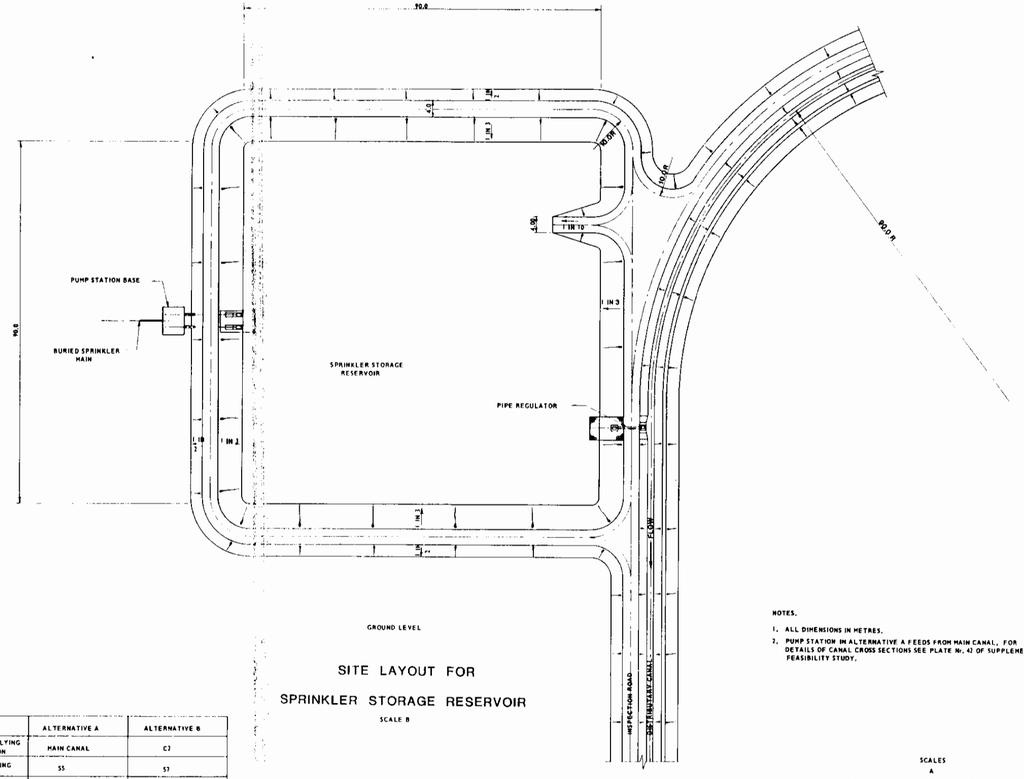
TYPICAL ELEVATION

SCALE A



PLAN

SCALE A



GROUND LEVEL

SITE LAYOUT FOR

SPRINKLER STORAGE RESERVOIR

SCALE B

	ALTERNATIVE A	ALTERNATIVE B
CANAL SUPPLYING PUMP STATION	MAIN CANAL	C7
TOTAL PUMPING HEAD (m)	55	57
TOTAL DISCHARGE (m^3/s)	0.28	0.21

NOTES.

1. ALL DIMENSIONS IN METRES.
2. PUMP STATION IN ALTERNATIVE A FEEDS FROM MAIN CANAL. FOR DETAILS OF CANAL CROSS SECTIONS SEE PLATE Nr. 42 OF SUPPLEMENTARY FEASIBILITY STUDY.

