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TANA RIVER FEASIBILITY STUDIES

MASINGA AND BURA AREAS

T H E   B U R A   A R E A

Volume II - Technical Annexes

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I L A C O
INTERNATIONAL LAND DEVELOPMENT CONSULTANTS B.V.
Arnhem, the Netherlands

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1 GENERAL

In the study, data of three meteorological stations situated near the Bura area, have been used. Their records cover short periods only and are not very reliable; some information about these stations is given in Table A.1.

Table A.1 - Meteorological stations used in the study

Station	Index	Periods recorded	Altitude	Distance from the project area	Data used in:
Bura	9139000	1920, 1923-1930 and 1967-1971	93 m	12 km eastward	rainfall calculations
Hola	9140005	1963-1970	65 m	40 km southward	evaporation calculations
Tana	9140006	1966-1970	68 m	38 km southward	comparison only

Unfortunately, recording at Bura was discontinued from 1930 to 1967 so that only data of 14 years could be used. The Hola and Tana stations lying very close together, the Hola station was selected because of its longer and more reliable period of recording. The evaporation calculated at each of the stations showed very little difference.

The data of the Bura rainfall station have been used only for calculation of the effective rainfall, the other calculations have been based on Hola figures. All the data used in this annex have been obtained from the East African Meteorological Department (1 and 2). The data have been summarized in Table A.5.

It is strongly recommended that one meteorological station, recording temperatures, humidity, sunshine, radiation, wind speed, rainfall and evaporation should be established in the Bura area; in addition, a number of rain gauges should be installed.

2 RAINFALL

2.1 Annual rainfall

Table A.2 shows the annual rainfall of those years for which records are available for all the three stations (1967-1970).

Table A.2 - Annual rainfall (mm) at Bura, Hola and Tana from 1967-1970

Year	Bura	Hola	Tana
1967	394.0	records incomplete	630.7
1968	801.5	701.6	1,019.8
1969	274.4	497.1	628.7
1970	260.5	276.5	183.9

The differences between the figures for Hola and Tana, which lie only 3 km apart, illustrate the variation in rainfall records. Whether this is due to actual differences from place to place or to inaccurate recording could not be traced.

2.2 Seasonal rainfall

Like in the whole of East Africa, the Bura area has two rainy seasons, i.e. from March to May and from October to December. The rainfall is low and very erratic, with large variations between months of different years, between annual totals, and also from place to place.

The average monthly rainfall recorded at the Hola and Bura stations is given in Table A.5.

2.3 Daily rainfall

As the data of daily rainfall of the Bura station covered a limited number of years only, those of the Hola station had to be used to calculate heavy daily rainstorms, based on the relevant data of the Lower Tana report; the one-day rainfall has been used, which means that the drainage system should be able to discharge the full maximum rainfall within 24 hours.

Table A.3 - Recurrence intervals of maximum rainfall, as calculated for the Hola station

1 out of 10 years	81.3 mm
1 out of 5 years	63.5 mm
1 out of 3 years	52.1 mm

3 TEMPERATURE

Temperatures in the area are very high; extreme maximum temperatures of 40° C have been recorded. The hottest period is in February and March, lower temperatures occur in June, July and August due to the overcast weather in these months.

The minimum temperatures are also high, almost always over 20^{o}C. Average temperatures are given in Table A.5. Temperature is no restriction for those crops anticipated to be grown in the area at any time of the year.

4 SOLAR RADIATION

Duration of sunshine hours has not been recorded at either the Hola or the Tana station. Solar radiation was measured with a Gunn-Bellani radiation integrator. Radiation is high from December till March and low from June till August. The low values may reduce growth, but this has not been established experimentally. Cotton grown at Hola during this period produced high yields, but generally for rice, lower yields must be expected during this season than in the October to January period.

5 HUMIDITY

The relative humidity varies from 60 to 70%, with a value of 70-80% at 09.00 E.A.S.T. and of 45 to 55% at 15.00. The average monthly figures vary only slightly over the year. Average dew point values, as used in the evaporation calculations, are given in Table A.5.

6 WIND SPEED

Wind speed at Bura is rather high, varying from 80 to 135 miles per day. Occasionally, heavy dust storms occur. The prevailing wind directions are South from May till November, when the strongest winds prevail, North and East in December and January, and East to South during February till April.

7 EVAPORATION

The Penman estimate of open-water evaporation was calculated by a method developed for East Africa by McCulloch (4), using Hola meteorological data. As no sunshine hours have been measured at Hola, the relation of actual to maximum possible sunshine hours ($\frac{n}{N}$ in the Penman formula) has been derived from the relation of actual to maximum possible solar radiation. This is a reasonable approximation, but it may over-estimate this factor during the overcast months of June, July and August, and under-estimate the evaporation during these months. The differences will, however, be small.

The calculated monthly open-water evaporation for both the Hola (8 years) and the Tana (5 years) stations is given in Table A.4. For the calculation of the water requirements only the Hola figures have been used.

Table A.4 - Penman estimate of open-water evaporation, Bura area (mm)

Month	Hola station	Tana station
January	217.8	206.8
February	201.0	203.6
March	231.9	228.5
April	198.3	193.8
May	196.5	191.9
June	176.1	174.9
July	176.1	183.2
August	181.4	188.5
September	185.4	199.2
October	203.4	222.0
November	194.1	196.8
December	208.3	200.0
Total	2,370.3	2,389.2

Table A.5 - Meteorological data for the Bura area (based on data of Hola and Bura stations)

Month	Max. temp. °C	Min. temp. °C	Mean temp. °C	Dew-point °C	Sunshine hours	Solar radiation $cal/cm^2/day$	Windspeed miles/day	Rainfall Hola mm	Rainfall Bura mm
January	34.7	22.4	28.6	23.0	not recorded	544	80	28.5	16.2
February	35.5	22.8	29.2	23.6		568	80	16.0	5.0
March	35.0	23.6	29.3	24.4		586	94	41.5	53.5
April	33.5	23.6	28.6	24.1		520	109	71.3	93.8
May	32.8	22.8	27.8	23.1		496	128	38.3	21.6
June	32.3	21.7	27.0	22.8		471	131	26.3	11.9
July	31.9	20.9	26.4	22.2		459	132	20.6	6.8
August	32.0	20.6	26.3	22.1		474	136	12.4	4.3
September	32.7	20.5	26.6	22.9		504	136	40.2	7.7
October	33.6	21.8	27.7	23.7		524	126	32.0	28.0
November	33.5	22.7	28.1	24.1		532	83	90.3	101.6
December	34.2	22.6	28.4	23.8		550	74	55.2	65.7
								472.6	415.8
Years	8	8	8	8		8	5	11	14

LIST OF REFERENCES

1. East African Meteorological Department. Meteorological data recorded at Agricultural, Hydrological and other stations in Kenya during the years 1963-1969. E.A. Met. Dept., E.A. Community, Nairobi, 1965, 1967, 1969.

2. Summary of rainfall in Kenya for the years 1958, 1959, ... 1970 East African Met. Dept., Nairobi, 1958-1970.

3. FAO/ILACO/ACRES, Survey of the Irrigation Potential of the Lower Tana River Basin, 1967.

4. J.S.G. McCullogh - Tables for the rapid computation of the Penman estimate of evaporation. E.A. Agr. and For. J., January 1965.

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1 GENERAL CHARACTERISTICS OF THE TANA RIVER

The source for irrigation of the Bura scheme is the Tana river, which has enough discharge to meet the scheme's irrigation requirements.

The catchment area of the Tana river is generally divided into three parts: the upper catchment area upstream the Kamburu suspension bridge, the middle catchment area between the Kamburu and Garissa bridges and the lower catchment area south of the Garissa bridge.

In the upper catchment area, discharge mainly originates from tributaries descending Mount Kenya and the Aberdares. The main tributary is the Thika river. Although this river is partly fed by snowfields and glaciers in the upper catchment, the main part of the discharge is caused by direct runoff of rainwater and groundwater supply. The average yearly rainfall ranges from 750 to 2,100 mm. The soils are of volcanic origin and vary considerably in depth. They provide a sizeable groundwater reservoir resulting in a gradual decrease after peak discharges. On the other hand, increases in discharges can occur rather suddenly.

In the middle catchment area, the average yearly rainfall is less than 400 mm a year; in the lower catchment area it is increasing again.

For the Bura Irrigation Scheme, the lower tract of the Tana river is only important. Between Garissa and Bura it meanders through flood plains at a fairly gentle, average slope of about 0.46 pro mille. The flood plains vary in width from an average of about 3 km at Garissa to almost 8 km near Bura.

2 RIVER DISCHARGES

Gauging of the Tana river started in the 1920s, but although a large number of recording stations has been installed since, only a few of them have records suitable for engineering purposes.

One of the stations, 4G1, located near Garissa has been in operation since 1934. The reliability of the measurements taken in the first years is, however, questionable, since at that time natural adjustments of the river section at the site affecting the relationship between river stage and discharge were not closely observed. The drainage area of the Tana river at the site of station 4G1 is 31,700 sq.km. The station is located 57 km upstream the proposed site of the gravity intake and 80 km upstream that of the pumping intake (see for these locations Annex E, Section 3).

Another important station is 4G4 near Lahza, which is situated 115 km downstream the gravity intake and 92 km downstream the pumping intake. There are records from 1953 onwards, but the available rating curve is valid only from about 22 to 350 m^3/sec. Water levels caused by discharges of over 350 m^3/sec have not been recorded.

A third observation site is near Korokora where an automatic recorder - 4G6 - was installed in 1965. The station is located 25 km upstream the gravity intake site. A rating curve is not available.

In our statistical calculation of the maximum and minimum water flows to be expected at the intake sites, we have only used the recordings at station 4G1. When comparing these runoffs with the discharges measured at Lahza, we have come to the conclusion that the increase in flows between Garissa and the intake sites is negligible. Considering the unreliability of the early recordings at station 4G1, the daily records of the last 16 years have been used to compute the probability of occurrence of maximum and minimum yearly flows. In doing so, we have assumed that the probability of occurrence of the maximum yearly flows follows a Gumbel-I distribution (see Figure B.1). The yearly maximum flows to be expected based on the frequency distribution found will be:

Q 2,600 m^3/sec (return period 50 years);
Q 2,900 m^3/sec (return period 100 years).

The probability of occurrence of the minimum flows has been computed accepting the Gumbel-III distribution (see Figure B.2). The yearly minimum flows to be expected are then:

Q 31 m^3/sec (return period 5 years);
Q 27 m^3/sec (return period 10 years).

For the calculated monthly average discharges, the monthly minimum flows with a return period of 10 years and the monthly maximum flows with a return period of 100 years, we refer to Table B.1.

In general, floods exceeding 1,000 m^3/sec are likely to occur in the periods April-June and October-December. Minimum flows less than 50 m^3/sec can be expected in the periods January-April and August-November, while extremely low flows (less than 30 m^3/sec) may occur mainly during March.

We must keep in mind that the Kamburu dam will influence the flows mentioned in that the minimum and maximum flows will be less pronounced. This will have only a positive effect on the water availability.

3 RIVER STAGES AT THE PROPOSED INTAKE SITES OF THE BURA SCHEME

To define the design water levels at the proposed intake sites, water levels at the site were observed and velocities roughly measured at two times in October 1972. Later on, in March 1973, measurements were made for a third time. Based on these data, the derived discharges and the cross-sections measured (see Figure E.2 and Figure E.11), tentative stage-discharge and stage-velocity relations have been determined. These relations are not very reliable, however, especially not for extremely high discharges, for which several assumptions had to be made.

Based on these calculations we have arrived at a low low-water level at the gravity intake of 108.90 m (357.3 feet, return period 10 years) and a high high-water level of 115.45 m (378.8 feet, return period 100 years). At the pumping intake, these levels have been assumed to be 96.93 m (318 feet) and 102.72 m (337 feet) respectively (see Fig. B.3).