SCALES

A

m 1 0 1 2 3 4 5 m

B

m 10 0 10 20 30 40 50 m

MOGAMBO IRRIGATION PROJECT
TYPICAL SPRINKLER PUMP STATION

PLATE Nr. 7

MARCH 1980

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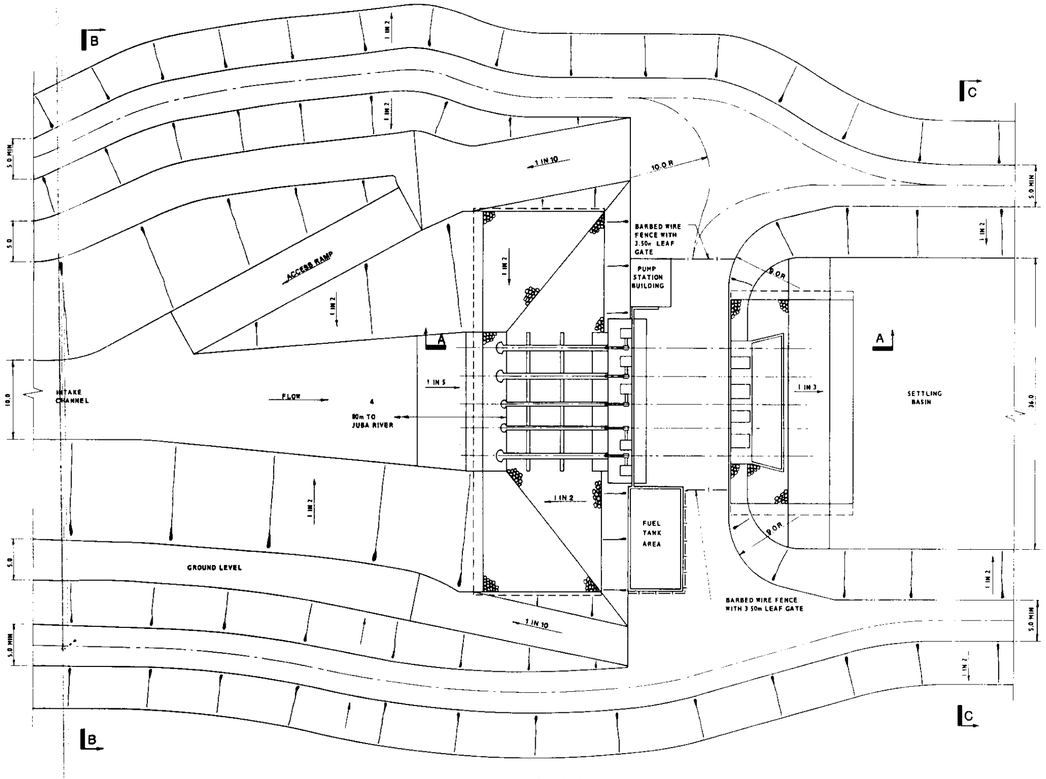
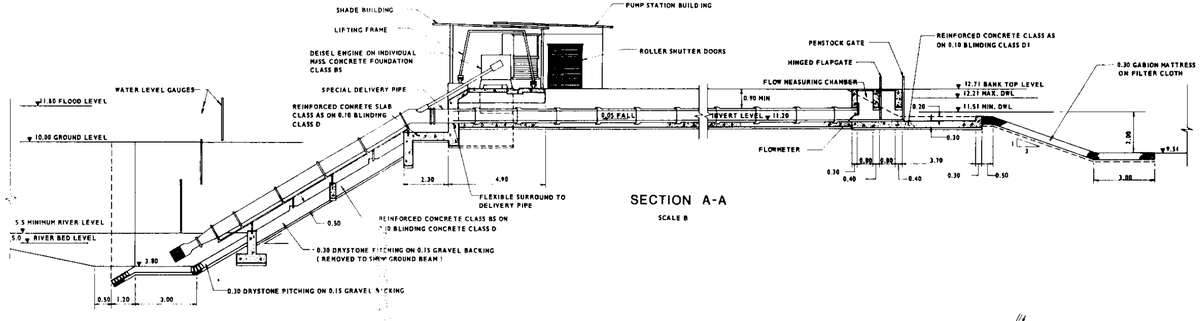