LOWER TANA RIVER - PROBABILITY OF OCCURRENCE MAXIMUM ANNUAL FLOW AT R.S. 4G1 - GARISSA

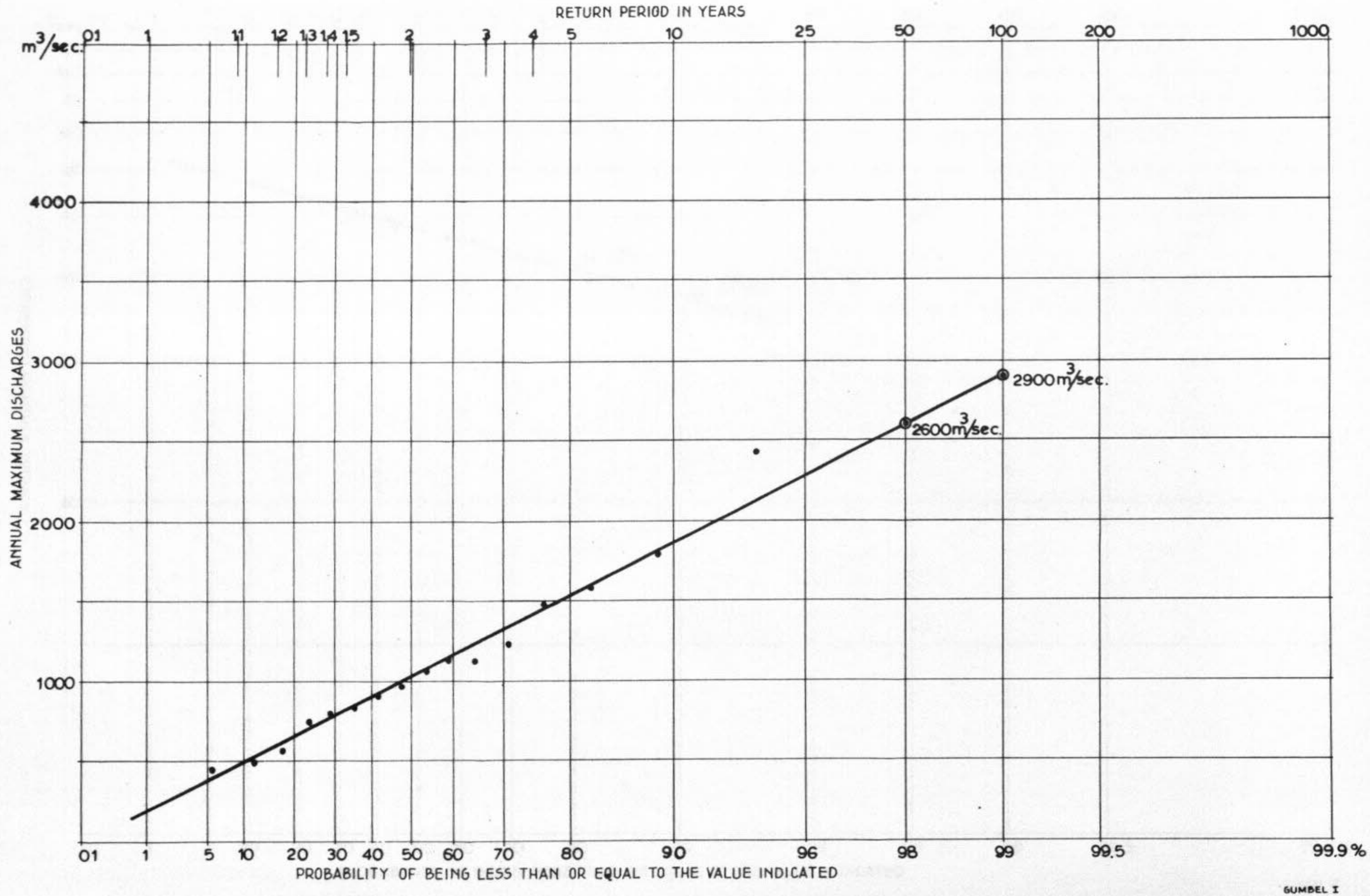

FIG. B.1

BURA

LOWER TANA RIVER - PROBABILITY OF OCCURRENCE MINIMUM ANNUAL FLOW AT R.S. 461 - GARISSA

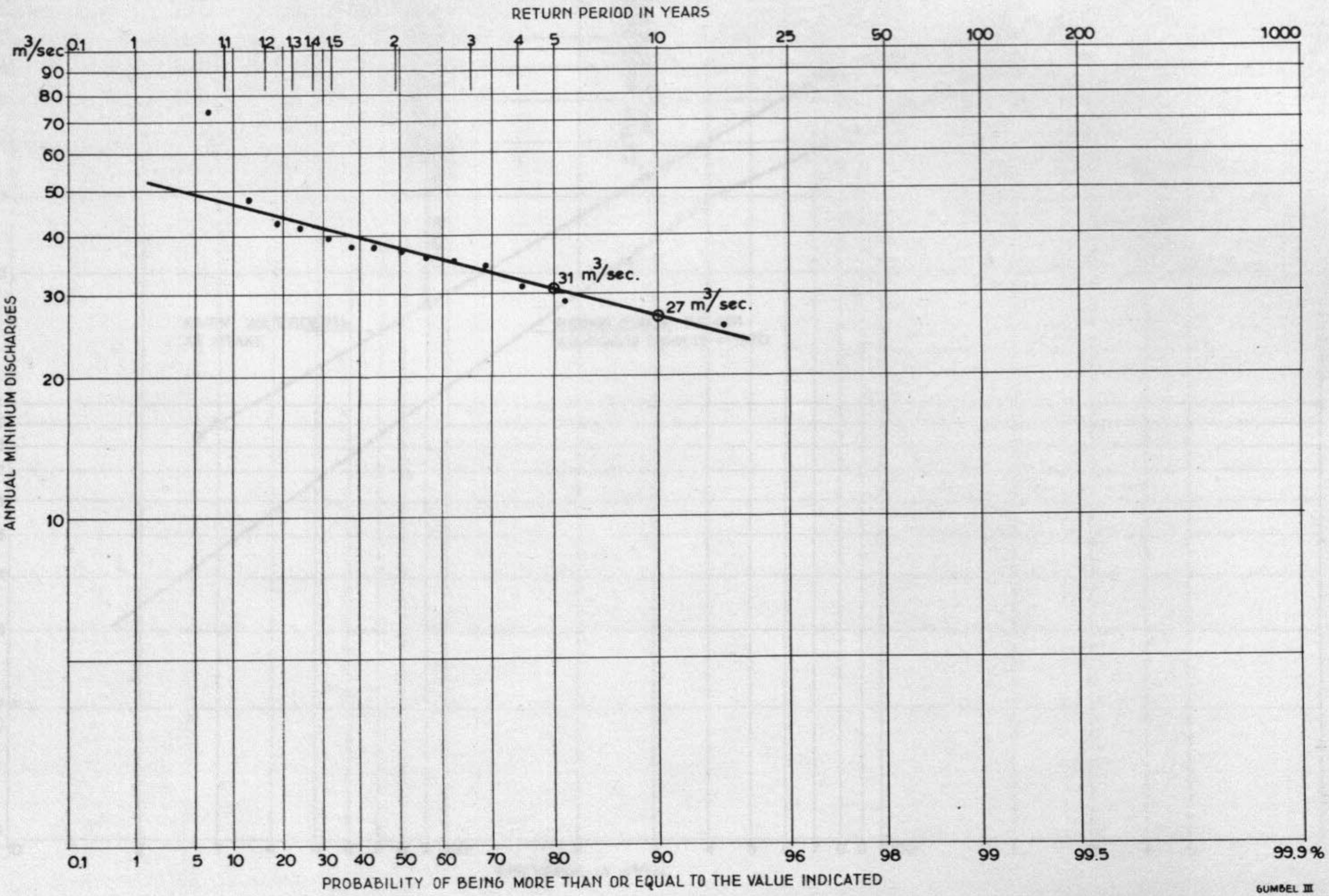

FIG. B.2

BURA

BURA INTAKE , WATER DEPTH AT R.S. 4G1

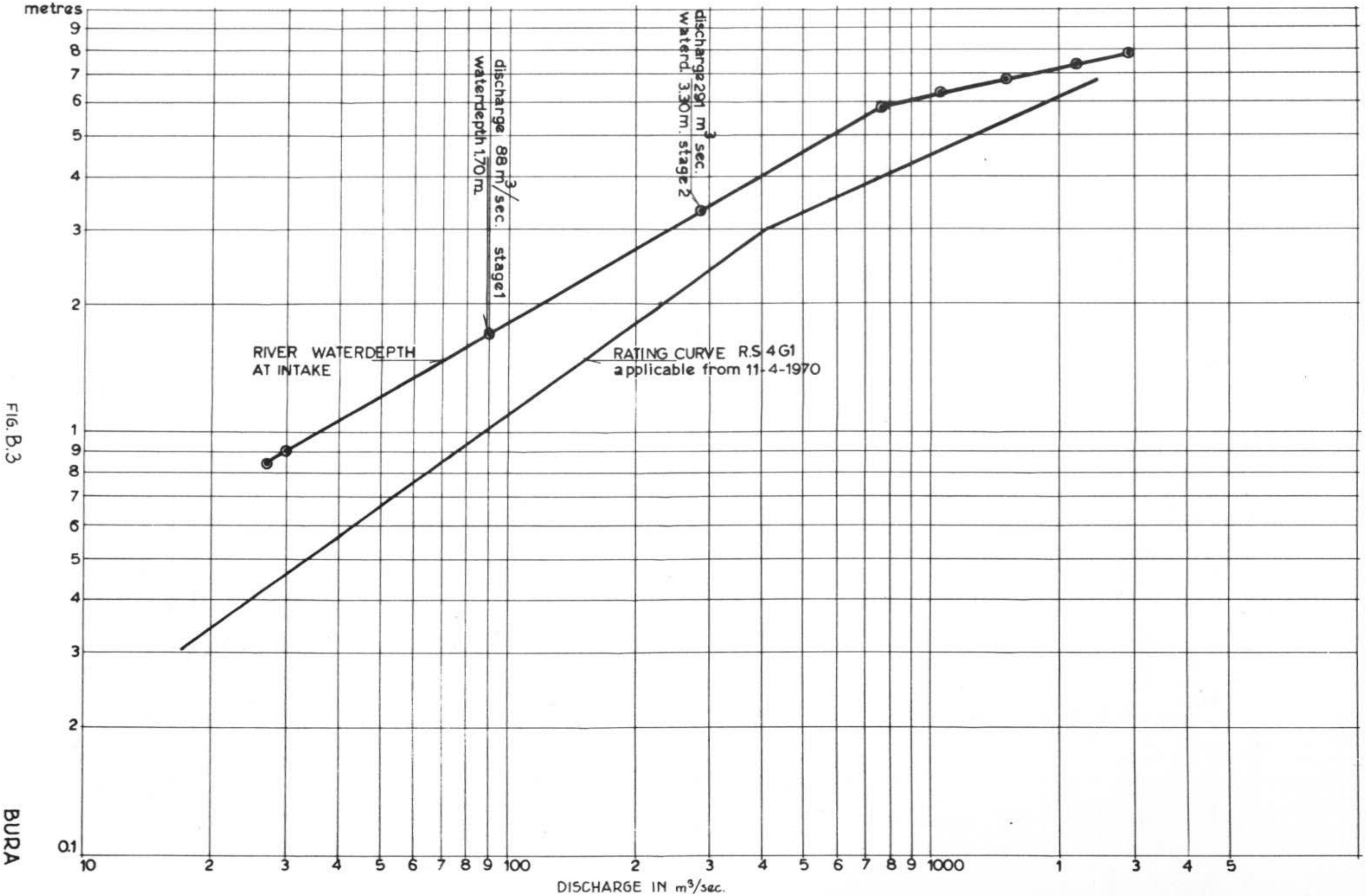

FIG. B.3

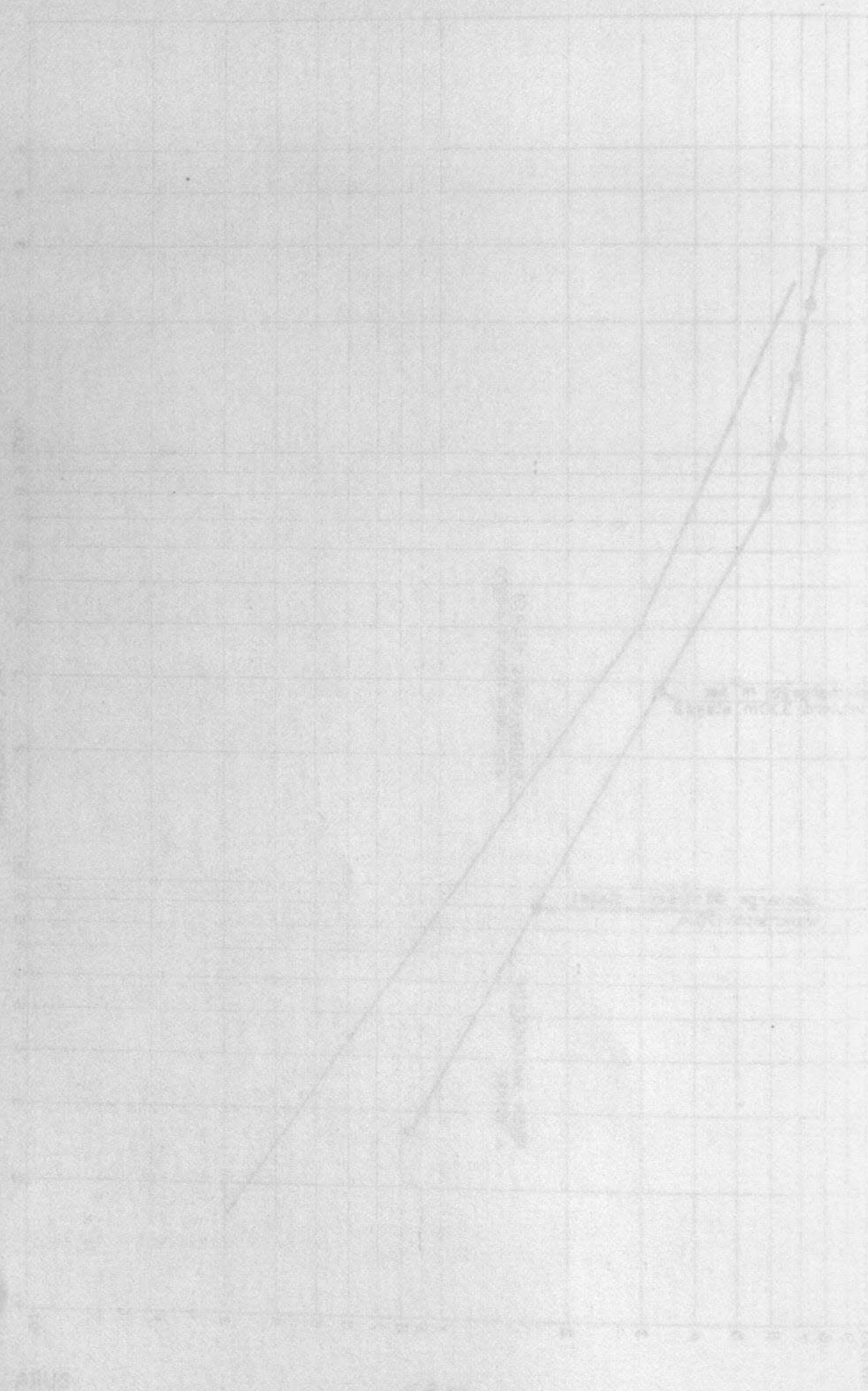

Table B.1 - Probability of occurrence of average, minimum and maximum monthly flows at station 4G1 - Garissa

Month	Average flow (m^3/sec)	Minimum flow (m^3/sec) p = 0.10	Maximum flow (m^3/sec) p = 0.01
January	141	42	2,090
February	86	33	320
March	102	28	670
April	277	37	2,000
May	491	91	2,340
June	219	75	1,320
July	120	64	380
August	91	47	270
September	77	45	260
October	118	33	2,850
November	379	38	2,900
December	298	58	2,700

We do not consider these data to be accurate enough. Therefore, once a decision has been made on the alternative to be adopted, i.e. pumping or gravity intake, additional daily measurements of river stages at the proposed intake site should be started as soon as possible. For the stage-discharge relation, the recordings of station 4G1 near Garissa can be used, or, to be more accurate, measurements should be made at the site proper.

4 WATER QUALITY

The sediment load of the water of the Lower Tana river is mainly silt, the content of which builds up with increasing discharges. During extremely low discharges, the silt content of the water may range between 200 and 300 p.p.m. (m gr/l) while at discharges of 100 m^3/sec, 400 to 500 p.p.m. can be expected. For discharges of some 1,000 m^3/sec. a silt/fine sand content ranging from 700 to 3,000 p.p.m. has been found. This wide diversification is undoubtedly due to the varying degree of erosion in the catchment area. Clearly, building storage dams in the upper part of the Tana river will affect the sediment transport in the river.

Data of the chemical composition of the Tana river water have been taken from the Lower Tana Report (1). The water of the Tana river is classified as low-salinity, low-sodium water with an average EC value of 215 micro-mhos/cm and an average S.A.R. of 0.6. The average residual sodium carbonate content is 0.4 ME per litre, the boron content is 0.07 p.p.m., which values are both well below the danger range; the iron content is negligible. Although the water of the Tana river is of excellent quality for irrigation, it does contain some salts, which makes leaching necessary. Determinations at Hola have demonstrated that this happens indeed; the salts are leached from the upper horizons (to about 1 m) and accumulate in the deeper layers.

REFERENCE:

FAO (Acres, ILACO), Survey of the irrigation potential of the Lower Tana River Basin, 1967.

ANNEX C

SOILS

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SOILS

1 PURPOSE OF THE SURVEY

In 1963, a detailed soil survey was made in an area near Bura covering approximately 4,000 ha. The area was intended for the establishment of a Research and Training Centre on irrigated agriculture. A detailed soil map and suitability map were prepared at a scale of 1 : 10,000. As regards their suitability for irrigated agriculture, the soils were divided into 5 classes, viz. highly suitable (class 1), well suitable (class 2A), suitable (class 2B), fairly suitable (class 3), marginally suitable (class 4A) and unsuitable (class 4B).

During the present study, only the physical and chemical data of the problem soils, i.e. the fairly and marginally suitable soils, have been reviewed.

The area north of L. Hiraman and south of that mapped for the Research and Training Centre presented some problems, because the boundaries of the detailed suitability classes for the Centre, scale about 1 : 10,000, did not fully coincide with those of the semi-detailed survey at a scale of about 1 : 50,000; minor adjustments had to be made.

2 GEOLOGICAL INFORMATION

Sub-section 6.2.1 of Volume 3 of the Lower Tana River Basin Survey Report (ACRES-ILACO, 1967) describes the geology of the area. The superficial deposits intended for irrigated agriculture are of Tertiary and Quaternary origin. After a peneplain had formed in mid-Tertiary, an uplift of the whole continent has taken place. Subsequently, it was warped and flooded by the sea, while Lower Pliocene deposits were laid down. In Quaternary times, the rivers incised further and seasonal streams as the L. Hiraman were cut in the plain. The salts of the area are, therefore, of ancient marine origin.

3 WORKING METHOD

In the survey, the detailed soil map, scale approximately 1 : 10,000, of the Lower Tana River Basin Report of January 1967 was used. The fairly suitable soils represented by the Natric Grumusterts (GU2), Vertic Hapludents (U2) and Vertic Natrargids (N42) and the marginally suitable soils represented by the Typic Natrargids (N1, N21) have been investigated.

In the area occupied by these units, field investigations have been made. Detailed soil descriptions have been made of soil pits and samples have been taken for physical and chemical determinations. Core samples have been taken in the selected units to determine the amount of available moisture; this has been done at the Irrigation Research Station at Ahero. Soil-chemical analyses have been conducted at the National Agricultural Laboratories in Nairobi.

By the end of January 1973 the National Agricultural Laboratories let us know that all analytical data requested could not be provided in good time because of limitations in laboratory capacity. The trends of the data received so far proved to be in line with our expectations.

4 SOILS

4.1 Description of the soil mapping units and the suitability for irrigated agriculture

The soils of the project area are of sedimentary origin. Part of the area is covered by young alluvial, very fine-textured deposits which belong to the Low Terrace of the Tana river. Another part of it belongs to the high-lying old alluvial mainland (High Terrace). The difference in elevation between the two terraces is very distinct. The soils of the High Terrace consist of sandy clay loam or sandy loam; those of the Low Terrace are dark-coloured, heavy, cracking clays.

Highly suitable soils (class 1)

The Typic Camborthids (C) belong to the highly suitable soils. They are situated in the relatively higher-lying flat areas and are well drained. The caliche is found at an average depth of approx. 1 m. Above this horizon the profile is practically lime-free. Generally, these non-saline non-alkali soils have a topsoil which is slightly more sandy than the subsoil; the latter consists mainly of clay and sandy clay.

Well suitable soils (class 2A)

The Typic Halorthids (S) and the Vertic Hapludents (U1) belong to this suitability class. The Typic Halorthids occur on the flat plateau. They have a non-saline non-alkali topsoil, approximately 0.40 m thick, changing in depth into a saline-alkali subsoil of blocky to prismatic structure. All the profiles contain lime.

They have a non-saline non-alkali topsoil of at least 0.75 m. The profiles show rather high clay percentages and contain a slight amount of lime.

Suitable soils (class 2B)

The strongly cracking, very heavy, clayey Natric Grumusterts (GU1) are found in the lower-lying flats of the Old Alluvial area. The non-saline non-alkali topsoil has a thickness of approx. 0.25-0.30 m. The soils contain lime throughout the profile.

Beside this soil unit, the Vertic Natrargids (N41) belong to the suitable soils. The Vertic Natrargids (N41) are found between the higher-lying Natrargids (N22, N31) and the lower-lying Natric Grumusterts (GU1). The natric horizon is found at a depth of 0.25 m or more below the soil surface. The prismatic natric horizon is approximately 0.25 m thick and overlies a saline-alkali subsoil, with a clay content of 45 to 70%. The topsoil varies from sandy clay loam to sandy clay. Lime is found throughout the profile.

The above soils do not pose any problems, so the work has been concentrated on the next two classes of soils.

Fairly suitable soils (class 3)

The soil units belonging to the fairly suitable soils are the Vertic Natrargids (N42), Natric Grumusterts (GU2) and the Vertic Hapludents (U2).

The Vertic Natrargids occur predominantly in the depressions between the ridges of the higher-lying Natrargids and on the fringes of the Natric Grumustert plains. The natric horizon is found within 0.20 m below the soil surface. Their profiles are not decalcified. The prismatic natric horizon is approximately 0.25 m thick. The subsoil is saline-alkali.

The Natric Grumusterts (GU2) can be compared with the GU1 soil units of the suitable soil class, from which they differ as regards the depth of the non-saline non-alkali topsoil. The natric horizon in this soil unit is generally found at a depth of 0.15 m. The GU2 soil unit occurs in the lowest parts of the Old Alluvial land; these soils are somewhat heavier than those of the GU1 unit. Lime is found throughout their profiles.

The low-lying Young Alluvial Vertic Hapludents (U2) form the river basin of the Tana river as well as the streambed of the L. Hiraman. This soil unit can be compared with the U1 unit. The only difference is that the non-saline non-alkali topsoil of the first unit is shallower than that of the U1 unit, which is 0.75 m.

Marginally suitable soils (class 4A)

To this suitability class belong the Typic Natrargids (N1 and N21). These units are found scattered over the area in the highest parts of the terrain as irregular, undulating ridges. They show a dense, impermeable, hard to very hard, bleached layer (hardpan) at varying depths, overlying a natric horizon with a low permeability. The N1 unit has a hardpan at a depth of 0.50 m or more below the soil surface, overlying a non-saline alkali horizon. If the hardpan is found between 0.20 and 0.50 m below the soil surface and overlies a non-saline alkali horizon, the area has been mapped as N21.

Unsuitable soils (class 4B)

No investigations have been made into the soils of this class, which includes the Typic Natrargids as described above but with a bleached layer (hardpan) within 0.20 m below the soil surface. These soils overlie a non-saline alkali horizon in the unit N22, while in soil unit N23, this bleached layer is poorly developed. The Mazic Natrargids also belong to this suitability class; they are always found next to unit N23 in strongly eroded bare patches and in superficial gullies which frequently occur between the Typic Natrargids. These profiles are truncated.

In soil unit N31, the saline-alkali horizon is found at 0.20 m or less below the soil surface; unit N32 has no saline-alkali horizon (colluvial layer) or a very shallow one. The topsoil is practically lime-free.

4.2 Soils of suitability class 3

4.2.1 Vertic Hapludent (U2)

As stated earlier, these soils lie in the valley of the Tana river as well as in the streambed of the L. Hiraman. They are relatively low-lying Young Alluvial soils, and are not flooded by the Tana river except during periods of high discharge. Periodically, they are inundated by the L. Hiraman and, therefore, these soils on both sides of the L. Hiraman have been classified as unsuitable (class 4B). Close to the L. Hiraman they are threaded by gullies and intensive levelling and proper protection against flooding would be needed if these soils were used for irrigated agriculture. On drying they crack intensively; the hydraulic conductivity is high, but after moistening, the cracks close and the soils become less permeable.

The depth of the non-saline non-alkali topsoil varies with the topography. The average thickness of this layer is 0.20 m. A representative profile has been described in Table C.1; the average physio-chemical characteristics of the unit have been summarized in Table C.2.

Table C.1 - Representative soil profile of Vertic Hapludent unit (U2)

Soil layer	1	2	3	4
Depth in cm	0-2	2-20	20-80	80-130
Texture	C	C	C	C
Consistence-actual	loose	hard/extremely hard	hard	very hard
Structure	moderate crumb medium	moderate prismatic coarse	moderate blocky medium and fine	weak blocky medium
Colour	7.5YR 3/2	7.5YR 3/2	7.5YR 3/2	10YR 4/2
Concretions	common $CaCO_3$ very fine	common $CaCO_3$ fine	abundant $CaCO_3$	abundant $CaCO_3$ + Mn
Mottles	-	-	few lime spots	few to abundant lime spots
Roots	common	common	few	rare
Boundary with next layer	clear smooth	gradual smooth	gradual smooth	
Remarks			abundant salt + gypsum crystals	abundant salt + gypsum crystals

Table C.2 - Average analytical data of Vertic Hapludent (soil unit U2)

Soil layer	1	2	3
Depth in cm	0-20	20-50	50-130
Percentage sand/silt/clay	24/14/62	28/9/63	29/10/61
pH 5 - H_2O	7.2	8.6	8.6
pH 5 - KCl	7.0	7.0	7.1
EC 5 mmhos/cm	0.27	0.39	1.00
C/N	5	-	-
Exchangeable cations:			
ME percentage Ca	36.3	65.9	24.0
" " Mg	16.6	23.1	15.6
" " K	2.46	2.31	2.10
" " Na	4.18	5.98	10.96
CEC ME percentage	52.7	49.4	48.0
Percentage base saturation	67.2	63.8	78.9
ESP	8.0	12.4	23.6

EC_5 = Electrical conductivity of the soil water (ratio 1 : 5) suspension in mmhos/cm
CEC = Cation Exchange Capacity in ME percentage
ESP = Exchangeable Sodium Percentage

4.2.2 Natric Grumustert (GU2)

This soil unit forms part of the heavy clay soils in the low-lying Old Alluvial mainland. These soils crack very strongly when they dry and they have a non-saline non-alkali topsoil layer of 0.15 m. When the alkali horizon is dry, it consists of very dense, prismatic structural elements that are separated from each other by wide cracks. Depending on the moisture content, these soils expand and contract considerably because of the montmorillonitic clay fraction. Under wet conditions, the alkali layer puddles and becomes muddy while the cracks disappear. During the dry season, part of the surface soil disappears in the cracks. At the start of the wet season most of the water runs into the cracks and remoistens the soil. Remoistening and swelling of these soils have caused shearing within the profile, and have produced slickensides and a wedge-shaped, or parallelepiped structure. The lime content in these soils increases with depth. A representative soil profile has been shown in Table C.3 while the average physio-chemical data have been listed in Table C.4.

Table C.3 - Representative soil profile of a Natric Grumustert (soil unit GU2)

Soil layer	1	2	3
Depth in cm	0-16	16-61	61-120
Texture	C	C	C
Consistence-actual	loose-soft	very hard	hard/slightly hard
Structure	moderate subangular blocky fine/medium	strong prismatic medium/coarse	moderate blocky medium
Colour	5YR 3/4	5YR 3/4	5YR 3/4
Concretions	few $CaCo_3$ very fine	abundant $CaCO_3$ very fine	abundant Ca-Mn, fine
Mottles	-	common lime fine	common lime very fine
Roots	common	few	rare
Boundary with next layer	clear smooth	clear smooth	diffuse smooth
Remarks			abundant salt crystals

Table C.4 - Average analytical data of a Natric Grumustert (soil unit GU2)

Soil layer	1	2	3
Depth in cm	0-16	16-61	61-120
% sand/silt/clay	31/14/55	29/12/59	26/12/62
pH_5 - H_2O	8.9	9.0	8.4
pH_5 - KCl	7.3	7.5	7.5
EC_5 mmhos/cm	0.35	0.91	3.88
C/N	9	-	-
Exchangeable cations:			
ME % Ca	36.7	29.2	29.3
" " Mg	11.6	14.2	15.8
" " K	2.19	1.87	1.74
" " Na	6.89	14.42	22.68
CEC ME %	48.2	48.2	48.3
ESP	14.7	31.9	46.8

4.2.3 Vertic Natrargid (N42)

The Vertic Natrargids are found in between the higher-lying Natrargids (Typic) and the lower-lying plains of the Natric Grumusterts. The Vertic Natrargids have some Vertisol tendencies. They have a rather high clay content, some weak cracks and a more or less prismatic structure. In this unit the natric horizon is found within 0.20 m below the soil surface. Compared with the Typic Natrargids (see Sub-section 4.2.4), they have a finer texture and are not decalcified. The subsoil is saline-alkali and the clay content varies between 35 and 65%. The topsoil contains more sand, the textural classes vary between sandy clay loam and clay. The silt percentage varies between 8 and 12. Lime is found throughout the profile.

A representative profile has been described in Table C.5, while the average physio-chemical characteristics have been summarized in Table C.6.

Table C.5 - Representative soil profile of Vertic Natrargids (soil unit N42)

Soil layer	1	2	3
Depth in cm	0-17	17-57	57-120
Texture	SCL/C	C	C
Consistence-actual	soft	extremely hard	hard
Structure	moderate crumb medium	moderate prismatic coarse	moderate blocky medium
Colour	5YR 4/4	5YR 3/4	5YR 4/4
Concretions	-	abundant $CaCO_3$, very fine	abundant $CaCO_3$ very fine
Mottles	-	few to common lime spots	
Roots	common	few	few to rare
Boundary with next layer	clear smooth	gradual smooth	
Remarks			common salt + gypsum crystals

Table C.6 - Average analytical data of Vertic Natrargid (soil unit N42)

Soil layer	1	2	3
Depth in cm	0-18	18-50	50-120
% sand/silt/clay	45/10/45	42/11/47	35/10/55
pH_5 - H_2O	8.7	8.1	8.7
pH_5 - KCl	7.4	7.7	7.7
EC_5 mmhos/cm	0.43	1.05	3.17
C/N	5	–	–
Exchangeable cations:			
ME % Ca	33.9	28.7	40.5
" " Mg	9.6	14.2	15.5
" " K	1.86	1.15	1.20
" " Na	3.79	12.62	22.04
CEC ME %	31.6	37.1	43.05
ESP	6.0	38.4	55.4

4.3 Soils of suitability class 4A

4.3.1 Typic Natrargid (N1)

These soils represent the truncated remnants of a late-Pliocene/early-Pleistocene surface. Their most prominent feature is the presence of a natric horizon, which is capped by a bleached, hard impervious layer. This hardpan is overlain by a layer of sand, or loamy sand, which is non-saline non-alkali. The sand cover is more than 0.50 m thick, while the hardpan is found at an average depth of 0.90 m. These soils are covered by deep-rooting bush.

A representative profile has been described in Table C.7; the average physio-chemical characteristics of the unit have been listed in Table C.8.

Table C.7 - Representative soil profile of a Typic Natrargid (soil unit N1)

Soil layer	1	2	3	4
Depth in cm	0-44	44-72	72-95	95-130
Texture	S	S	SL	SL
Consistence-actual	loose	hard	very hard	very hard
Structure	structureless single grain	structureless single grain	structureless massive	weak blocky to columnar
Colour	5YR 4/4	10YR 5/3	10YR 5/3	10YR 4/3
Concretions	–	–	–	Fe black
Mottles	–	–	–	few, very fine lime spots
Roots	few	few	rare	–
Boundary with next layer	gradual smooth	abrupt smooth	gradual smooth	–
Remarks				– Fe accumulation

Table C.8 - Average analytical data of a Typic Natrargid (soil unit N1)

Soil layer	1	2	3
Depth in cm	0-30	30-65	65-120
% sand/silt/clay	87/6/7	81/6/13	65/6/29
pH_5 - H_2O	6.1	6.4	8.4
pH_5 - KCl	4.7	5.0	6.9
EC_5 mmhos/cm	0.05	0.04	0.60
C/N	2	-	-
Exchangeable cations:			
ME % Ca	2.0	3.1	18.2
" " Mg	1.5	3.1	7.0
" " K	0.90	0.90	1.95
" " Na	0.60	1.22	5.08
CEC ME %	6.5		
ESP	9.5	16.2	31.9

4.3.2 Typic Natrargid (N21)

This soil unit can be compared with the Typic Natrargid (N1). The difference between these two units is based on the depth of the hardpan. If the cap is found between 0.20 and 0.50 m below the soil surface and overlies a non-saline non-alkali horizon, the soil has been mapped as N21.

A representative profile has been described in Table C.9 and the average physio-chemical characteristics of the unit have been summarized in Table C.10.

Table C.9 - Representative soil profile of a Typic Natrargid (soil unit N21)

Soil layer	1	2	3	4
Depth in cm	0-45	45-65	65-100	100-130
Texture	SL/SCL	SL/SCL	SCL/SC	SC
Consistence-actual	slightly hard	hard, extremely hard	slightly hard	slightly hard
Structure	structureless single grain	strong blocky to columnar	strong blocky medium-coarse	moderate blocky to subangular blocky medium-coarse
Colour	2.5YR 3/6	2.5YR 3/6	5YR 4/6	7.5YR 5/4
Concretions	-	-	few $CaCO_3$ fine	abundant $CaCO_3$ medium
Mottles	-	-	-	abundant $CaCO_3$ medium
Roots	common/few	occasional	occasional	-
Boundary with next layer	abrupt wavy	clear smooth	gradual smooth	-
Remarks		iron coating	iron coating common	fine salt crystals common

Table C.10 - Average analytical data of a Typic Natrargid (soil unit N21)

Soil layer	1	2	4
Depth in cm	0-45	45-65	65-120
% sand/silt/clay	70/8/22	63/13/24	58/7/35
pH_5 - H_2O	7.0	7.4	7.6
pH_5 - KCl	5.5	6.5	6.5
EC_5 mmhos/cm	0.04	0.07	1.13
C/N	5	-	-
Exchangeable cations:			
ME % Ca	5.8	8.5	20.7
" " Mg	3.8	6.7	8.8
" " K	1.30	1.35	1.03
" " Na	0.50	1.55	4.07
CEC Me %	12.0		
ESP	4.1	9.3	20.5

4.4 Soil salinity and alkalinity

All soil units discussed under Sub-sections 4.2 and 4.3 have a non-saline non alkali topsoil, except the units GU2 and N42, which in some cases have an alkaline and a saline topsoil respectively. The topsoil generally overlies an alkali horizon, which changes into a saline-alkali subsoil. Soil units N21, N42, GU2 and U2 each have an alkali horizon of varying thickness (0.20 to 0.37 m) which is found at depths of 0.15 - 0.45 m below the soil surface. The alkali horizon either shows a pronounced hard grey cap on top of columnar structural elements (N1 and N21) or it consists of hard to very hard clay prisms (N42, GU2 and U2). The higher-lying N1 unit has an alkali horizon which is found at a greater depth of approximately 0.60 m.

The upper soil horizons generally have a lower CEC value than the deeper ones. In the subsoil, which is highly base-saturated, the absorption of sodium is more pronounced than that of calcium.

4.5 Soil moisture

Plants can flourish within a certain range of soil moisture content, which varies between field capacity and wilting point.

The quantity of moisture retained by soils at the same moisture tension depends on their texture, structure and on variations in pore size distribution.

The relationship between the soil moisture tension and the quantity of moisture retained by the various soil units have been shown in Figure C.1.1 (5-10 cm depth), Figure C.1.2 (35-50 cm depth) and Figure C.1.3 (65-80 cm depth). The logarithm of the soil moisture tension in cm (pF) has been plotted as the abscissa of the relevant graph. Table C.11 shows the quantitative results of the moisture retension determinations at various pF values.

FIG. C.1 : pF CURVES 5-10 cm

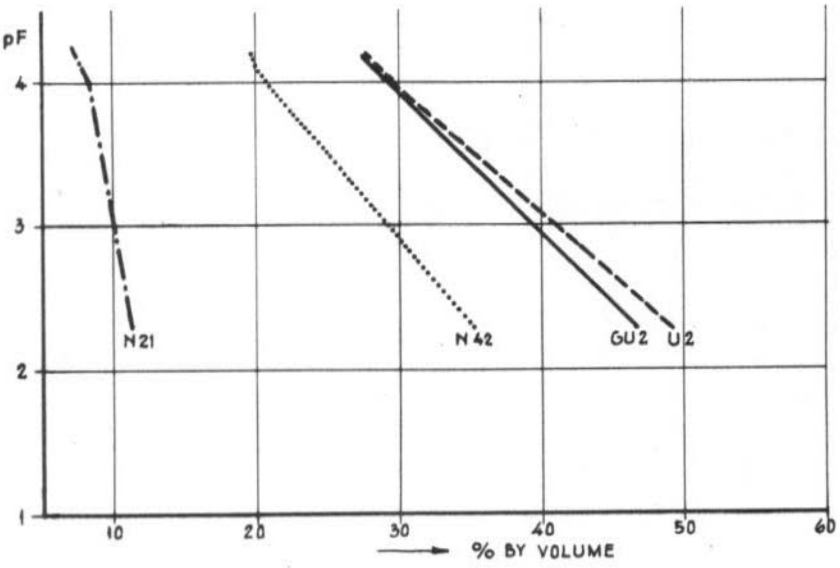

FIG. C.2 : pF CURVES 35-50 cm

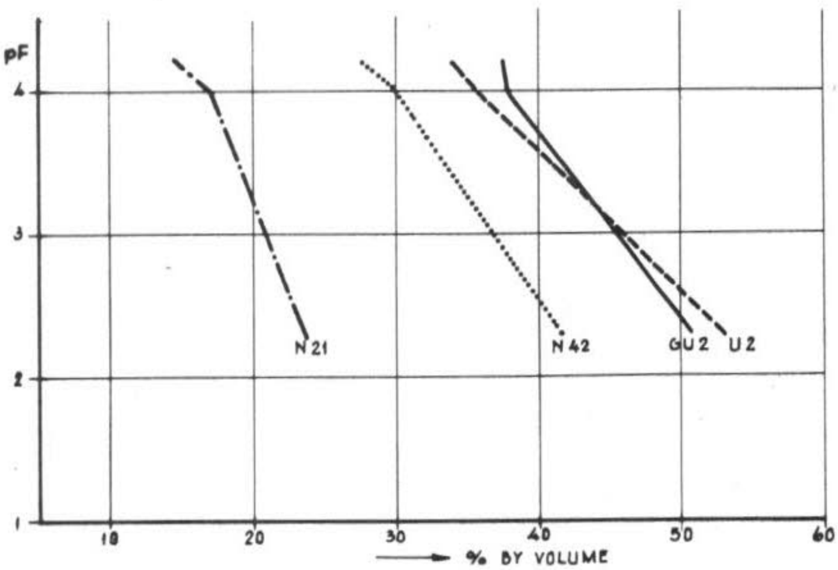

FIG. C.3 : pF CURVES 65-80 cm

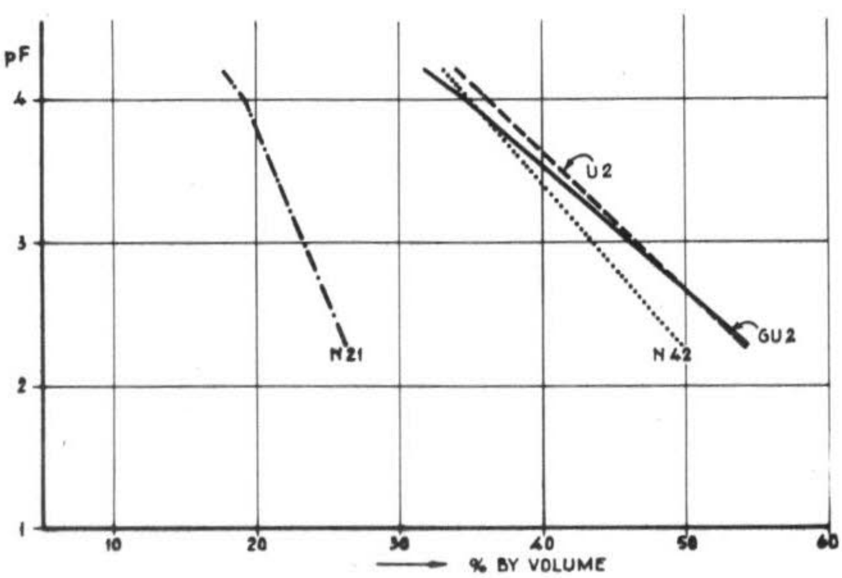

Table C.11 - Moisture percentage retained at various soil moisture tensions

Soil unit	Depth in cm	Soil moisture tension in % by weight			Available moisture in % by volume	Clay percentage
		pF 2.3	pF 4.0	pF 4.2		
U2	5-10	37.88	22.94	21.20	19.18	68
(Vertic Hapludent)		52.01	31.02	29.73	21.17	68
GU2		33.24	20.79	19.97	15.80	44
(Natric Grumustert)		39.77	23.86	22.17	21.47	56
		48.80	31.41	28.61	21.80	48
N42		29.47	17.69	16.88	15.35	44
(Vertic Natrargid)		26.15	14.82	14.39	14.46	44
N21	30-35	6.88	3.62	3.09	6.10	16
(Typic Natrargid)						
U2	40-50	37.21	25.75	24.00	18.49	58
	45-50	43.61	28.31	28.18	19.14	68
GU2	40-45	32.35	24.78	23.36	12.67	58
	35-40	40.07	28.79	26.75	17.45	58
	40-45	45.19	31.94	29.26	20.07	68
N42	40-45	28.34	20.18	18.37	14.36	44
	45-50	29.95	22.05	20.01	14.22	48
N21	55-60	14.01	10.13	8.74	8.86	12
U2	65-70	40.53	26.09	24.42	20.94	52
		41.77	28.73	27.21	19.51	64
GU2	75-80	36.16	26.37	23.21	16.32	64
	70-75	44.64	27.25	24.41	26.50	68
	65-70	52.82	31.47	30.50	25.00	60
NU2	70-75	35.75	24.64	24.59	14.96	52
		39.25	28.46	25.52	18.12	56
N21		16.97	12.41	11.43	8.53	28

5 EVALUATION OF THE DATA

The problem soils of the Bura area are characterized by a generally non-saline/non-alkali topsoil on a saline or a saline-alkali subsoil. The values found as averages of the soils sampled during this feasibility study (Table C.12) have been compared in Table C.13 with:

- the Lower Tana Survey data for the Training Centre;
- the results of soil analyses of samples taken at Hola in 1968, early in 1972 and during the current survey. The last-mentioned sampling concerned 5 pits only.

When comparing these data with the criteria for salinity and alkalinity of Handbook no 60, the cropping results at Hola, both on the Experimental Station and on farmers' fields, would suggest that these criteria need not be applied so strictly. ESP values of up to 25 are acceptable if the topsoils are 0.30 m thick at least. Salt can be leached from the topsoils by a number of overirrigations when a drainage system is present.

The subsoils are impermeable once they have been moistened and thus the possibility of leaching salts or replacing sodium ions by amendments or by good-quality irrigation water is very limited. When the salinity of the subsoils decreases, alkalinity is expected to increase. This was found to occur to some extent.

Table C.13 gives a comparison of selected soil properties, important in assessing salinity and alkalinity hazards.

Parts 1 and 2 of the table show that in the resampling during this survey about the same results were obtained as in the Lower Tana River Basin Survey. Where the average values differ, they reflect the high variation in properties of the layers concerned.

The figures of part 3 of Table C.13 reflect the original saline-alkali condition at the Hola Experimental Farm. When comparing these figures with those of parts 4 and 5 in Table C.13 it is found that with irrigation, salinity in the topsoil decreases while alkalinity of the subsoil increases.

6 CONCLUSIONS

The Lower Tana River Basin Survey has arrived at the following suitability classification for the Hola soils:

class	1	highly suitable	
"	2A	well suitable	A soil Hola, intergrade 2 A/3
"	2B	suitable	A/B soil Hola
"	3	fairly suitable	B soil Hola
"	4	marginally suitable	C soil Hola

During the current survey, attention has been focussed on class 3 and class 4 soils; the other classes have been considered to pose no serious problems.

Table C.12 - Analytical data of all soil samples taken at Bura

BURA

Fairly suitable - GU 2 soil unit

Depth	Percentage of:			1:5 suspension			C/N	Saturation extract			CEC	Exchangeable cations				Qualification $CaCO_3$	ESP
	sand	silt	clay	pH H_2O	pH KCl	EC		Saturation (%)	EC_e	pH		Ca	Mg	K	Na		
Pit 10																	
0-15	40	12	48	9.0	7.1	0.45	40	-	-	-	59.4	46.8	15.0	1.95	11.25	++	19.0
15-60	24	8	68	8.8	7.2	1.62	-	87.4	7.0	7.0	61.2	45.0	15.2	2.10	13.65	++	22.4
60-120	24	16	60	7.9	7.2	7.00	-	85.0	25.5	7.3	54.6	45.6	18.0	1.90	33.00	++	60.0
Pit 4																	
0-15	36	20	44	8.7	7.4	0.12	1	50.6	0.5	7.2	45.0	45.6	14.3	2.95	1.35	++	3.0
15-50	36	6	58	9.3	7.7	0.72	-	72.5	3.0	8.1	46.8	42.0	18.0	1.90	14.70	++	31.4
50-70	28	8	64	9.2	8.0	2.70	-	80.0	15.0	8.3	46.8	37.2	16.9	1.75	27.40	+++	58.5
70-120	24	12	64	9.1	7.9	3.40	-	92.5	16.0	8.2	46.8	32.4	16.0	1.75	32.75	+++	70.0
Pit 11																	
0-15	28	8	64	8.9	7.3	0.33	7	-	-	-	59.4	49.6	14.8	1.75	6.70	++	11.3
15-60	24	12	64	8.2	7.3	0.27	-	-	-	-	59.4	43.2	14.8	1.85	17.25	++	29.1
60-120	20	8	72	8.1	7.3	6.20	-	105.9	30.0	7.4	59.4	36.0	17.3	1.55	34.25	++	57.8
Pit 7																	
0-15	40	8	52	9.4	7.7	0.46	3	-	-	-	32.0	50.4	11.7	2.75	10.35	-	32.4
15-65	32	12	56	9.2	8.0	2.40	-	70.4	19.0	8.0	35.8	15.0	15.8	1.55	21.00	-	58.7
65-120	24	12	64	9.0	7.9	3.40	-	331.1	8.0	7.5	45.0	16.8	16.3	1.70	27.40	-	61.0
Pit 21																	
0-18	24	20	56	8.4	7.0	0.19	4	-	-	-	46.8	19.2	16.3	2.15	2.40	-	5.1
18-60	32	12	56	8.9	7.2	0.26	-	-	-	-	49.8	37.2	15.8	2.10	5.60	+	11.2
60-80	36	8	56	8.0	7.2	1.60	-	73.7	5.5	7.5	46.8	44.4	12.4	1.75	7.20	+	15.4
80-120	24	12	64	7.9	7.3	3.70	-	61.0	4.5	7.9	35.8	38.4	17.3	1.50	15.00	+	42.0
Pit 17																	
0-16	30	14	56	9.1	7.5	0.40	8	-	-	-	35.8	17.8	16.9	1.65	7.40	++	20.6
16-55	32	10	58	9.1	7.8	1.32	-	79.2	24.5	7.6	35.8	11.6	15.0	1.50	21.60	++	60.4
55-80	26	6	68	8.2	7.6	6.10	-	64.7	14.5	7.3	35.8	17.2	15.0	1.50	19.65	++	55.0
Pit 16																	
0-16	28	16	56	8.7	7.4	0.40	3	-	-	-	36.8	19.0	16.3	1.80	4.35	+	11.8
16-55	28	16	56	8.9	7.4	0.60	-	-	-	-	36.8	31.2	18.5	1.75	10.05	+	28.5
55-80	26	18	56	8.1	7.3	2.90	-	59.8	19.5	7.2	34.8	28.8	18.5	1.55	15.00	++	43.2
80-120	24	8	68	7.8	7.4	5.00	-	72.1	8.0	7.6	59.4	40.8	17.7	1.55	18.75	++	31.6
Pit 23																	
0-15	34	10	56	8.6	7.2	0.32	4	-	-	-	59.4	39.6	15.8	2.20	4.00	-	6.7
15-55	24	20	56	9.0	7.3	0.30	-	-	-	-	46.8	18.0	14.8	1.60	6.25	-	13.4
55-80	34	10	56	8.9	7.4	0.50	-	-	-	-	43.8	21.6	11.9	1.80	11.25	-	25.7
80-120	38	6	56	8.6	7.3	1.40	-	69.7	8.0	7.6	48.0	18.6	13.0	1.85	14.25	+	29.7
Pit 8																	
0-17	20	16	64	9.2	7.5	0.50	7	-	-	-	59.4	42.0	15.8	2.50	14.25	+	24.0
17-50	24	16	60	9.3	7.6	0.70	-	-	-	-	61.2	19.4	15.0	2.45	19.65	++	32.1
50-90	16	20	64	8.3	7.3	4.90	-	78.8	26.0	7.7	59.4	18.8	15.0	2.25	27.40	++	46.2
90-120	20	20	60	8.4	7.4	5.40	-	78.9	32.0	7.1	59.4	13.0	45.8	1.95	34.25	+	57.7
Average																	
0-15	31	14	55	8.9	7.3	0.35	9	50.6	0.5	7.2	48.2	36.7	11.6	2.19	6.89	++	14.9
15-55	29	12	59	9.0	7.5	0.91	-	77.4	13.4	7.7	48.2	29.2	14.2	1.87	14.42	++	28.6
55-120	26	12	62	8.4	7.5	3.88	-	96.4	16.3	7.6	48.3	29.3	15.8	1.74	22.68	++	46.7