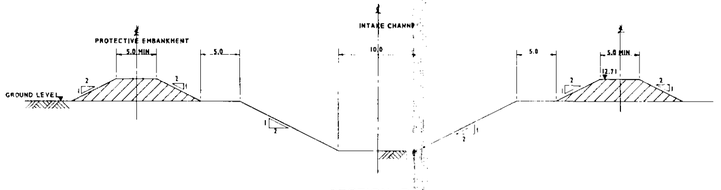
SITE PLAN

SCALE A



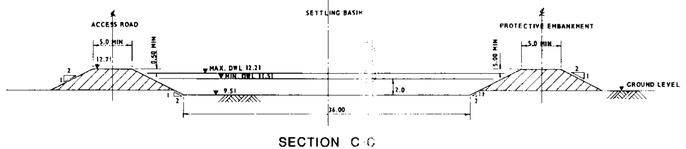
SECTION A-A

SCALE B



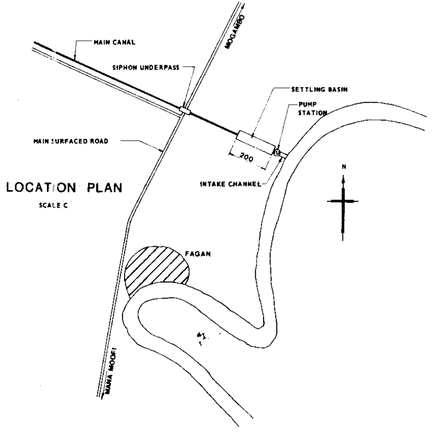
SECTION B-B

SCALE A



SECTION C-C

SCALE A



LOCATION PLAN

SCALE C

NOTES.

1. ALL DIMENSIONS IN METRES.
2. ALL EMBANKMENT SLOPES TO BE 1 IN 2 UNLESS OTHERWISE SHOWN.
3. FOR DETAILS OF RIVER CROSS SECTIONS SEE FIG. 7.3 ANNEX I OF SUPPLEMENTARY FEASIBILITY STUDY

SCALES

A

m 5 0 5 10 15 20 25 m

B

m 0 1 2 3 4 5 6 7 8 9 10 m

C

m 100 0 100 200 300 400 500 600 700 800 900 1000 m

MOGAMBO IRRIGATION PROJECT
ALTERNATIVE B : MAIN IRRIGATION PUMP STATION

PLATE Nr. 6

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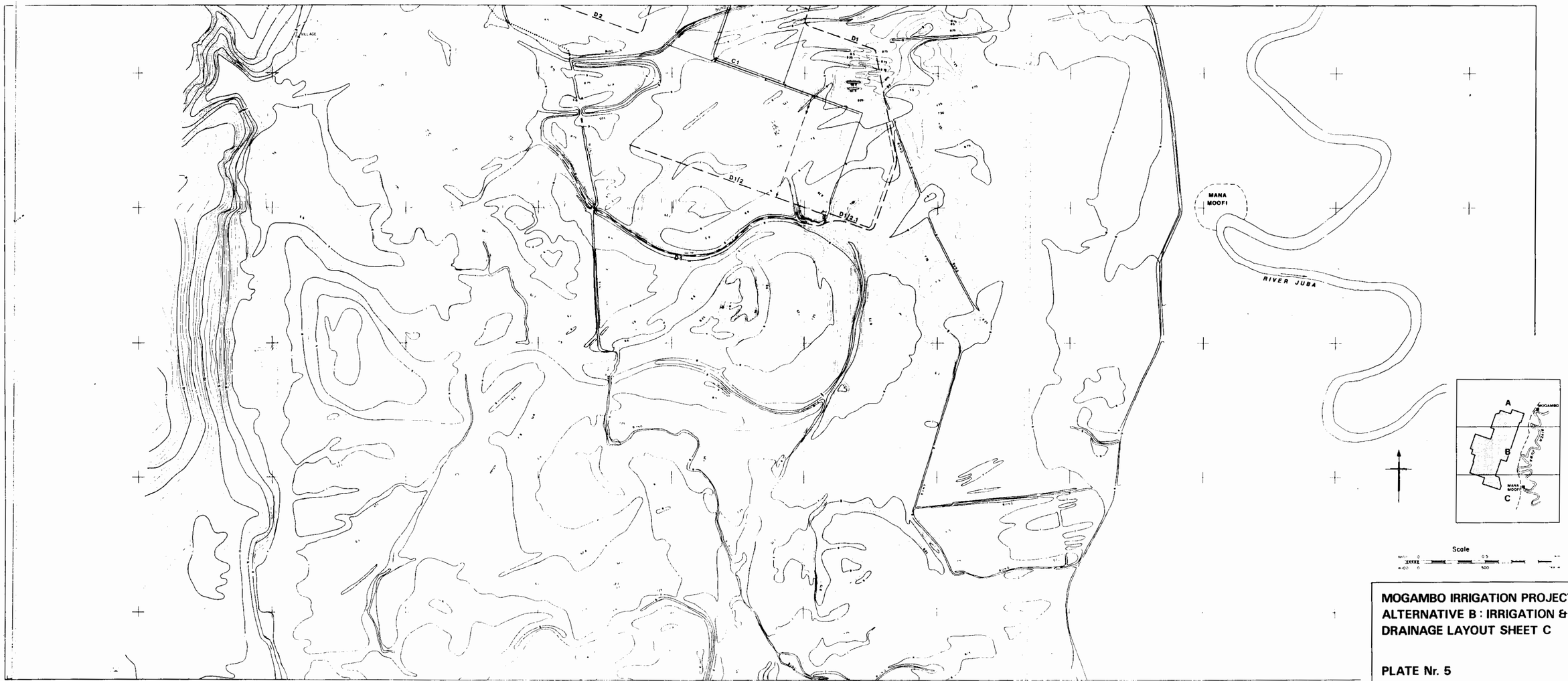