BURA

Fairly suitable-U2 soil unit

Depth	Percentage of:			1:5 suspension			C/N	Saturation extract			CEC	Exchangeable cations				Qualification $CaCO_3$	ESP
	sand	silt	clay	pH H_2O	pH KCl	EC		Saturation (%)	EC_e	pH		Ca	MG	K	Na		
Pit 13																	
0-15	24	8	68	8.4	6.8	0.26	4	71.2	1.00	7.8	63.0	39.6	16.6	2.90	4.10	+	6.5
15-55	24	6	70	8.6	7.0	0.35	-	49.9	1.40	8.2	59.4	38.4	18.5	2.75	5.85	+	9.9
60-120	24	6	70	8.3	6.9	1.10	-	70.3	5.00	7.5	55.8	19.2	18.0	2.50	11.25	+	20.0
Pit 12																	
0-15	36	6	58	8.7	6.9	0.20	6	63.3	1.05	8.1	51.0	19.4	16.9	2.30	5.10	+	10.0
15-56	36	6	58	8.6	7.1	0.90	-	77.7	45.0	7.7	46.8	16.0	16.9	1.95	11.25	+	24.0
56-120	39	9	52	8.6	7.4	2.40	-	94.1	12.00	7.8	43.8	10.0	16.0	1.60	21.60	+	49.4
Pit 14																	
0-20	28	8	64	8.6	7.0	0.24	5	-	-	-	52.8	40.2	17.7	2.55	4.10	+	7.8
20-55	32	8	60	8.8	7.2	0.40	-	-	-	-	49.8	38.4	16.3	2.20	6.70	++	13.4
55-120	36	8	56	8.8	7.5	1.90	-	70.3	11.50	8.1	45.0	36.0	17.7	1.85	20.55	-	45.6
Pit 24																	
0-25	20	24	56	8.7	7.2	0.30	3	-	-	-	48.0	40.8	14.8	2.15	4.10	-	8.6
25-50	24	12	64	8.8	7.0	0.19	-	-	-	-	51.0	37.2	16.6	2.30	4.65	-	9.1
50-70	28	8	64	8.8	7.0	0.25	-	-	-	-	49.8	36.0	15.5	2.20	5.75	+	11.5
70-120	24	12	64	8.7	6.9	0.32	-	-	-	-	35.8	15.6	8.6	2.10	5.60	+	15.6
Pit 19																	
0-14	20	12	68	8.4	6.9	0.31	4	-	-	-	34.6	37.2	16.6	2.65	3.35	-	6.1
14-50	24	8	68	8.8	7.0	0.25	-	-	-	-	36.8	36.0	14.0	2.20	4.55	+	12.4
50-100	26	10	64	8.7	7.1	0.30	-	-	-	-	49.8	34.8	16.3	2.25	6.25	+	12.5
Pit 20																	
0-12	16	26	58	8.7	7.2	0.32	6	-	-	-	46.8	40.8	16.9	2.20	4.35	+	9.3
12-30	28	12	60	8.3	6.8	0.25	-	-	-	-	52.8	33.6	16.3	2.45	2.90	+	5.5
30-90	30	8	62	8.7	7.0	0.34	-	-	-	-	59.4	32.4	16.3	2.20	5.75	-	9.7
90-130	24	16	60	8.2	7.1	1.42	-	81.0	7.00	7.3	45.0	8.4	16.3	2.10	10.95	+	24.4
Average																	
0-20	24	14	62	7.2	7.0	0.27	5	67.2	1.02	8.0	52.7	36.3	16.6	2.46	4.18	+	8.0
20-50	28	9	63	8.6	7.0	0.39	-	63.8	3.00	8.0	49.4	65.9	23.1	2.31	5.98	+	12.4
50-120	29	10	61	8.6	7.1	1.00	-	78.9	8.90	7.7	48.0	24.0	15.6	2.10	10.96	+	23.6

Table C.12 - cont'd

BURA

Marginally suitable-N 1 soil unit

Depth	Percentage of: sand	silt	clay	1:5 suspension pH H_2O	pH KCl	EC	C/N	Saturation extract Saturation (%)	EC_e	pH	CEC	Exchangeable cations Ca	Mg	K	Na	Qualification $CaCO_3$	ESP
Pit 2																	
0-40	90	4	6	5.8	4.6	0.05	1	-	-	-	5.2	1.6	0.5	0.55	0.55	-	10.6
40-72	94	4	2	6.4	5.2	0.04	-	-	-	-	3.4	0.4	1.0	0.40	0.60	-	17.6
72-95	74	6	20	8.2	5.8	0.09	-	-	-	-	8.0	2.8	1.8	1.20	2.80	-	35.0
95-100	72	8	20	8.7	6.8	0.40	-	-	-	-	15.6	5.8	3.9	1.70	6.00	-	38.4
Pit 1																	
0-22	84	8	8	6.5	4.9	0.05	4	-	-	-	7.8	2.4	2.5	1.25	0.65	-	8.3
22-60	68	8	24	6.4	4.9	0.05	-	-	-	-	12.6	5.8	5.3	1.40	1.85	++	14.7
60-100	56	4	40	8.4	7.4	1.00	-	44.3	16.00	7.5	22.2	39.6	7.4	2.60	6.00	++	27.0
100-120	56	8	36	8.4	7.5	0.90	-	41.7	7.00	7.3	20.4	24.6	15.0	2.30	5.50	++	27.0
Average																	
0-30	87	6	7	6.1	4.7	0.05	2	-	-	-	6.5	2.0	1.5	0.90	0.60	-	9.5
30-65	81	6	13	6.4	5.0	0.04	-	-	-	-	8.0	3.1	3.1	0.90	1.22	++	16.2
65-120	65	6	29	8.4	6.9	0.60	-	43.0	11.50	7.4	16.5	18.2	7.0	1.95	5.08	++	31.9

BURA

Marginally suitable-N 21 soil unit

Depth	Percentage of: Sand	silt	clay	1:5 suspension pH H_2O	pH KCl	EC	C/N	Saturation extract Saturation (%)	EC_e	pH	CEC	Exchangeable cations Ca	Mg	K	Na	Qualification $CaCO_3$	ESP
Pit 3																	
0-45	64	8	28	8.1	6.9	0.07	6	35.2	0.50	7.3	16.6	9.4	5.0	2.00	0.70	-	4.2
45-65	56	8	36	8.6	6.8	0.09	-	40.6	0.70	8.0	21.6	13.4	6.4	2.00	1.80	-	8.4
65-100	56	8	36	8.0	7.4	1.22	-	140.2	10.50	7.5	21.0	17.2	6.9	1.15	3.55	++	16.9
100-120	52	8	40	7.9	7.4	2.00	-	97.6	15.50	7.2	21.0	38.4	12.6	1.10	5.00	++	23.8
Pit 5																	
0-43	76	8	16	6.0	4.1	0.02	5	85.5	0.50	6.0	7.4	2.2	2.7	0.60	0.30	-	4.0
43-65	70	18	12	6.2	4.1	0.05	-	95.2	0.50	5.7	12.6	3.6	5.0	0.70	1.30	-	10.3
65-100	66	6	28	6.9	4.8	0.18	-	60.2	2.30	6.9	17.6	6.4	6.8	0.85	3.65	-	20.8
Average																	
0-40	70	8	22	7.0	5.5	0.04	5	60.3	0.50	6.6	12.0	5.8	3.8	1.30	0.50	-	4.1
40-65	63	13	24	7.4	6.5	0.07	-	67.9	0.60	6.8	17.1	8.5	6.7	1.35	1.55	-	9.3
65-120	58	7	35	7.6	6.5	1.13	-	99.3	9.43	7.2	19.9	20.7	8.8	1.03	4.07	++	20.5

BURA

Fairly suitable-N 42 soil unit

Depth	Percentage of: sand	silt	clay	1:5 suspension pH H_2O	pH KCl	EC	C/N	Saturation extract Saturation (%)	EC_e	pH	CEC	Exchangeable cations Ca	Mg	K	Na	Qualification $CaCO_3$	ESP
Pit 9																	
0-18	64	8	28	8.9	7.7	1.40	7	42.1	8.0	7.8	17.6	8.0	3.2	0.95	9.00	+	5.1
18-51	64	8	28	9.1	7.9	1.90	-	42.2	9.5	7.9	21.0	10.4	7.0	0.80	13.95	+++	66.5
51-120	56	8	36	9.1	7.9	2.20	-	69.5	11.5	7.9	24.6	29.6	14.3	0.75	17.25	+++	70.0
Pit 6																	
0-18	46	10	44	8.7	7.3	0.14	4	91.6	0.7	8.2	32.0	49.2	15.2	1.60	1.45	+++	4.5
18-50	42	14	44	4.3	7.8	0.53	-	79.6	2.0	8.6	35.8	40.8	18.0	0.85	8.90	+++	24.8
50-75	38	10	52	9.2	8.0	1.82	-	92.5	8.5	8.4	35.8	48.0	17.7	1.05	18.20	+++	50.1
75-120	34	10	56	9.1	7.9	2.40	-	67.7	12.5	8.2	43.8	51.6	18.5	1.15	24.40	+++	55.1
Pit 15																	
0-15	28	12	60	8.9	7.2	0.28	3	-	-	-	55.8	48.0	15.5	2.00	6.00	++	10.7
15-50	24	12	64	8.9	7.4	1.30	-	76.6	6.5	7.9	55.8	49.2	16.9	1.65	17.25	++	30.9
50-90	28	8	64	8.0	7.3	6.20	-	73.1	2.5	7.4	52.8	48.0	15.2	1.65	24.00	++	45.5
90-120	24	12	64	8.3	7.4	4.90	-	66.7	9.5	7.7	54.6	36.0	18.0	1.00	28.00	++	51.3
Pit 18																	
0-18	44	12	44	8.4	7.2	0.22	2	-	-	-	23.4	36.6	7.6	2.65	1.60	++	6.7
18-50	44	8	48	9.3	7.9	1.00	-	75.2	14.0	8.1	29.0	18.6	14.8	1.00	15.00	+++	51.8
50-75	36	8	56	9.0	8.0	2.50	-	75.4	2.5	7.5	30.6	45.6	15.2	1.10	24.00	+++	78.5
75-120	36	8	56	8.6	7.9	4.60	-	84.9	6.0	8.1	32.0	45.6	15.0	1.15	28.80	++	90.0
Pit 22																	
0-18	44	8	48	8.6	7.4	0.13	11	-	-	-	29.0	27.6	6.3	2.10	0.90	+	3.1
18-58	38	12	50	9.1	7.7	0.30	-	-	-	-	43.8	24.6	14.5	1.45	8.00	+	18.2
58-80	30	12	58	8.9	7.7	1.40	-	100.0	5.5	8.0	51.0	22.8	12.4	1.60	16.50	++	32.4
80-120	34	10	56	8.5	7.6	2.50	-	66.2	8.0	7.7	66.6	27.6	13.0	1.35	17.25	-	25.9
Average																	
0-18	45	10	45	8.7	7.4	0.43	5	66.8	4.3	8.0	31.6	33.9	9.6	1.86	3.79	++	6.0
18-50	42	11	47	8.1	7.7	1.05	-	68.4	8.0	8.1	37.1	28.7	14.2	1.15	12.62	++	38.4
50-120	35	10	55	8.7	7.7	3.17	-	77.3	7.4	7.9	43.5	40.5	15.5	1.20	22.04	+++	55.4

HOLA

Depth	Percentage of: sand	silt	clay	1:5 suspension pH H_2O	pH KCl	EC	C/N	Saturation extract Saturation (%)	EC_e	pH	CEC	Exchangeable cations Ca	Mg	K	Na	Qualification $CaCO_3$	ESP
Pit H 1																	
0-20	36	8	56	8.6	7.4	0.21	5	-	-	-	49.80	34.80	12.20	1.75	2.30	++	4.6
20-40	40	4	56	9.0	7.6	0.44	-	-	-	-	37.80	48.00	12.60	1.45	10.35	++	27.4
40-75	24	12	64	8.3	7.4	1.40	-	90.8	5.00	7.9	63.00	51.60	13.20	1.50	10.05	+++	16.0
75-120	28	8	64	9.2	7.7	0.60	-	-	-	-	59.40	44.40	15.20	1.50	13.15	++	22.2
Pit H 2																	
0-20	36	8	56	8.9	7.4	0.24	4	-	-	-	55.80	41.40	12.40	1.30	4.10	++	7.4
20-60	32	12	56	9.1	7.7	0.70	-	-	-	-	46.80	44.40	13.40	1.40	13.65	+++	29.2
60-120	24	12	64	8.6	7.6	2.00	-	116.3	6.50	7.4	55.80	36.00	7.15	0.85	12.30	+++	22.0
Pit H 3																	
0-15	24	12	64	8.8	7.4	0.90	4	46.2	1.75	8.0	17.00	39.00	14.10	2.00	2.80	+++	16.5
15-45	36	8	56	9.5	8.1	0.60	-	-	-	-	21.00	44.40	10.60	1.05	15.00	+++	71.5
45-100	23	8	64	9.7	8.3	0.90	-	152.3	2.40	8.7	59.40	37.20	12.40	1.25	18.00	+++	30.3
100-150	24	12	64	8.8	7.8	3.00	-	135.2	4.50	8.6	57.60	19.80	6.80	1.25	39.30	++	63.2
Pit H 4																	
0-18	20	28	52	8.6	7.5	0.30	8	-	-	-	49.80	38.40	12.80	2.30	2.55	++	5.1
18-65	36	6	58	9.3	7.7	0.50	-	-	-	-	37.80	51.60	13.00	1.20	11.25	++	29.8
65-120	32	8	60	9.3	8.1	1.32	-	128.6	13.00	8.0	40.80	27.80	14.50	1.25	30.00	++	73.4
Pit H 5																	
0-18	44	12	44	8.3	7.1	0.60	15	-	-	-	27.60	33.60	12.80	2.00	2.90	++	10.5
18-50	36	16	48	9.2	7.5	0.24	-	-	-	-	29.00	40.80	12.00	1.25	4.35	+++	15.0
50-70	20	36	44	9.4	7.9	0.66	-	-	-	-	37.80	46.80	12.50	0.95	11.25	+++	29.8
70-110	32	12	56	8.5	7.5	0.52	-	-	-	-	29.80	39.60	15.00	1.00	10.65	+++	35.8

Table C.13 - Comparison of data of salinity and alkalinity at Bura and Hola derived from various sources

(1) Average data of soil units of the Research and Training Centre (Bura area). Source: Lower Tana River Basin Survey, Annex C, Table C III

Suitability	Soil units	Depth inches	CEC	EC5	ECe	ESP	pH H_2O	Na
Suitable class 2B	S	0-17	27	0.3	1.6	5	8.7	nil
		17-30	35	2.3	17.0	26	8.9	5.6
		30-60	38		18.0			
Fairly suitable class 3	GU 2	0-6	33	0.3	1.2	6	9.0	nil
		6-20	39	0.6	1.5	28	9.3	7.0
		20-30	39	4.8	26.0	40	8.7	11.7
	GA*	top soil	33	0.2	0.8	4	8.5	nil
		alkali hor.	37	0.5	1.4	24	9.3	5.2
		subsoil	43	3.5	12.0	28	8.5	7.8
	U 2	0-6	37	0.3	0.9	7	9.0	nil
		6-21	37	0.3	1.0	19	9.1	3.3
		21-30	41	2.0	12.0	23	8.5	5.3
	N 42	0-7	23	0.3	1.1	3	9.0	nil
		7-19	31	0.5	1.9	26	9.7	5.0
		19-30	35	3.0	22.0	42	9.3	11.2
Marginally suitable class 4	N 1	0-30	5	0.1	0.2	2	5.4	nil
	N 21	0-17	10	0.1	0.7	4	7.2	nil
		17-25	15	0.4	3.0	18	7.6	1.2
		25-30	19	1.4	14.0	26	7.8	2.2

(2) Average data of the soil samples collected during the Upper and Lower Tana Feasibility Study in the Bura area

Soil units	Depth cm	CEC	EC5	ECe	ESP	pH5 H_2O	Na
GU 2	0-15	48	0.5	0.5	15	8.9	6.9
	15-55	48	0.9	13.4	29	9.0	14.4
	55-120	48	3.9	16.3	47	8.4	22.7
U 2	0-20	53	0.3	1.0	8	7.2	4.2
	20-50	49	0.4	3.0	12	8.6	6.0
	50-120	48	1.0	8.9	24	8.6	11.0
N 42	0-18	32	0.4	4.3	6	8.7	3.8
	18-50	37	1.1	8.0	38	8.1	12.6
	50-120	44	3.2	7.4	55	8.7	22.0
N 1	0-30	7	0.1	n.d.	10	6.1	0.6
	30-65	8	0.0	n.d.	16	6.4	1.2
	65-120	17	0.6	11.5	32	8.4	5.1
N 21	0-40	12	0.0	0.5	4	7.0	0.5
	40-65	17	0.1	0.6	9	7.4	1.6
	65-120	20	1.1	9.4	21	7.6	4.1

(3) Hola Experimental Farm; averages of at least 6 samples of each of three soil types on non-irrigated fields. Source: Soil Survey Galole Pilot Demonstration and Training Project; May 1968

Soil types	Depth cm	CEC	EC5	ECe	ESP	pH5 H_2O	Na
A-soil**	0-16	30	0.7	1.8	n.d.	8.3	n.d.
	16-45	29	1.4	4.9	n.d.	8.9	n.d.
	45-75	42	2.6	9.0	30	9.1	12.6
	75-95	41	8.0	28.0	30	9.2	12.3
A/B-soil	0-15	44	0.6	-	n.d.	8.6	n.d.
	15-30	29	0.8	-	n.d.	8.6	n.d.
	30-60	39	1.8	-	36	9.0	13.9
	60-80	45	2.5	-	39	8.8	17.7
B-soil	0-22	40	0.3	0.8	6	8.3	2.6
	22-35	40	0.4	0.9	12	8.9	4.7
	35-65	47	0.9	0.5	37	9.0	17.2
	65-80	48	2.2	4.5	42	8.6	20.0

(4) Hola Experimental Farm; averages of 6A and 6 A/B topsoils in two layers, samples on irrigated fields in January 1972

Soil types	Depth cm	CEC	EC5	ECe	ESP	pH5 H_2O	Na
A-soil**	0-15	31.7	0.24	1.07	0.6	8.3	0.18
	15-30	31.2	0.23	1.09	0.6	8.3	0.20
A/B-soil	0-15	26.3	0.31	1.65	0.82	8.1	0.23
	15-30	26.6	0.24	1.36	1.21	8.4	0.34
not sampled							

(5) Hola Experimental Farm; averages of 2A- and 2B-soils, and values of 1 A/B-soil, sampled during the Upper and Lower Tana Feasibility Study on irrigated fields in August 1972

Soil types	Depth cm	CEC	EC5	ECe	ESP	pH5 H_2O	Na
A-soil**	0-20	52.8	0.43	n.d.	6.0	8.7	3.20
	20-50	42.3	0.57	n.d.	28.3	9.0	12.00
	50-120	59.4	1.33	n.d.	30.1	8.9	11.80
A/B-soil	0-15	27.6	0.60	n.d.	10.5	8.3	2.90
	15-30	29.0	0.24	n.d.	15.0	9.2	4.35
	30-60	37.5	0.66	n.d.	29.8	9.4	11.25
	60-80	29.8	0.52	n.d.	35.8	8.5	10.65
B-soil	0-18	33.4	0.60	n.d.	10.8	8.8	2.68
	18-55	29.4	0.55	n.d.	50.6	9.4	14.75
	55-110	52.6	1.41	n.d.	55.6	9.2	34.65

Notes:

* Not present in the Bura area

CEC = cation exchange capacity m.eq.%
EC5 = electr. cond. in 1 : 5 suspension
ECe = electr. cond. in saturation extract
ESP = exchangeable sodium percentage
pH5H_2O = pHH_2O in 1:5 suspension
Na = exchangeable Na in ME %
n.d. = not determined.