MOGAMBO IRRIGATION PROJECT
ALTERNATIVE B : IRRIGATION & DRAINAGE LAYOUT SHEET C

PLATE Nr. 5

MARCH 1980

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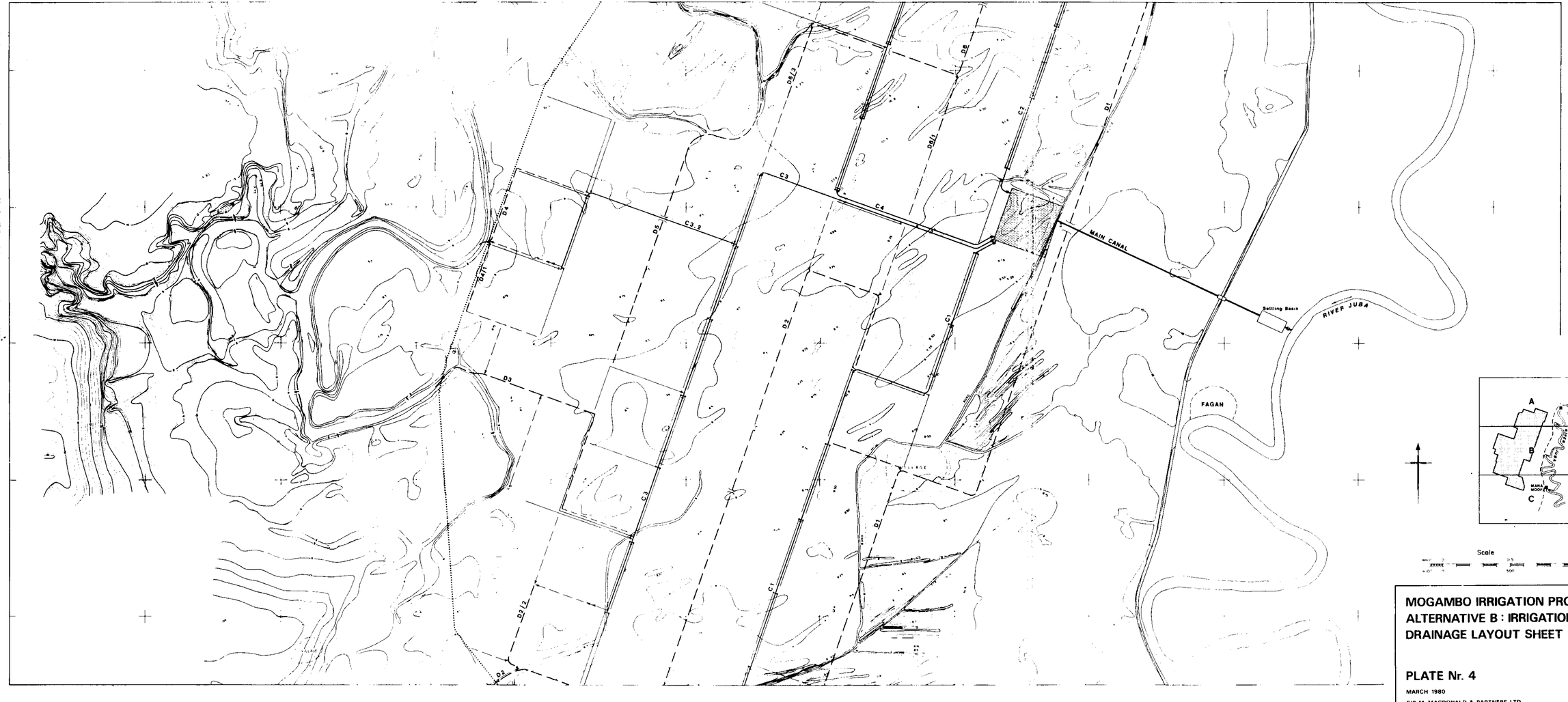

MOGAMBO IRRIGATION PROJECT
ALTERNATIVE B : IRRIGATION & DRAINAGE LAYOUT SHEET B

PLATE Nr. 4

MARCH 1980

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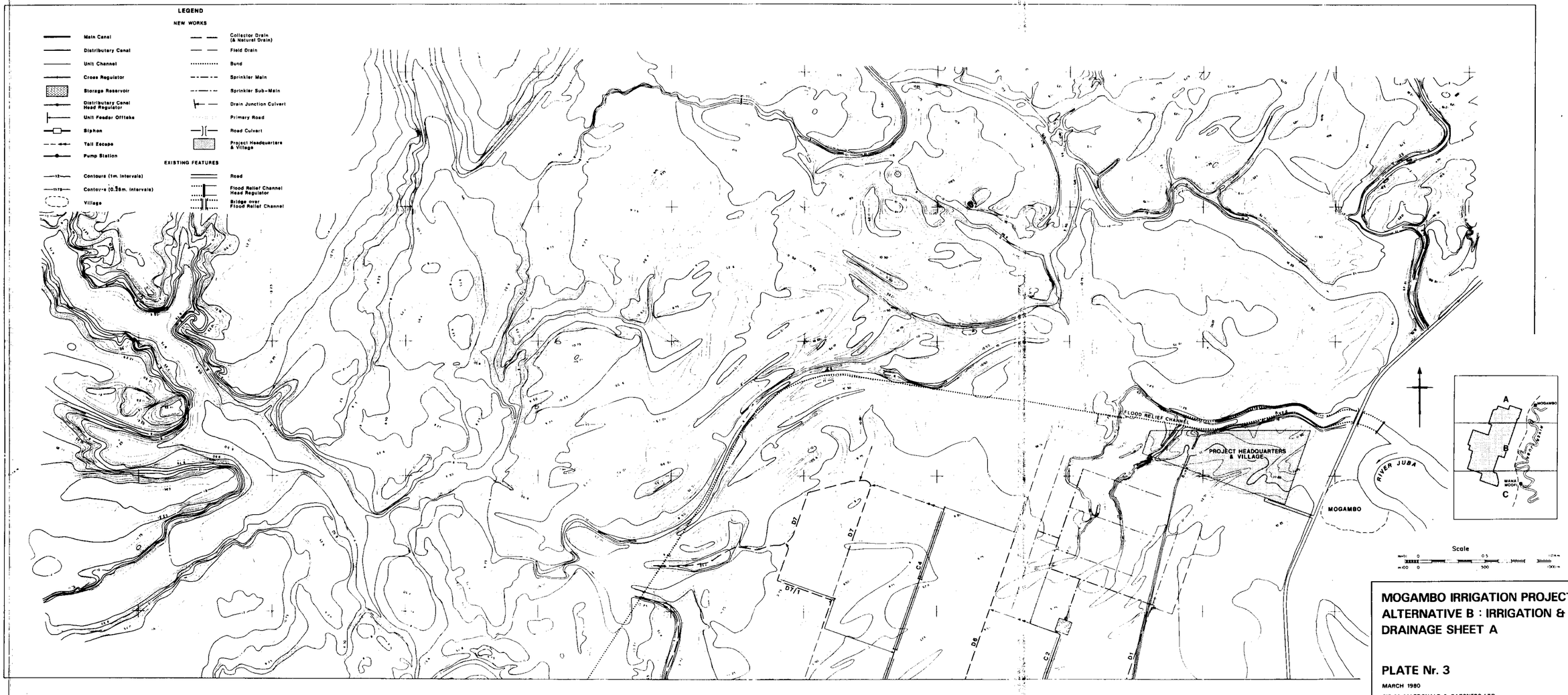