** intergrade between a Typic Halorthid (S in item (1) of this Table) and a Vertic Natrargid (N 42 in item (1) of this Table).

The yield results on A and A/B soils at Hola are such that the same or maybe even better results can be obtained on class 1, 2A and 2B soils at Bura.
On class 3 soils, the results will be less due to saline-alkali conditions below the shallow topsoil; yield results are expected to be about 20% lower than on class 2 soils.
Yield levels on class 2 soils have been projected to be about 10% lower than those on class 1 soils.

The use of gypsum as an amendment has been considered, because the Lower Tana Study has laid much emphasis on this point. The more recent results obtained in the Sudan indicate that the water availability in these soils increases with a certain percentage of exchangeable sodium. The levels of ESP at Bura are not expected to reach the values indicated for the Sudan; it is recommended that the ESP levels should be checked regularly on the Scheme. If necessary, gypsum could then be applied to some soils of the Scheme.

Acreages of soils of the various suitability classes (rounded figures)

		Soil units	Net ha
Class 1	Highly suitable	C	750
2	Well suitable and suitable	S, U1 and N41, GU1	1,800
3	Fairly suitable	N42, GU2, N2	1,450
		Total	4,000

within a gross area of 7,000 ha.

LIST OF REFERENCES

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1 INTRODUCTION

This Annex discusses the agronomic and agro-economic aspects of the proposed Bura Irrigation Scheme. The area concerned is situated west of Bura and covers 7,000 ha gross, 4,000 ha of which are suitable for irrigated agriculture.

Due to the low rainfall, rainfed crop production is impossible; only some cattle is being grazed in the area during and after the rainy periods.

In assessing the future development potential of irrigated crop production, we have heavily relied on the experience gained at the Hola Pilot Project and we have assumed that the same high-level and strict management will be adhered to as on the existing NIB irrigation schemes. High-level inputs will be provided from the start of the project; they will include fully mechanized soil preparation, adequate fertilizing, strict disease and pest control, controlled water management, credit facilities for the farmers and backing of agricultural, research and managerial project staff.

2 PRESENT SITUATION

The project area, sparcely covered with shrubs and small trees, is too dry for rainfed crop production. It is virtually uninhabited. During the wetter periods of the year and shortly afterwards, tribal groups (Orma) roam through the area to let their cattle graze. During dry periods they move to the Tana river and other places where water and grazing are more abundant.

3 DEVELOPMENT WITHOUT IRRIGATION

Under rainfed conditions the area can be used only as grazing grounds during the rainy months. It is estimated that on the average one livestock unit can be raised on 25 ha. Thus, a total of 280 livestock units could be kept in the gross area of 7,000 ha, with a take-off of 10%, or 28 livestock units a year. Estimating the net production value of one unit at K.Sh. 300, the total production value would amount to K.Sh. 8,400 a year. This value is expected to rise by about 10% over the project period due to the use of better breeds and better care of the animals.

4 DEVELOPMENT OF IRRIGATED AGRICULTURE

4.1 Project area and implementation

The net irrigable area of 4,000 ha consists of 750 ha of soils of suitability class 1, 1,800 ha of soils of suitability class 2, and 1,450 ha of soils of suitability class 3. The soils of class 2 are comparable to the A-soils at Hola (see Annex C). Those of class 3 are shallow with in places alkali subsoils at depths of about 15 cm.

The tertiary irrigation system will be implemented in four years after the main system has been completed. In the first year, 700 ha will be ready for planting and in the following years 1,100 ha will be taken into cultivation annually.

4.2 Crop selection

The crop selection for the scheme has been based mainly on the experience gained at the Tana Irrigation Scheme (Hola) and its research station.

The two major constraints on crop production are lack of rain and the saline and alkali subsoils. When water is brought into the area, climate will no longer be a limiting factor to the growing of most tropical crops. At Hola, salinity and alkalinity do not prevent high-level crop production, provided the soils are handled properly. But in the Bura area, the non-alkali and non-saline top layer of the soils of class 3 is much thinner than that of the soils under cultivation at Hola. Therefore, these soils are not considered to be suitable for deep-rooting crops like sugar-cane. Rice, which is rather sensitive to alkalinity, should not be grown on these soils either, the more so since in constructing the bunds and levelling them, unavoidably alkali subsoil will come to the surface. For the other crops, yield reductions due to alkalinity have been projected.

For the economic evaluation many crops have been considered, among them a group fetching high economic prices, such as cotton, sugar-cane, rice, groundnuts, sesame and horticultural crops. In addition, a great number of other crops have been considered which are less attractive because of their low economic prices, high labour requirements, marketing constraints, rotation requirements or technical difficulties in processing. Among this group are food crops like maize and beans, soy-beans and fibre crops (rosella).

At Hola where many crops have been tried out, cotton turned out to be the most profitable one. It is grown every year between February and September. During the off-season maize, beans and groundnuts are favoured at present. Crops like rosella and kenaf require high labour inputs and cause trouble in processing. Sunflower gives low yields while prices have gone down during the last few years. Sesame is being tested. It is a high-priced crop, but the yields have been disappointingly low so far. Growing of horticultural crops is not recommended because the heavy soils in the area are less suitable for these crops and the distances to potential markets are wide. Rice is expected to give high yields and a reasonable economic return on the soils of classes 1 and 2. Sugar-cane would be a suitable crop for the Bura scheme. It has produced very good yields in trial plantings at Hola. On class 1 and 2 soils, the crop is expected to yield on the average about 75 tons of cane per ha in year 1 and about 100 tons of cane in year 31; class 3 soils are considered to be too shallow for this crop. But as explained in the ILACO Interim Report of January 1973, the limited area of soils suitable for sugar-cane growing (2,550 ha) within the boundaries of the scheme does not allow to start the cultivation of this crop from an economic point of view.

In view of the foregoing, we have limited the number of crops to be considered in the economic evaluation to cotton, rice, maize, beans and groundnuts. It may well be that in the course of time other crops will also prove profitable. It is unlikely, taking into account the prevailing agronomic and climatic conditions, that the economic return of such crops will differ appreciably from that of the crops considered in this study.

4.3 Yield projections

Yield projections for the selected crops when grown on different soil types are given in Table D.1. Considering the envisaged high-level management and research organisations (see Annex G), the farmers are expected to familiarize themselves with irrigated farming and achieve high yields fairly soon. On soils of classes 1 and 2, yields will increase rapidly in the first few years. On soils of class 3, the yields will be about 20-40% lower than those on soil 2 and they will increase more slowly in the first years due to alkalinity problems.

As rice is grown in a puddled layer of about 20 cm and the upper 20 cm of class 1 and class 2 soils do not differ, yields of the crop on these types of soil have been taken equal. Projections vary, however, for the different varieties and the different growing seasons. As shown at other projects in Kenya, rice grown between October and February yields much more than that grown from March to August. This holds especially true for Basmati, which gives a very low yield in the latter period and no yield projections have been made for this variety in the off-season.

The yield levels of other crops than rice on class 2 soils are comparable to those attained at Hola and those projected for the Masinga Irrigation Scheme. When grown on class 1 soils, the crops are expected to produce somewhat higher yields at Bura than in the two other aforementioned areas.

The projected yields of maize, beans and groundnuts may seem to be rather low, but they are yields of short-duration varieties, the season between two cotton crops being four months only.

For calculation purposes, weighed yields have been used in this Annex unless otherwise stated.

4.4 Inputs and production costs

To achieve the high and rapidly increasing yields as predicted in the foregoing section, a high level of inputs has to be applied from the start of the project and should be improved over the years. For instance, seed of new varieties and of better quality are to be introduced, disease and pest control has to be improved and fertilizer applications should be increased.

The main production costs, which have been summarized in Table D.2 and presented in detail in Appendix D.1 are: mechanical soil preparation, fertilizing, and disease and pest control. The tedious

Table D.1 - Crop yields in kg/ha for the different soil classes

Crop	Soil class	Reference years				
		1	6	11	21	31
Cotton (seed cotton)	1	2,300	2,800	3,000	3,250	3,400
	2	2,000	2,500	2,700	2,900	3,000
	3	1,600	1,700	1,800	2,100	2,400
	average*	1,900	2,250	2,450	2,650	2,850
Maize (grain)	1	2,000	3,200	3,700	4,200	4,500
	2	1,600	2,700	3,150	3,650	4,000
	3	1,200	1,350	1,500	2,400	3,000
	average	1,550	2,300	2,650	3,300	3,750
Beans (dried)	1	900	1,200	1,400	1,550	1,600
	2	750	1,000	1,200	1,350	1,400
	3	500	600	700	950	1,100
	average	700	900	1,050	1,350	1,350
Groundnuts (shelled)	1	1,200	1,600	1,900	2,250	2,400
	2	1,000	1,350	1,600	1,900	2,000
	3	600	700	800	1,150	1,400
	average	900	1,150	1,350	1,700	1,850
Rice - Basmati, main season (paddy)	1 + 2	2,000	2,600	3,200	4,000	4,500
Rice - IRRI, main season (paddy)	1 + 2	2,800	3,700	4,600	5,500	6,000
Rice - IRRI, off-season (paddy)	1 + 2	2,400	3,200	3,800	4,700	5,000

* Weighed averages based on the areas of the different soil classes.

and difficult harvesting of groundnuts will be mechanized, while threshing of maize will be done by simple hand-operated or power-driven shellers.

Apart from soil preparation and harvesting of groundnuts, all activities are to be done by manual labour. Planting, weeding and harvesting are most labour-intensive as shown in Appendix D.1.

Table D.2 - Production costs per crop in K.Sh./ha

Crop	Reference year				
	1	6	11	21	31
Cotton	950	1,025	1,065	1,100	1,125
Maize	470	570	640	730	780
Beans	390	400	410	425	435
Groundnuts	740	800	850	925	965
Rice	630	700	760	835	850

4.5 Net production values per average hectare

Net production values per average hectare have been derived from the yields and production costs mentioned in previous sections and from the economic prices in Annex I. They have been summarized in Table D.3; details are given in Appendix D.2.

Table D.3 - Net production values in K.Sh. per average hectare

Crop		Reference years			
	1	6	11	21	31
Irrigated dryland crops					
Cotton	1,600	1,980	2,220	2,490	2,750
Maize	- 50	- 110	- 60	15	100
Beans	120	250	350	480	550
Groundnuts	280	450	620	920	1,040
Rice					
Basmati variety	700	1,030	1,370	1,825	2,140
IRRI-variety, main season	670	1,020	1,380	1,720	1,940
IRRI-variety, off-season	490	790	1,000	1,350	1,470

Cotton is the most profitable crop, followed by rice. But rice cannot very well be included with other crops in one rotation, because changing from inundated bunds to fields adapted to furrow irrigation and vice versa is too costly. Consequently, rice has been evaluated as a separate alternative in Sub-section 4.13. The third profitable crop is groundnuts, while the food crops lag far behind. Economically, maize will be grown at a loss during the first few years.

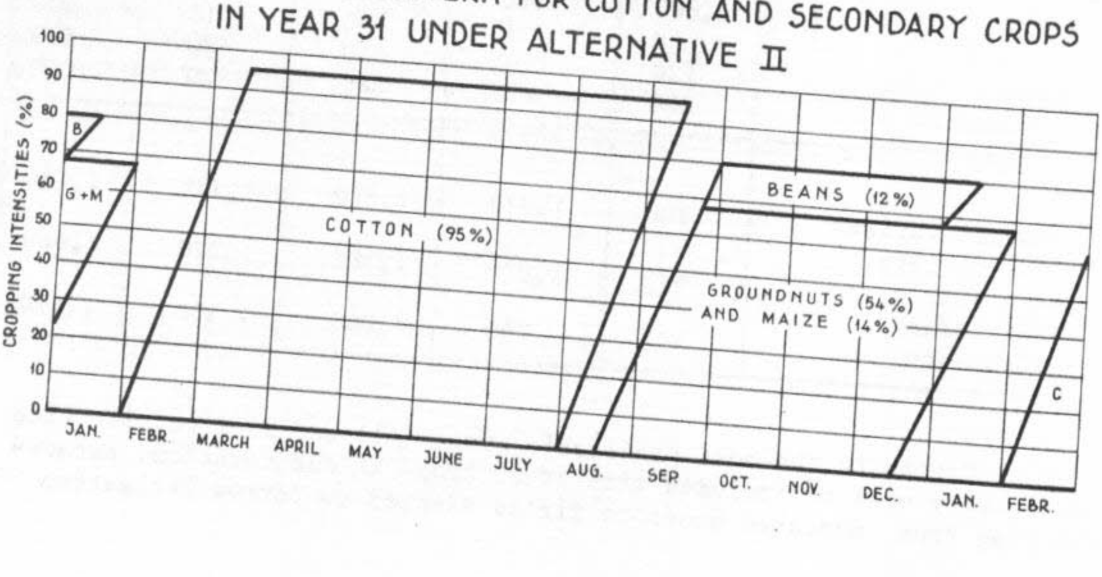
At Hola it has been found that cotton can be grown every year and that the best growing period is from February to August. During the remaining months groundnuts would be the most profitable crop, but then the farmers who are used to grow food crops for their subsistence, would have to buy all their food at much higher prices. Unless the income from groundnuts would be much higher, it is doubted that the farmers will grow only groundnuts during the off-season. We have, therefore, compared the income of a farmer cultivating mainly cash crops to that of one growing some cash crops in addition to the food crops needed to meet, either fully or partly, the food requirements of himself and his family. In calculating these incomes, the cropping calendar, the food requirements of a farmer's family, the areas to be grown with food crops and with groundnuts respectively, and the labour requirements had to be considered.

4.6 Cropping calendar and cropping intensity

Date of planting trials have shown that cotton will give the highest yield when planted in February and that yields will be considerably lower when planting is done late in March or April. At Hola, it is not possible in practice to do all the planting in February, but barring exceptional circumstances, planting could be completed before 15th March in the last few years. For Bura the same cropping season has been scheduled (see Figure D.1 showing the ultimate cropping patterns under alternative II vide page 50).

Harvesting of cotton will start in the second part of June and will be completed by the end of August.

FIG. D-1 CROPPING PATTERN FOR COTTON AND SECONDARY CROPS IN YEAR 31 UNDER ALTERNATIVE II



Ploughing for the secondary crops is to start immediately when the cotton has been harvested and the stalks have been removed, the season for these crops being rather short because of the stringent condition that the following cotton crop must be planted in the period February to early March. The varieties to be used should be short-duration varieties; especially a crop like beans is suitable for the purpose.

In the main season, cotton will be planted at an intensity of 95%; only the odd plot will not be planted due to circumstances such as too late harvesting of the previous crop or sickness of the farmer. During the off-season the cropping intensity will be rather low, i.e. 40% in the first years, since the farmers have to get used to growing two crops a year under irrigation. In later years, the intensity is expected to increase to some 50, 60 and 80% in years 6, 11, 21 and following years respectively. A high intensity during the off-season offers the advantage that less fields are left fallow which otherwise would be overgrown with weeds hampering land preparation for the following crop.

4.7 Farmer's food requirements

The quantities of maize and beans (in kg), a farmer's family of 7 persons will consume annually are, losses included, estimated as follows.

Crops	Reference years				
	1	6	11	21	31
Maize	1,110	1,190	1,220	1,230	1,230
Beans	340	370	380	380	380

4.8 Cropping patterns

On basis of the food requirements and the crop yields, the areas to be cropped by a farmer on a 1.2-ha farm under three alternatives have been established. The 1.2-ha farm size has been selected because it provides the farmers with a reasonable income and can be coped with by the greater part of the farmers' families. At Hola it has been found that 1.6-ha plots cannot be handled by family labour only, and call for either hiring seasonal labour or leaving the land fallow.

The three alternatives considered are the following.

I. Cotton in the main season and as many groundnuts as possible in the off-season with the restriction that for reasons of disease and pest control a certain area is grown with groundnuts only 2 out of every 3 years, thus with a maximum intensity of 66%, or on a 1.2-ha farm not more than 0.8 ha. This intensity will be reached in about year 21.

II. Cotton in the main season and in the off-season food crops to meet 50% of the food requirements of the farmer and his family, where possible supplemented with groundnuts.

III. As alternative II but in this case the farmer will grow food crops to meet 100% of his food requirements, supplemented with groundnuts, if possible.

The areas to be cropped in the reference years under the three alternatives are given in Table D.4.

Table D.4 - Cropped area (in ha and in %) on a 1.2-ha farm under three alternatives

Reference years		1		6		11		21		31	
	Season*	ha	%	ha	%	ha	%	ha	%	ha	%
Alternative I											
cotton	MS	1.14	95	1.14	95	1.14	95	1.14	95	1.14	95
maize	OS	-	-	-	-	-	-	0.09	8	0.09	8
beans	OS	-	-	-	-	-	-	0.07	6	0.07	6
groundnuts	OS	0.48	40	0.60	50	0.72	60	0.80	66	0.80	66
Alternative II											
cotton	MS	1.14	95	1.14	95	1.14	95	1.14	95	1.14	95
maize	OS	0.27	22	0.26	22	0.23	19	0.18	15	0.17	14
beans	OS	0.21	18	0.20	17	0.18	15	0.15	13	0.14	12
groundnuts	OS	-	-	0.14	11	0.31	26	0.63	52	0.65	54
Alternative III											
cotton	MS	1.14	95	0.34	95	1.14	95	1.14	95	1.14	95
maize	OS	0.27	22	0.26	28	0.40	33	0.37	31	0.35	29
beans	OS	0.21	18	-	22	0.32	27	0.30	25	0.28	23
groundnuts	OS	-	-	-	-	-	-	0.29	24	0.33	28

* MS = main season
OS = off-season

In reference year 1, only 40% of food crops is grown under alternative II instead of 50% due to the low cropping intensity; for the same reason only 40, 65 and 88% of food crops instead of 100% are grown under alternative III in reference years 1, 6 and 11 respectively.

4.9 Labour requirements

The labour requirements for a 1.2-ha farm under the three alternatives have been calculated. During the cotton growing season they do not differ because the area under cotton is the same under each of the alternatives. In the off-season there are small variations due to the different crops grown, but under none of the alternatives does the total labour requirement exceed the capacity of the farmer's family. In view of the foregoing, only details of alternative II have been presented in Appendix D.II. They show that during the first years sufficient labour is available within the farmer's family, but in years 6, 11, 21 and 31 casual labour has to be hired during 9, 13, 16 and 18 days respectively. The cost of the casual labour increases from K.Sh. 32 in year 6 to K.Sh. 108 in year 31.

4.10 Farmer's income

The average farmer's income under the three alternatives, calculated on the basis of economic as well as financial prices, has been presented in Table D.5. The financial prices are producer's prices for cotton and groundnuts, and consumer's prices for the food crops maize and beans (for more details on these prices, see Annex I). The production costs and the cost of casual labour used to calculate the incomes are the costs mentioned in Table D.2 and in the previous section respectively. The figures represent gross incomes, charges for management or water have not been accounted for; these charges will be dealt with in Annex J.

Table D.5 - Average farmer's income (in K.Sh.) from a 1.2-ha farm

Reference years	1	6	11	21	31
Based on economic prices:					
Alternative I	1,950	2,490	2,920	3,530	3,910
" II	1,830	2,310	2,720	3,410	3,790
" III	1,830	2,250	2,570	3,180	3,560
Based on financial prices:					
Alternative I	1.870	2.480	2.900	3.590	3.960
" II	1.900	2.510	2.900	3.560	3.930
" III	1.900	2.520	2.890	3.500	3.870

The figures show that economically alternative I results in a slightly higher income than the two other alternatives, but financially there is no appreciable difference between the income under the three alternatives. Thus, it is hardly profitable to the farmer to grow only groundnuts in between two cotton crops, without any food crops for his own consumption.

Agronomically, it would seem to be preferable to rotate cotton with more than one crop and consequently, a cropping pattern with cotton to be grown in the main season, and groundnuts with in addition food crops for home consumption during the off-season, is recommended.

4.11 Different farm sizes in relation to the farmer's income

This sub-section briefly discusses the farmer's income from farms other than the 1.2-ha holding used so far.

Our calculations have shown that the cropping pattern is only of minor influence on the farmer's income and the labour requirements. Therefore, only one cropping pattern has been used in the detailed calculations of the farmers' incomes and labour requirements for the different farm sizes. Use has been made of the cropping pattern of alternative II in which cotton is grown in the main season and food crops to meet the food requirements of the farmer's family for 50% in the off-season, if possible supplemented with groundnuts.

The cropping patterns for an 0.8 and a 1.6-ha farm under this alternative are compared with that of a 1.2-ha farm in Table D.6.

Table D.6 - Cropping patterns and intensities in % for three different farm sizes under alternative II

Crops	Farm size		
	0.8 ha	1.2 ha	1.6 ha
Year 1			
cotton	95	95	95
maize	23	22	23
beans	17	18	16
groundnuts	-	-	1
Year 31			
cotton	95	95	95
maize	23	14	11
beans	19	12	9
groundnuts	38	54	60

During the first few years, the cropping patterns will differ slightly only, but later relatively more food crops will be grown on the smaller farms. Labour requirements as detailed in Appendix D.II show that no labour has to be hired for the 0.8-ha farm throughout the evaluation period. As mentioned in Sub-section 4.9, only some labour has to be hired in later years on the 1.2-ha farm. On the 1.6-ha farm, the farmer has to hire labour during 18 days in year 1, increasing to 70 in year 31. The cost of this labour increases from K.Sh. 54 in year 1 to K.Sh. 420 in year 31.

Farmers' incomes from an 0.8-ha and from a 1.6-ha farm have been calculated in the same way as explained in Sub-section 4.9. They have been presented and compared with the incomes from a 1.2-ha farm in Table D.7.

Table D.7 - Farmers' incomes (in K.Sh.) at different farm sizes under alternative II

Reference year	1	6	11	21	31
Farm size:					
0.8 ha	1,270	1,700	1,970	2,360	2,610
1.2 ha	1,900	2,510	2,900	3,560	3,930
1.6 ha	2,490	3,220	3,710	4,540	4,990

Like at Masinga, the farmer's income from an 0.8-ha farm is rather small, the more so since charges for management and water have not been accounted for. These charges will be dealt with in the economic evaluation (Annex J). By enlarging the farms, incomes can be increased considerably, but if so, less tenants can be settled and more casual labourers have to be hired for cotton picking (see Table D.8).

Table D.8 - Number of tenants and number of hired labourers required for the three farm sizes

Reference years	1	6	11	21	31
Farm size: 0.8 ha					
number of tenants	875	5,000	5,000	5,000	5,000
hired labourdays	-	-	-	-	-
number of labourers hired	-	-	-	-	-
Farm size: 1.2 ha					
number of tenants	583	3,333	3,333	3,333	3,333
hired labourdays	-	30,000	43,330	53,330	60,000
number of labourers hired	-	600	866	1,066	1,200
Farm size: 1.6 ha					
number of tenants	438	2,500	2,500	2,500	2,500
hired labourdays	7,880	110,000	135,000	162,500	175,000
number of labourers hired	157	2,200	2,700	3,250	3,500

The number of labourers to be hired has been calculated on the basis of the number of days that each farmer has to hire labour (see Appendix D.II) and on the assumption that a labourer will work 25 days a month during the cotton-picking season which is assumed to last two months.

The number of casual labourers needed for the 1.6-ha farm increases rapidly over the years. In the rather isolated project area such high number of labourers for only a short period may not be available, and it will not be easy to transport and house these people. For these reasons, a farm size of about 1.2 ha would seem to be preferable, which is confirmed by the experience gained at Hola.

4.12 Production volumes of cotton, maize, beans and groundnuts

On the basis of the different cropping patterns, the total production volumes under the three alternatives for the whole irrigation scheme have been calculated (see Table D.9).

Table D.9 - Total production volumes in tons under the three alternatives

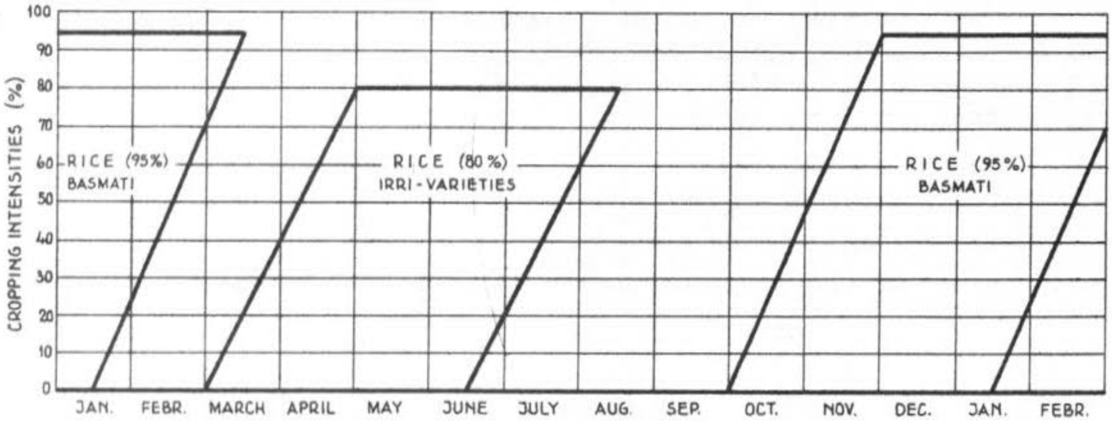
Reference years	1	6	11	21	31
Alternative I					
cotton	1,260	8,360	9,310	10,070	10,830
maize	-	-	-	1,060	1,200
beans	-	-	-	300	320
groundnuts	250	1,760	3,240	4,490	4,884
Alternative II					
cotton	1,260	8,360	9,310	10,070	10,830
maize	240	1,940	2,010	1,980	2,100
beans	90	580	630	680	700
groundnuts	-	480	1,900	3,540	4,000
Alternative III					
cotton	1,260	8,360	9,310	10,070	10,830
maize	240	2,460	3,500	4,090	4,350
beans	90	750	1,130	1,250	1,240
groundnuts	-	-	-	1,630	2,070

4.13 Possibilities of rice cultivation

Climatologically, the Bura area would seem to be suitable for rice growing if irrigation is provided. But rice is rather sensitive to high alkalinity of the soils and it should, therefore, be grown only on the 2,550 ha of soils of classes 1 and 2. As it is difficult to rotate rice with other crops, the possibilities of rice growing are discussed separately in this section.

At Mwea as well as at Ahero, the best rice yields are obtained if rice is grown from October to February. A second crop, giving lower yields, is grown at Ahero from March until August. Comparing the climatological data these two periods would seem to be best for rice growing at Bura too. The cropping patterns have been presented in Figure D.2.

FIG. D-2 CROPPING PATTERN FOR TRANSPLANTED RICE IN YEAR 11 AND FOLLOWING YEARS



Yield projections have been given in Table D.1; production costs have been dealt with in Appendix D.I and summarized in Table D.2. The main cost items are rotavating, fertilizing, and pest and disease control.

The net production values (see Table D.3) show that main-season Basmati has the highest NPV. It should, therefore, be preferred for this season, while IRRI varieties should be grown in the off-season, when the Basmati yields are very low.

The farmer's income from a 1.2-ha farm has been calculated at a cropping intensity of 95% Basmati in the main season and of 40, 60 and 80% in the off-season in years 1, 6 and 11 and following years respectively. These intensities have been based on the experience gained on the Ahero scheme and they are somewhat higher than those under the alternatives with irrigated dryland crops. Financial producer's prices have been used. The labour requirements (see Appendix D.II) show that for a 1.2-ha farm no casual labour has to be hired.

The resulting farmer's gross income (in K.Sh.), excluding water and management charges is as follows in the different reference years.

Reference years	1	6	11	21	31
Farmer's income	862	1,479	2,166	2,956	3,365

The incomes are lower than those derived from a 1.2-ha farm with cotton and second crops in the off-season. Hence, rice growing is less attractive to the farmer.

4.14 Cropping on soils of class 3

If a rice scheme is implemented the soils of class 3 could be used for other crops, but they will yield less because of the alkalinity of the subsoil (see Table D.1).

The production costs are estimated to be the same as those presented in Table D.2, except for groundnuts, for which they will be somewhat lower because combining will cost less. For groundnuts on class-3 soils, these costs are estimated as follows.

Reference year	1	6	11	21	31
Production cost (in K.Sh./ha)	730	790	830	900	935

The NPV per ha for each of the suggested crops have been given in Table D.10.

Table D.10 - NPV (in K.Sh./ha) for crops to be grown on class-3 soils

Reference years	1	6	11	21	31
Based on economic prices:					
cotton	1,146	1,245	1,347	1,746	2,139
maize	- 146	- 300	- 310	- 190	- 75
beans	- 27	35	98	264	361
groundnuts	- 52	- 30	38	348	584
Based on financial prices:					
cotton	1,194	1,245	1,347	1,746	2,139
maize	130	44	20	166	420
beans	110	200	290	525	663
groundnuts	- 79	- 44	22	325	556

The financial prices used are producer's prices for cotton and groundnuts and consumer's prices for the food crops maize and beans (see Annex I).

The figures show that cotton is the most profitable crop and that cultivation of maize is economically not profitable, which is also the case for beans and groundnuts in the first years of the project.

Financially, however, the farmer will derive some income from all the crops, except groundnuts, during the first years.

The farmer would attain the highest possible income if he grows cotton in the main season and food crops supplemented with groundnuts from year 11 onwards in the off-season. The resulting cropping pattern for a 1.2-ha farm has been presented in Table D.11.

Table D.11 - Cropping pattern for a 1.2-ha farm on class 3 soils based on 50% food crops where possible

Crops	Reference years				
	1	6	11	21	31
cotton	95	95	95	95	95
maize	25	29	33	21	17
beans	15	21	23	17	14
groundnuts	-	-	4	42	49

The farmers' incomes on a 1.2-ha farm are then as follows.

Reference year	1	6	11	21	31
Farmer's income (in K.Sh.)	1,420	1,460	1,530	2,240	2,870

These incomes have been calculated similarly as the average incomes in Sub-section 4.10, except that the cost of casual labour to be hired during cotton picking has been reduced by 15% because yields on class-3 soils will be some 15% lower. The resulting incomes are considerably lower than the average incomes presented in Table D.5. To improve the situation for the farmers cultivating class-3 soils, two alternatives could be considered:

a) having the farmers on class-3 soils pay less for management and water than those cultivating the better soils;

b) increasing the farm size on class-3 soils and reducing it on soils of classes 1 and 2.

4.15 Summary and conclusions

1. The only climatic constraint on crop production in the Bura area is the low rainfall; if irrigation is provided, a wide range of tropical crops can be grown in the area.

2. The soils are fertile, but in the greater part of the area the subsoils are saline or alkaline, or both. In about 36% of the area, the topsoil has a depth of 15 cm only.

3. With irrigation, high yields can be attained on class-1 and class-2 soils; yields on class-3 soils are expected to be lower.

4. Many crops have been considered; for the economic evaluation the cash crops cotton, groundnuts and rice, and the food crops maize and beans have been chosen. Other crops are not recommended for reasons such as:

- too small a size of the area to make them profitable (sugar-cane);
- too labour-intensive and technical difficulties in processing (rosella and kenaf);
- low price (sunflower).

5. Cash crops are economically more profitable than food crops, but if the farmer's income is considered, it hardly pays for the farmer to grow cash crops only during the off-season without any food crops for his own consumption.

6. The cropping calendar and cropping intensity have been based on the experience gained at the Hola Pilot Project, where similar conditions prevail as in the Bura area.

7. The farmer's gross income is only slightly influenced by the cropping pattern, as long as the farmer consumes the food crops he cultivates; therefore, it is directly related to the farm size and increases from year 1 to year 31 from K.Sh. 1,270 to K.Sh. 2,600 a year for an 0.8-ha farm, from K.Sh. 1,900 to K.Sh. 3,900 for a 1.2-ha farm and from K.Sh. 2,500 to K.Sh. 5,000 for a 1.6-ha farm.

8. Labour requirements are such that for an 0.8-ha farm no casual labour has to be hired. For a 1.2-ha farm, some casual labourers have to be hired during the cotton picking in later years of the evaluation period, while for a 1.6-ha farm the number of days, during which help of casual labour is needed, will increase from about 18 in year 1 to 70 in year 31. The number of labourers to be hired during the two-month cotton picking will increase to 1,200 in case of 1.2-ha farms and to 3,500 for the 1.6-ha farms.

9. Rice which is difficult to rotate with other crops, has been reviewed separately. It can be grown twice a year. The crop had better not be grown on soils of class 3 because of alkalinity hazards in the subsoil. The gross farmer's income from a 1.2-ha farm on soil classes 1 and 2 is expected to increase from K.Sh. 860 in year 1 to K.Sh. 3,365 in year 31. No casual labour has to be hired on a rice farm of this size.

10. If it is decided to grow rice on classes 1 and 2 soils, cotton and other crops can be grown on class 3 soils. But because of the shallow topsoil and the alkali subsoil, yields will be lower than on soils of classes 1 and 2. Cotton will still be economically attractive; maize will not be a profitable crop throughout the project period, while for beans and groundnuts this will be so in the first few years. Financially, maize and beans will provide some profit to the farmer. Groundnut growing will result in a financial loss in the first few project years, but when the yields will rise in later years it can be grown at a profit. Hence, the cropping pattern on class 3 soils should include mainly maize and beans in the off-season during the first few years and only later should groundnuts be added. The gross farmer's income on a 1.2-ha farm on class 3 soils will increase from K.Sh. 1,420 in year 1 to K.Sh. 2,900 in year 31.

11. From an agronomic point of view and as far as the gross farmer's income is concerned, we would recommend for the 4,000-ha Bura Irrigation Scheme that:

a) the cropping pattern adopted at Hola should be followed;
b) cotton be grown as the main crop;
c) in the off-season, in addition to groundnuts which is the most profitable crop, food crops be grown to meet the food requirements of the farmer's family;
d) the farm size, given the available labour, be set at 1.2-ha;
e) farmers on the problem soils of class 3 should be charged less for water and management than the farmers on classes 1 and 2 soils, while a larger farm size on the former soils might be considered;
f) research at Hola, especially with a view to a greater diversification of profitable crops, be transferred to Bura as soon as possible.

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APPENDIX D.I

INPUTS AND PRODUCTION COSTS

1 SUMMARY OF INPUTS AND PRODUCTION COSTS PER HECTARE

In the table on the next page, the inputs, production costs and labour requirements per ha have been summarized. For explanation of the data, see Sections 2 and 3 of this Appendix. The labour requirements have been elaborated in Appendix D.II.

2 MECHANIZATION

2.1 Tractors and implements needed

Soil preparation for all crops and harvesting of groundnuts will be mechanized. The time needed for these activities has been based on the experience gained at Hola and Mwea, and at the Tambul Pilot Farm on the Rahad Development Project in the Democratic Republic of the Sudan, where similar circumstances prevail as in the Bura area.

The number of hours per activity per ha, and the tractors and implements needed at the time when the scheme will have been fully developed and will be cropped for 95% with cotton in the main season and for 80% with maize, beans and groundnuts in the off-season (see Subsection 4.10 of Annex D) are listed hereunder.

	Hours/ha	Number needed
Tractors		40 (62 h.p. each)
Ploughing	3.5	16 disc-ploughs
Harrowing	1.5	7 disc-harrows
Ridging	1.0	5 ridgers
Groundnut lifting and shaking	1.5	4 groundnut digger-shakers
Wind rowing	0.5	2 side-delivery rakes
Combining	2.0	5 combines.

The combining time of 2 hours per ha refers to a crop of 2-2.5 ton per ha. If yields are lower, the cost for combining has been reduced accordingly.

The total number of hours required for mechanized operations has been arrived at as follows:

3,800 ha soil preparation (main season)	x 6 hours	= 22,800 hrs
3,200 ha soil preparation (off-season)	x 6 hours	= 19,200 hrs
2,160 ha groundnut harvesting	x 4 hours	= 8,640 hrs
	Total	50,640 hrs

Table D.I.1 - Inputs, production costs and labour requirements per hectare

	Cotton						Maize						Beans					
	Year 1			Year 31			Year 1			Year 31			Year 1			Year 31		
	Inputs	Costs K.Sh./ha	Manday per ha	Inputs	Costs K.Sh./ha	Manday per ha	Inputs	Costs K.Sh./ha	Manday per ha	Inputs	Costs K.Sh./ha	Manday per ha	Inputs	Costs K.Sh./ha	Manday per ha	Inputs	Costs K.Sh./ha	Manday per ha
Soil preparation:																		
- ploughing	3½ hrs	144	3	3½ hrs	144	3	3½ hrs	144	1	3½ hrs	144	1	3½ hrs	144	1	3½ hrs	144	1
- harrowing	1½ "	72		1½ "	72		1½ "	72		1½ "	72		1½ "	72		1½ "	72	
- ridging	1 hr	40		1 hr	40		1 hr	40		1 hr	40		1 hr	40		1 hr	40	
Levelling	1 "	44	1															
Seed	25 kg	15		25 kg	15		20 kg	9		20 kg	40		30 kg	36		30 kg	36	
Planting			12			18			8			10			10			12
Thinning/gapping			6			8			2			4			2			4
Weeding			35			42			20			40			25			40
Fertilizing	60 kg N	150	2	100 kgN	250	3	50 kg N	125	1	100 kg N	250	2	10 kg N	25	1	10 kg N	25	1
Disease and pest control	8 appl.	400	4	10 appl.	500	5	1 appl.	40	1	3 appl.	120	3	1 appl.	40	1	2 appl.	80	2
Irrigation			5			7			4			4			3			3
Harvesting			90			125			23			38			8			14
Threshing									23		45	5			1			2
Grading			25			35												
Miscellaneous	10%	85	17	10%	104	24	10%	40	7	10%	69	10	10%	33	4	10%	40	7
Total		950	200		1,125	270		470	90		780	117		390	56		437	86

	Groundnuts						Rice					
	Year 1			Year 31			Year 1			Year 31		
	Inputs	Costs K.Sh./ha	Manday per ha	Inputs	Costs K.Sh./ha	Manday per ha	Inputs	Costs K.Sh./ha	Manday per ha	Inputs	Costs K.Sh./ha	Manday per ha
Soil preparation:												
- ploughing	3½ hrs	144	1	3½ hrs	144	1						
- harrowing	1½ "	72		1½ "	72		5 hrs	300	1	5 hrs	300	1
- ridging	1 hr	40		1 hr	40							
Levelling												
Seed	150 kg unshelled	180		150 kg unshelled	180		30 kg	30	3	30 kg	30	
Planting			10			12			30			35
Thinning/gapping			4			5						
Weeding			30			35			50			50
Fertilizing				40 kg N	100	2	60 kg N	150	2	125 kg N	315	4
Disease and pest control	2 appl.	80	2	3 appl.	120	3	2 appl.	80	2	3 appl.	120	2
Irrigation			4			5			6			6
Harvesting		164	30		226	43			35			60
Winnowing/cleaning			22			35						
Miscellaneous	10%	60	10	10%	83	14	10%	70	12		85	16
Total		740	113		965	155		630	138		850	174

For soil preparation for cotton, the main-season crop, and harvesting of groundnuts, there are about 70 days available between the beginning of December and the end of February.

With double shifts of 9 hours, (i.e. 2 shifts of 6 effective hours accounting for 30% lost time), one tractor can work 840 hours in 70 days.

The total number of tractors needed is then: 22,800 hours soil preparation + 8,640 hours harvesting of groundnuts = 840 hours per tractor or 37 tractors. It is recommended that 3 extra tractors should be purchased.

In the off-season, soil preparation will take 19,200 hours for which 50 working days are available (see cropping calendar, Figure D.1) Thus, 384 hours per day have to be spent on soil preparation. The 40 available tractors can, by working with double shifts, put in 480 hours a day. Hence, the number of tractors will suffice for the off-season ploughing too.

One tractor will be operated 50,640 : 40 = 1,266 hours a year. It is estimated that the tractors will run about 100 hours extra for transport, etc. Therefore, the annual number of hours has been taken at 1,400.

The hours for each implement are related to the number needed and the number of worked hours per ha.

For rotavating of the rice fields, 47-h.p. tractors will be used with rotavators attached. Based on data from the Mwea and Ahero projects, it is estimated that it will take 5 hours to rotavate one hectare. If all soils of classes 1 and 2 are planted to rice at an intensity of 95% in the main season and of 80% in the off-season, 2,420 ha and 2,040 ha will have to be rotavated respectively.

About 9 weeks are available for planting of the off-season crop; 24 tractors working 12 hours a day (8 effective hours) would be able to complete the rotavating in 53 days or just within the 9 weeks available, when working 6 days a week.

For the main crop, there is much more time available but to avoid excessive irrigation of the fallow fields once they have been rotavated, the period of rotavating should be limited. The 24 tractors working 8 effective hours a day can complete rotavating of the 2,420 ha in about 63 working days or about 10½ weeks, which is an acceptable period.

There should be a rotavator for each tractor, so when the scheme is fully cultivated, 24 rotavators will be needed.