MOGAMBO IRRIGATION PROJECT
ALTERNATIVE B : IRRIGATION & DRAINAGE SHEET A

PLATE Nr. 3

MARCH 1980

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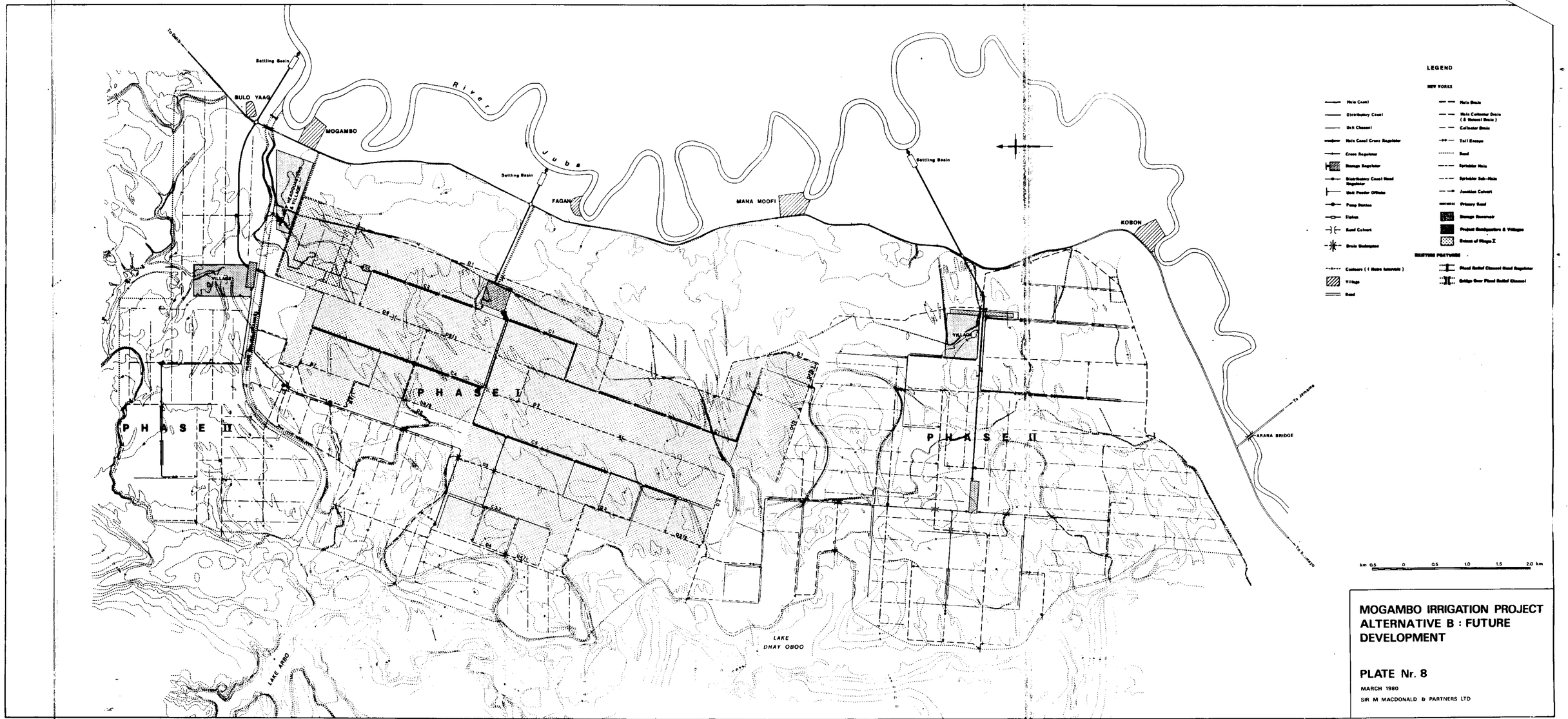

MOGAMBO IRRIGATION PROJECT
ALTERNATIVE B : FUTURE DEVELOPMENT

PLATE Nr. 8

MARCH 1980

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APPENDIX VIII

PLATES

Plate Nr	
1	Alternative A: Irrigation and Drainage Layout (1 : 20 000)
2	Alternative B: Irrigation and Drainage Layout (1 : 20 000)
3	Alternative B: Irrigation and Drainage Layout Sheet A
4	Alternative B: Irrigation and Drainage Layout Sheet B
5	Alternative B: Irrigation and Drainage Layout Sheet C
6	Alternative B: Main Irrigation Pump Station
7	Typical Sprinkler Pump Station
8	Alternative B: Future Development