Each tractor will be used for rotavating about 930 hours a year; adding some hours for transport, the tractors are estimated to be used 1,000 hours a year for this activity.

2.2 Tractor costs

The following cost calculations have been based on the methods described in FAO Agricultural Development Paper No 85: Multifarm Use of Agricultural Machinery (1967).

	62 h.p. wheel tractor	47 h.p. wheel tractor
Purchase price tractor	K.Sh. 34,000	K.Sh. 29,000
Rate of interest	10%	10%
Period of depreciation	5 years	5 years
Annual use	1,400 hrs	1,000 hrs
Cost of housing and insurance	3½% of purchase price	3½% of purchase price

	62 h.p. wheel tractor	47 h.p. wheel tractor
Repairs and maintenance	120% of purchase price	150% of purchase price
Fuel diesel engine, 50% load on engine	9 l/hr	9 l/hr
Fuel price (exclusive of duties and taxes)	K.Sh. 0.53/l	K.Sh. 0.53/l
Cost of oil	20% of fuel cost	20% of fuel cost
Operator's wages	K.Sh. 480/month	K.Sh. 480/month
Field efficiency	75%	75%

The 62-h.p. tractor is used for cotton and secondary crops and that of 47 h.p. for rotavating of the rice crop.

The costs per hour are:

	62-h.p. tractor	47-h.p. tractor
Depreciation	K.Sh. 4.86	K.Sh. 5.80
Interest	" 1.21	" 1.45
Housing and insurance	" 0.85	" 1.00
Repairs and maintenance	" 5.83	" 8.70
Fuel	" 4.77	" 4.77
Oil	" 0.95	" 0.95
Operator	" 4.11	" 7.20
Sub-total	K.Sh. 22.58	K.Sh. 29.87
Cost per productive hour $\frac{100}{75}$ =	K.Sh. 30.00	K.Sh. 40.00

The costs of the farm implements have been based on the following data; the prices of the implements represent the retail price less 10% discount.

	Disc-plough	Disc-harrow	Ridger	Land plane	Rotavator
Purchase price	4,100	7,100	1,660	11,000	7,600
Rate of interest (%)	10	10	10	10	10
Depreciation (years)	3	6	8	10	3
Annual use (hours)	800	340	230	840	1,000
Repairs and maintenance (% of purchase price/100 hrs)	5½	7½	8	5	7½
Cost in K.Sh. per hour:					
Depreciation	1.71	3.48	0.90	1.30	2.50
Interest	0.26	1.04	0.36	0.65	0.38
Repairs and maintenance	2.26	5.33	1.33	5.50	5.70
Sub-total	4.23	9.85	2.59	7.45	8.58
Tractor costs	30	30	30	30	40
Supervision and overhead (20%)	7	8	7	7	11
Total cost per hour	41.-	48.-	40.-	44.-	60.-

The costs of ploughing one hectare are:

- ploughing 3½ hours at K.Sh. 41 = K.Sh. 144
- harrowing 1½ hours at K.Sh. 48 = K.Sh. 72
- ridging 1 hour at K.Sh. 40 = K.Sh. 40

Total K.Sh. 256

The cost of rotavating one hectare is: 5 x K.Sh.60 = K.Sh.300.

The cost of mechanical harvesting of groundnuts has been based on the following data, the purchase price being the retail price less 10% discount.

	Digger-shaker	Side-delivery rake	Combine
Purchase price (K.Sh.)	20,000	10,000	40,000
Rate of interest (%)	10	10	10
Depreciation (years)	5	5	5
Annual use (hours)	1,000	500	1,000
Repairs and maintenance (% of price per 100 hours)	5½	5½	5½
Cost in K.Sh. per hour:			
Depreciation	4	4	8
Interest	1	1	2
Repairs and maintenance	11	6	22
Sub-total	16	11	32
Tractor cost	30	30	30
Supervision and overhead (20%)	11	9	8
Total cost per hour	58	50	70

The cost of combining a yield of 1,100 kg/ha has been calculated as follows:

- digging and shaking $1\frac{1}{2}$ hours at K.Sh. 58 per hour	= K.Sh.	87
- wind rowing $\frac{1}{2}$ hour at K.Sh. 50 per hour	= K.Sh.	25
- combining K.Sh. 6 per 100 kg	= K.Sh.	66
Total	K.Sh.	178

The cost prices presented above have been used in the calculations of the NPV/ha in Sub-section 4.5 and of the farmers' incomes in Sub-sections 4.9 and 4.13.

In the economic evaluation in Annex J, only the following costs have been considered to be direct costs; capital cost and costs of personnel and supervision have been accounted for differently in the aforementioned Annex.

- cost of insurance - 50% of the costs of housing and insurance;
- costs of spare parts - 60% of the costs of repairs and maintenance;
- costs of fuel and oil.

3 OTHER INPUTS AND PRODUCTION COSTS

3.1 Seed

The following quantities and prices for seed have been used.

Cotton : 25 kg per ha at K.Sh. 0.30 per kg.

Maize : in year 1, farmers will still use local varieties, i.e. 20 kg per ha at a price of about 150% of the economic price. In the following years, farmers are expected to start using hybrid seed, which they will all use in year 31. The price has been set at K.Sh. 2 per kg and the seed rate at 20 kg per ha.

Beans : the price has been set at 150% of the economic price, the seed rate at 30 kg per ha.

Groundnuts: seed rate 150 kg unshelled per ha (about 100 kg shelled) at a price which is 150% of the economic price.

Rice : seed rate 30 kg per ha at about 150% of the economic price.

The prices of seeds refer to certified seed and include the costs of disinfectants where applicable.

3.2 Fertilizing

The soils are thought to be rich enough in potassium and phosphate. Therefore, only nitrogen has been felt to be necessary and accounted for in the production costs at a price of K.Sh. 2.50 per kg. Cotton and rice will be given high applications, the other crops lower ones. Groundnuts will be given a starter-fertilizer in later years.

3.3 Disease and pest control

The costs of disease and pest control have been based on the experience gained at Hola, where aerial spraying of cotton costs K.Sh. 400 a year for 8 applications. This rate has also been maintained for Bura. The number of applications will be increased to 10 in future years.

For other crops, the costs have been set at K.Sh. 40 per application. The number of applications for each crop are given in Table D.I-1 on page 63.

3.4 Harvesting

This will be done in hand labour except for the laborious and difficult harvesting of groundnuts. The costs have been based on the experience at the Tambul Pilot Farm in the Sudan, where groundnuts are mechanically harvested under similar conditions.

In addition to machine harvesting, a large number of mandays are needed for gleaning of nuts remaining in the soil after passing of the groundnut digger-shaker.

3.5 Threshing

Threshing of maize, which will be done with simple hand-operated or tractor-operated shellers, has been estimated at K.Sh. 10 per ton.

3.6 Miscellaneous

To account for small tools and replacement of bags in which the products are to be transported, about 10% of the costs have been added. In general, the costs of small farm tools are low and the bags can be used many times over.

APPENDIX D.II

LABOUR REQUIREMENTS

1 LABOUR REQUIREMENTS FOR 0.8, 1.2 AND 1.6-ha FARMS UNDER ALTERNATIVE II

The labour requirements per ha and the production costs have been presented in Table D.I.1 of Appendix D.I. It has been assumed that the farmers will improve their farming techniques and cultivate their crops more carefully, and thus will spend more time on planting, thinning, gapping, weeding and irrigation. Due to higher fertilizer rates, better disease and pest control and higher yields, the mandays spent on fertilizing, pest control and harvesting and grading will increase too.

Table D.II.1, next page, shows the labour requirements for 0.8, 1.2 and 1.6-ha farms. The cropping pattern used is cotton in the main season and 50% food crops (maize and beans) supplemented with groundnuts in the off-season (alternative II).

The average family size is 7 persons, of which 3 are potential workers. One worker is estimated to work 20 days a month, or in peak periods like planting and harvesting during 26-27 days a month. Thus, per half-monthly period 30-40 labour days per family are available.

In the following table the labour to be hired, expressed in mandays, and the cost of hired labour in K.Sh. have been presented.

Table D.II.2 - Hired-labour requirements and relevant costs for three farm sizes under alternative 2

Reference years	1	6	11	21	31
Wages in K.Sh./manday	3	3.5	4	5	6
0.8-ha farm					
mandays	-	-	-	-	-
cost	-	-	-	-	-
1.2-ha farm					
mandays	0	9	13	16	18
cost	-	32	52	80	108
1.6-ha farm					
mandays	18	44	54	65	70
cost	54	154	216	325	420

The wages in year 1 have been based on those mentioned in the Regulation of Wages and Conditions of Employment Act (1967 and revisions). They are expected to increase over the years.

Table D.II.1 - Labour requirements (in mandays per half-monthly periods) for three farm sizes under alternative II*

Farm size	Jan.		Febr.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.		Total
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	
0.8 ha																									
year 1	3	2	11	8	10	11	6	6	3	3	3	23	26	26	13	2	2	2	3	3	2	3	4	3	178
year 31	8	8	21	11	13	13	8	7	2	3	2	31	36	36	25	4	7	9	9	10	3	7	7	3	283
1.2 ha																									
year 1	4	2	16	12	15	16	9	9	5	5	5	34	39	39	20	3	2	3	4	4	3	5	6	5	265
year 31	17	15	34	16	19	19	11	10	3	4	3	47	54	54	37	5	12	15	14	15	4	8	8	17	441
1.6 ha																									
year 1	6	4	21	16	20	21	12	12	7	7	6	46	52	52	27	4	3	5	6	6	4	6	8	7	358
year 31	24	21	47	21	26	26	15	14	5	5	5	62	71	71	50	6	16	21	19	20	4	10	9	24	592

* Cotton in the main season; food crops to meet 50% of the food requirements of the farmer's family supplemented with groundnuts in the off-season.

2 LABOUR REQUIREMENTS FOR A 1.2-ha RICE FARM

The labour requirements in mandays per half-monthly periods for a 1.2-ha rice farm are as follows.

	Jan.		Febr.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.		Total
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	
Year 1	10	10	14	14	13	7	8	8	6	5	4	5	4	5	4		8	9	10	17	18	19	13	11	222
Year 31	17	17	25	27	28	16	17	16	12	10	14	15	14	15	14		9	11	13	20	21	19	15	14	379

APPENDIX D.III

PRODUCTION VOLUMES AND COSTS, GROSS AND NET PRODUCTION VALUES IN K.Sh. PER HA OF CROPS SUGGESTED FOR THE BURA IRRIGATION SCHEME

	Yield kg/ha	Economic price K.Sh./ton	GPV K.Sh./ha	Production costs K.Sh./ton	NPV K.Sh./ha
Cotton					
1	1,900	1,340	2,546	950	1,956
6	2,250	1,335	3,004	1,025	1,979
11	2,450	1,340	3,283	1,065	2,218
21	2,650	1,355	3,591	1,100	2,491
31	2,850	1,360	3,876	1,125	2,751
Maize					
1	1,550	270	418	470	- 52
6	2,300	200	460	570	- 110
11	2,650	220	583	640	- 57
21	3,300	225	743	730	13
31	3,750	235	880	780	100
Beans					
1	700	725	508	390	118
6	900	725	653	400	253
11	1,050	725	761	410	351
21	1,250	725	906	425	481
31	1,350	725	988	437	551
Groundnuts					
1	900	1,130	1,017	741	276
6	1,150	1,085	1,248	800	448
11	1,350	1,085	1,465	850	615
21	1,700	1,085	1,845	925	920
31	1,850	1,085	2,007	965	1,042
Rice-Basmati (main season)					
1	2,000	665	1,330	630	700
6	2,600	665	1,724	700	1,029
11	3,200	665	2,128	760	1,368
21	4,000	665	2,660	835	1,825
31	4,500	665	2,993	850	2,143
Rice-IRRI (main season)					
1	2,800	465	1,302	630	672
6	3,700	465	1,721	700	1,021
11	4,600	465	2,139	760	1,329
21	5,500	465	2,558	835	1,723
31	6,000	465	2,790	850	1,940
Rice-IRRI (off-season)					
1	2,400	465	1,116	630	486
6	3,200	465	1,488	700	788
11	3,800	465	1,767	760	1,007
21	4,700	465	2,186	835	1,351
31	5,000	465	2,325	850	1,475

ANNEX E

IRRIGATION AND DRAINAGE

CONTENTS

CONTENTS (cont'd)

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1 CALCULATION OF WATER REQUIREMENTS

The water requirements at the intake of the main supply canal have been calculated, based on the open-water evaporation and taking into account crop coefficients, cropping calendars, cropping intensities as well as effective rainfall, pre-irrigation and efficiencies. The calculations have been made in the same manner as for Masinga (see Annex E, Masinga Report).

1.1 Evaporation

The method of calculating the evaporation has been discussed in Annex A: Climate; the calculated monthly values are given in Table E.1 below.

Table E.1 - Monthly evaporation - Bura area, in mm

January	217.8	July	176.1
February	201.0	August	181.4
March	231.9	September	185.4
April	198.3	October	203.4
May	196.5	November	194.1
June	176.1	December	208.3
		Total	2,370.3

1.2 Crop coefficients, cropping calendars and cropping intensities

The crop coefficients have been based on research elsewhere in Kenya. Next to the crop coefficients for maize, groundnuts, grams and beans, which are the same as those used in the Masinga calculations, crop coefficients had to be estimated for rice and sugar-cane. These coefficients have been derived from Ahero data (1). Table E.2, next page, shows all crop coefficients established for the Bura area.

Planting and harvesting periods, as well as projected cropping intensities have been listen in Table E.3, next page; for details, see Annex D: Agronomy and Agro-economy.

Based on this cropping calendar, the crop coefficients as calculated as well as the land use intensities have been adjusted for staggered planting dates (see Table E.4, next page and Table E.5, page 80). Rice and sugar-cane have been included in the calculations for comparison purposes.

Table E.2 - Crop coefficients for the Bura area

	Cotton	Ground-nuts	Maize	Grams and beans	Rice	Sugar-cane	
						plant cane	ratoon
1st month	0.40	0.40	0.40	0.50	1.00	0.40	0.50
2nd "	0.70	0.70	0.80	0.95	1.05	0.70	0.75
3rd "	0.90	0.95	1.00	0.90	1.10	0.95	1.00
4th "	1.00	0.90	0.80		1.00*	1.05	1.05
5th "	0.90					1.05	1.05
6th "	0.70					1.05	1.05
7th "						1.05	1.05
8th "						1.05	1.05
9th "						1.05	1.05
10th "						1.05	1.00
11th "						1.00	0.85
12th "						0.85	0.50
13th "						0.50	

* half month only.

Table E.3 - Growing periods and projected cropping intensities (ultimate development)

Crop	Planting period	Harvesting period	Cropping intensity
Cotton	1/2 to 15/3	1/8 to 15/9	100%
Groundnuts	15/8 to 15/9	15/12 to 15/1	54%
Maize	15/8 to 15/9	15/12 to 15/1	14%
Grams, beans	1/9 to 1/10	1/12 to 1/1	12%
Rice, first crop	1/10 to 1/12	15/1 to 15/3	100%
, second crop	1/3 to 1/5	15/6 to 15/8	80%
Sugar-cane	1/3 to 1/8	15/1 to 15/10	100%

Table E.4 - Crop coefficients adjusted for staggered planting dates

	Cotton	Ground-nuts	Maize	Grams and beans	Rice	Sugar-cane
January		0.90	0.80		1.06	0.90
February	0.40				1.06	0.84
March	0.46				1.00	0.88
April	0.74				1.02	0.96
May	0.91				1.05	0.89
June	0.95				1.06	0.81
July	0.86				1.06	0.78
August	0.73	0.40	0.40		1.00	0.82
September	0.70	0.45	0.47	0.50		0.92
October		0.69	0.77	0.72	1.00	1.00
November		0.90	0.94	0.92	1.02	1.03
December		0.91	0.84	0.90	1.05	1.00

Table E.5 - Land use intensities (in per cent)

Crops	Cotton	Ground-nuts	Maize	Grams and beans	Rice	Sugar-cane
Intensity	100	54	14	12	100/80	100
January		9	2		90	92
February	36				50	93
March	90				34	90
April	100				56	86
May	100				80	88
June	100				80	92
July	100				28	95
August	64	9	2		24	95
September	11	45	12	6		92
October		54	14	12	30	93
November		54	14	12	70	92
December		45	12	6	100	92

Note: Some 200 ha of the cane area will be used as a nursery. It has been assumed that evapotranspiration in this area will be equal to that in the main area.

1.3 Pre-irrigation and depletion

As explained in Annex E on this subject of the Masinga report, a pre-irrigation should be applied to those fields that have been dry for a long period. The assumed quantities are the same as for the crops to be grown in the Masinga area, i.e. for cotton and off-season crops. For sugar-cane no extra allowance for pre-irrigation has been taken into account, because the area to be planted in one month (about 4 per cent) is so small that it will not influence the water requirements.

For rice, additional factors have to be taken into account. This crop is given a pre-irrigation or first flooding of 250 mm before rotavating. Subsequently the field is flooded before transplanting for 3-4 weeks, for which some 200 mm are required to replete both evaporation and leakage. During the last month of the growing period, the water layer in the field and some moisture from the root zone are used, 100 mm in total. These amounts have to be taken into account in the calculations (1).

The quantities of water discussed above and adjusted for staggered planting dates are given in Table E.6, next page. Cotton, groundnuts, maize, grams and beans have been combined in this table (see also Annex E, Table E.6 of the Masinga report).

Table E.6 - Adjustments for pre-irrigation, first irrigation, flooding and moisture depletion just before harvesting (rounded figures)

	Cotton and other crops	Rice	Sugar-cane
January	+ 19	- 40	-
February	+ 30	+ 120	-
March	-	+ 172	-
April	-	+ 110	-
May	-	-	-
June	-	- 16	-
July	- 10	- 40	-
August	- 16	- 44	-
September	+ 36	+ 154	-
October	-	+ 180	-
November	- 1	+ 107	-
December	- 11	-	-

1.4 Effective rainfall

The monthly effective rainfall has been calculated for the one out of five years dry month for the Bura station. This is the rainfall which will be exceeded in four out of five years.

Only part of this rainfall will be effective. Based on experience gained at Ahero, a reduction factor of 0.85 has been used. The results, which have served to calculate the water requirements, are given below (in rounded figures).

	One out of five years rainfall	Effective rainfall
March	14 mm	12 mm
April	25 mm	21 mm
November	29 mm	25 mm
December	21 mm	18 mm

1.5 Crop requirements

Subsequently, the crop or net irrigation requirement, i.e. the amount of water to be supplied to the crops at the rootzone by irrigation, has been calculated for each crop. The calculations are similar to those made for the Masinga area (see Annex E of the Masinga report).

In Table E.7, next page, the crop requirements have been given for cotton and other crops combined, for rice and for sugar-cane, which are the three alternative cropping combinations, as developed in Annex D: Agronomy and Agro-economy.

Table E.7 - Crop requirements for the different alternatives, Bura (mm)

Month	Cotton and other crops	Rice	Sugar-cane
January	40.1	167.8	178.6
February	58.9	226.5	157.0
March	84.0	238.9	157.5
April	125.5	202.1	142.5
May	178.8	165.1	153.9
June	167.3	132.8	131.2
July	141.4	12.3	103.5
August	76.5	0	141.3
September	103.2	154.0	156.9
October	115.5	241.0	189.2
November	115.3	221.0	159.3
December	106.1	200.8	173.7

1.6 Efficiencies

Certain water losses occur between the intake at the river and the rootzone. The same types of losses have been differentiated as in Masinga, but the assumed values vary due to the different characteristics of the two projects:

1. Conveyance losses, which can be split into:
   - project losses 5 per cent, remainder 95 per cent
   - seepage losses 15 per cent, remainder 81 per cent
2. Field losses, split into:
   - farm losses 15 per cent, remainder 69 per cent
   - deep drainage losses 5 per cent, remainder 65 per cent.

Project losses and deep drainage losses have been assumed to be equal to those in the Masinga area because the circumstances under which they occur are the same for both projects. The seepage losses are less at Bura, because the main supply canal flows through relatively heavy soils over its whole course (no red soils). The farm losses have been taken less, at 15 per cent, because slopes of the terrain are much gentler which makes it easier to handle the water properly.

The resulting efficiency of 65 per cent is fairly high but it can certainly be attained a number of years after the start of the project.

1.7 Water requirements at canal intake

The water requirements at the intake of the main supply canal have been calculated for four alternatives, i.e.:

- 4,000 ha cotton with other crops (groundnuts, maize, grams and beans);
- 2,550 ha rice and 1,450 ha cotton;
- 6,500 ha sugar-cane;
- 6,500 ha sugar-cane and 3,500 ha cotton.

The results have been given in Table E.8.

Table E.8 - Water requirements at intake (m^3/sec) for four alternatives at Bura

Month	Cotton and other crops 4,000 ha	Rice and cotton 2,550 ha and 1,450 ha respectively	Sugar-cane 6,500 ha	Sugar-cane and cotton 6,500 ha and 3,500 ha respectively
January	0.92	2.78	6.67	7.47
February	1.50	4.21	6.49	7.80
March	1.93	4.19	5.88	7.57
April	2.98	4.13	5.50	8.10
May	4.11	3.91	5.75	9.34
June	3.97	3.45	5.06	8.54
July	3.12	1.36	3.86	6.70
August	1.76	0.64	5.28	6.82
September	2.45	3.22	6.05	8.21
October	2.65	4.49	7.06	9.38
November	2.74	4.33	6.15	8.55
December	2.44	3.82	6.49	8.63

2 DESIGN CRITERIA

2.1 Water duty

The water duty is the water requirement for irrigation per unit time per unit area, expressed in litres per second per ha (l/sec/ha). The water duty is derived from the water requirements in the month with the highest demand, i.e. May. In the calculations, the water duty has not been affected by effective rainfall, the latter being zero in this month.

At the intake of the main canal, the water duty is 1.03 l/sec/ha. After deducting the losses in the main canal, the duty in the branch canals is 0.93 l/sec/ha. Downstream the night storage reservoirs, the block feeders have been designed at double capacity. For the design, the values have been rounded (upward) to 1 l/sec/ha for the branch canals and to 2 l/sec/ha for the block feeders.

The values for water duty are equal for Masinga and Bura. The higher evaporation at Bura is equalized by the lower water use efficiency at Masinga.

2.2 Drainage coefficient

This is the quantity of water to be discharged through the drains per unit of time per unit area. Storm rainfall has been discussed in Annex A. It has been decided to use the one-day rainfall once out of five years in the calculations.

The drainage coefficient can be calculated similarly as for Masinga: from the rainfall, the storage in the soil bringing the soil to saturation should be subtracted, i.e.:

- rainfall		63.5 mm
- storage in soil (to field capacity)	35 mm	
- additional (to saturation)	12 mm	
		- 47 mm
- resulting runoff		16.5 mm

This works out at a drainage coefficient of about 2 l/sec/ha, which is much lower than that for Masinga due to the more arid climate at Bura. At Bura a greater risk can be accepted because overflowing of drains would not have such serious effects as at Masinga.

No area reduction factor has been used because the drainage units are less than 1,000 ha.

2.3 Design criteria

After having discussed the two most important design criteria, the other ones have been listed in Table E.9. Certain differences with the criteria as established for Masinga may be explained.

- Based on experience gained at Hola (erosion of banks), the maximum velocity in the irrigation canals, which will be built in fill, will be lower than at Masinga.
- For the larger branch canals at Bura a higher K_M and a reduced side slope have been used.
- The maximum velocity in the drains (in cut) has been increased in view of the reduced risk.

Because of the allowed freeboard, canals and drains may convey more water than their design capacity, but for short periods only. Completely full drains, for example, can discharge almost twice as much water as their design capacity.

Table E.9 - Design criteria for the Bura area

	Branch	Block	Unit
1. <u>Irrigation canals:</u>			
- water duty	1 l/sec/ha	2 l/sec/ha	2 l/sec/ha
- maximum velocity	50 cm/sec	50 cm/sec	50 cm/sec
- K_M	40	30	30
- side slopes (vert. : hor.)	1 : 2	1 : 1	1 : 1
- freeboard	50 cm	30 cm	20 cm
- minimum bottom width	50 cm	50 cm	50 cm
- water level above highest surface level at offtake	40 cm	25 cm	15 cm
2. <u>Drains:</u>			
- drainage coefficient	2 l/sec/ha	2 l/sec/ha	2 l/sec/ha
- maximum velocity	80 cm/sec	80 cm/sec	80 cm/sec
- K_M	35	30	30
- side slopes (vert. : hor.)	1 : 1½	1 : 1	1 : 1
- freeboard	30 cm	30 cm	30 cm
- minimum bottom width	60 cm	60 cm	60 cm
3. <u>Roads:</u>			
- width of road (main)	9 m	6 m	4 m
- width of surfacing	3 m	2½ m	-

3 GRAVITY INTAKE AND MAIN SUPPLY CANAL

Two possibilities for the intake of irrigation water from the Tana river have been taken into consideration:

- intake by gravity;
- intake by pumping.

This section discusses the first possibility; the second possibility - intake by pumping - will be dealt with in Section 7 of this Annex.

3.1 General

The intake works for the gravity supply scheme have to be located at the end of a not too smooth bend in the river, with the inlet structure in the outer bend on the right bank. This will help keep away the sediment transported along the bottom of the river to the supply canal. Taking other factors into account as well, such as the altitude of the scheme and the losses in head in and the slope of the main supply canal (see Sub-section 3.2), a very suitable site for the intake has been found on the western bank of the Tana river, approximately 56 km upstream Bura Town (see Map 1). This site has been selected after comparative altimeter measurements of river bank and water levels of possible intake sites along the suitable river section.

Later on, a topographical survey has been made to determine more accurately the ground level of the river bank at the proposed intake site. The measurements have been taken with regard to bench mark SKT 13 of the Survey of Kenya. This and other - temporary - bench marks and spot levels have been shown in the layout (Map 1).

In March 1973, three cross-sections of the river near the proposed intake were measured during low flows to be able to define the site of the intake more precisely (see Figure E.2); for levels of the bank we also refer to this figure.

The bottom level of the intake canal leading the water to the intake structure has been taken at 107.40 m. This canal has a length of about 100 m to keep the intake structure outside the main riverbed for safety reasons (erosion).

The water level during a minimum flow of 27 m^3/sec which may occur once in 10 years is about 108.90 m. As high water level (return period 100 years) we have taken 115.45 m (see Annex B for the discharges and levels mentioned). We have adopted these levels as design levels. As pointed out in Annex B, additional measurements at the site of the intake have to be taken as soon as possible to come to a reliable stage-discharge curve and to define the design levels more accurately based on available and additional information.

The alignment of the proposed main canal (48 km in length) has been shown in the general layout (Map 1). The adopted design level for low flows calls for rather deep excavation over the first 11 km, after which the canal will more or less follow the contours.

FILE - MAIN CANAL

HOR. 1 : 100.000
VERT. 1 : 100

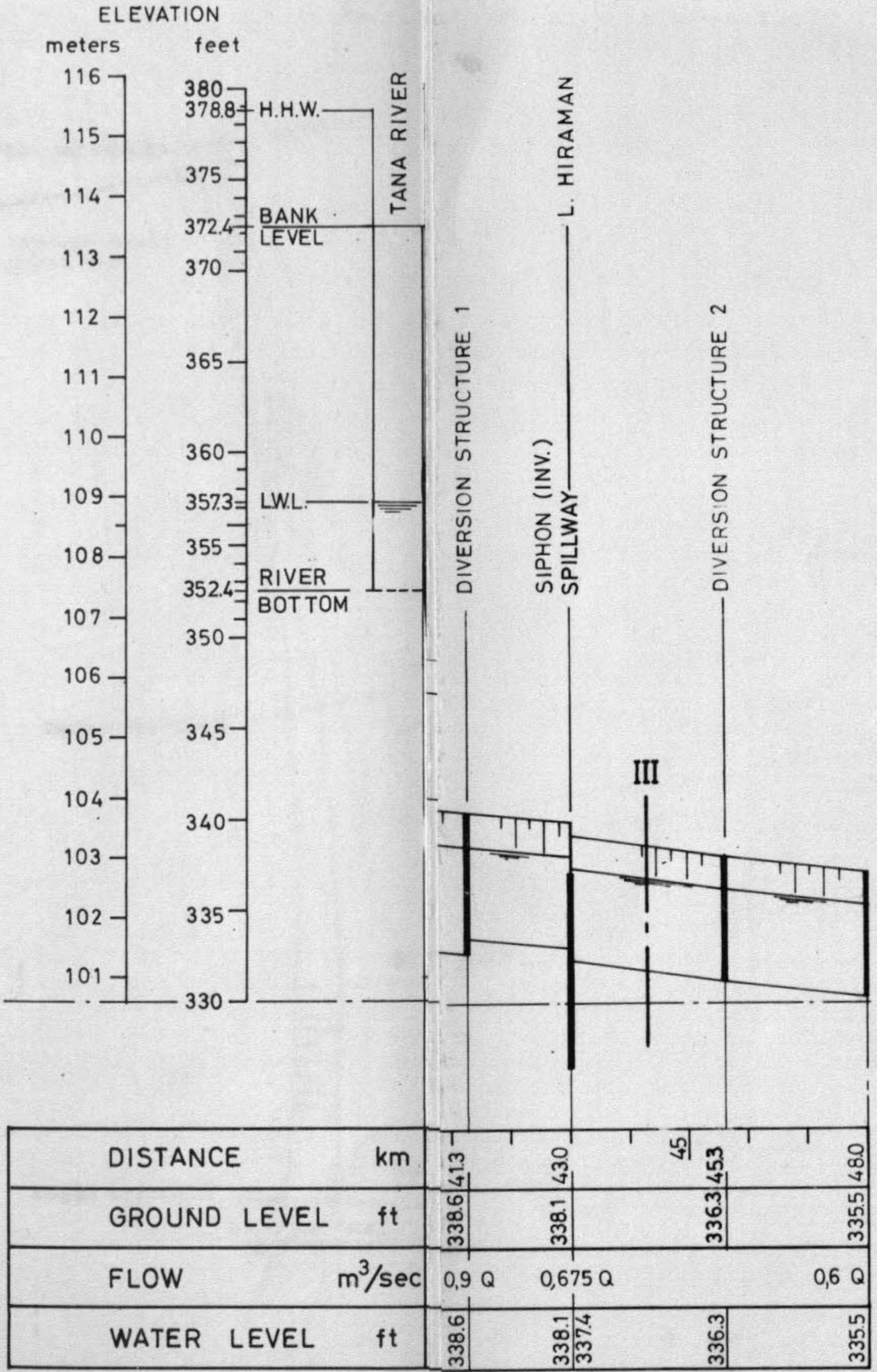

FIG. E.1

BURA

IN SUPPLY CANAL

the intake of irrigation water from the
to consideration:

s the first possibility; the second possi-
will be dealt with in Section 7 of this

the gravity supply scheme have to be lo-
smooth bend in the river, with the inlet
on the right bank. This will help keep away
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LONGITUDINAL PROFILE - MAIN CANAL

SCALE: HOR. 1:100.000
VERT. 1:100

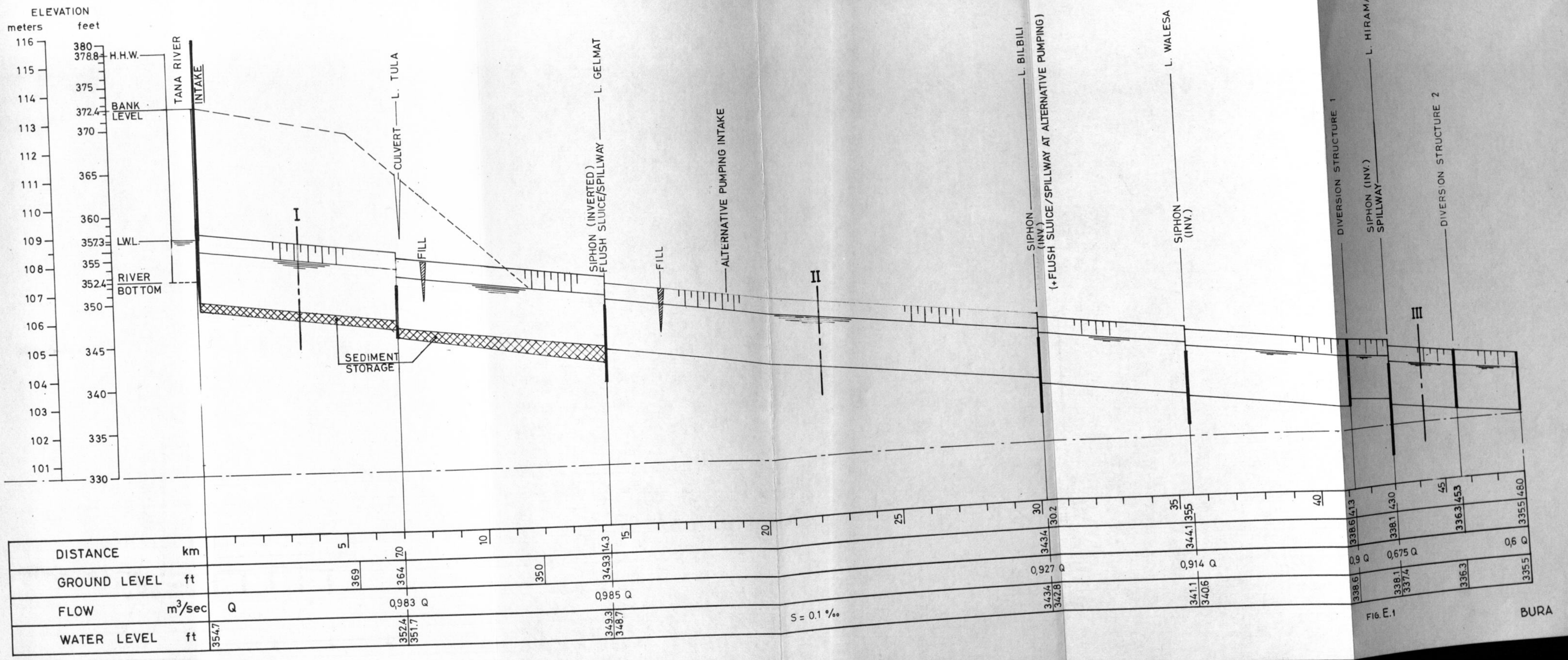

FIG. E.1

LONGITUDINAL PROFILE - MAIN CANAL

SCALE: HOR. 1:100.000
VERT. 1:100

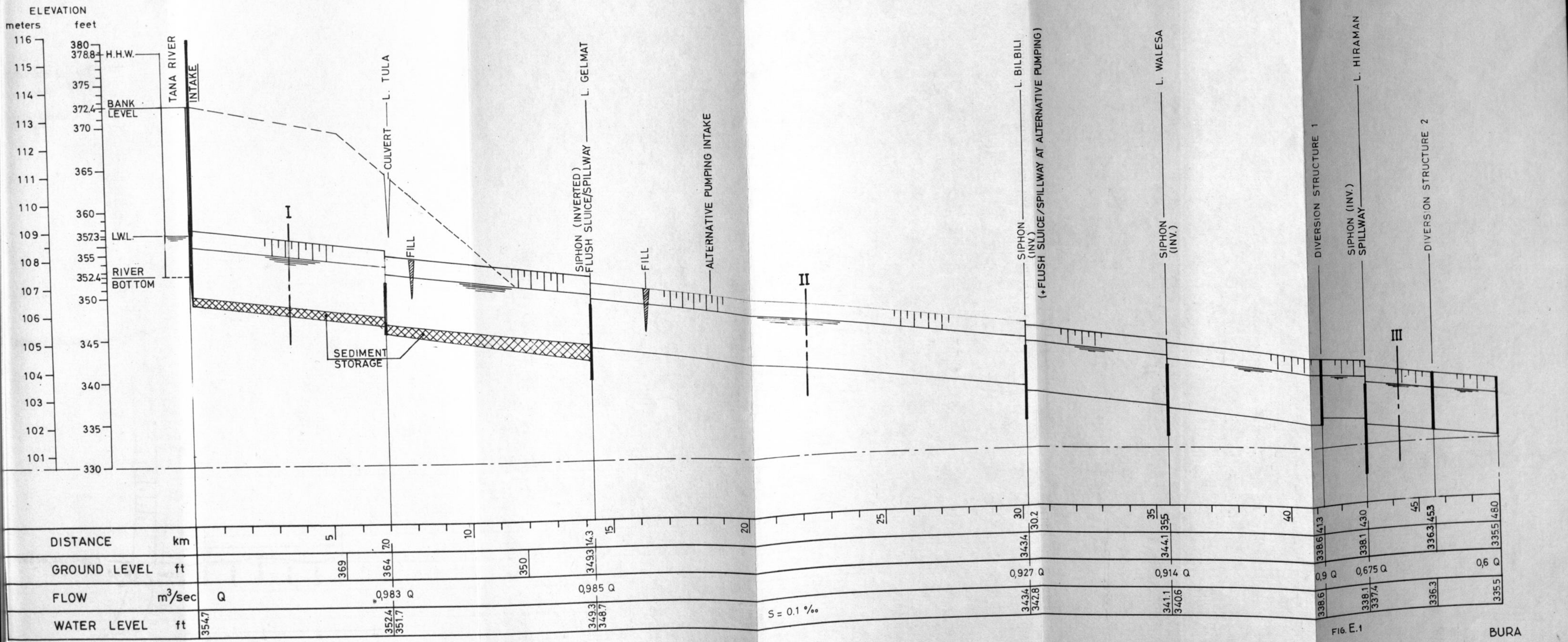

FIG. E.1

LONGITUDINAL PROFILE - MAIN CANAL

SCALE: HOR. 1:100.000
VERT. 1:100

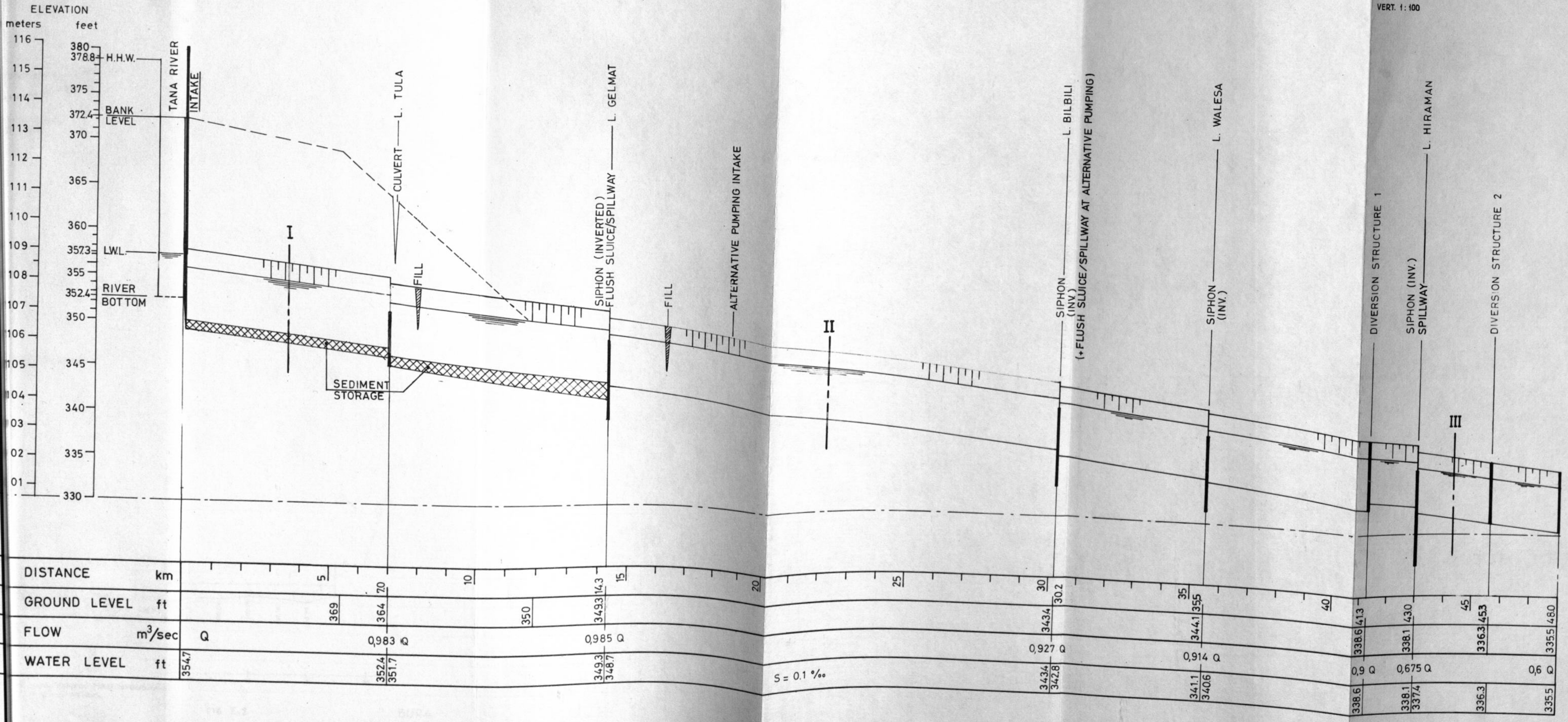

FIG. E.1

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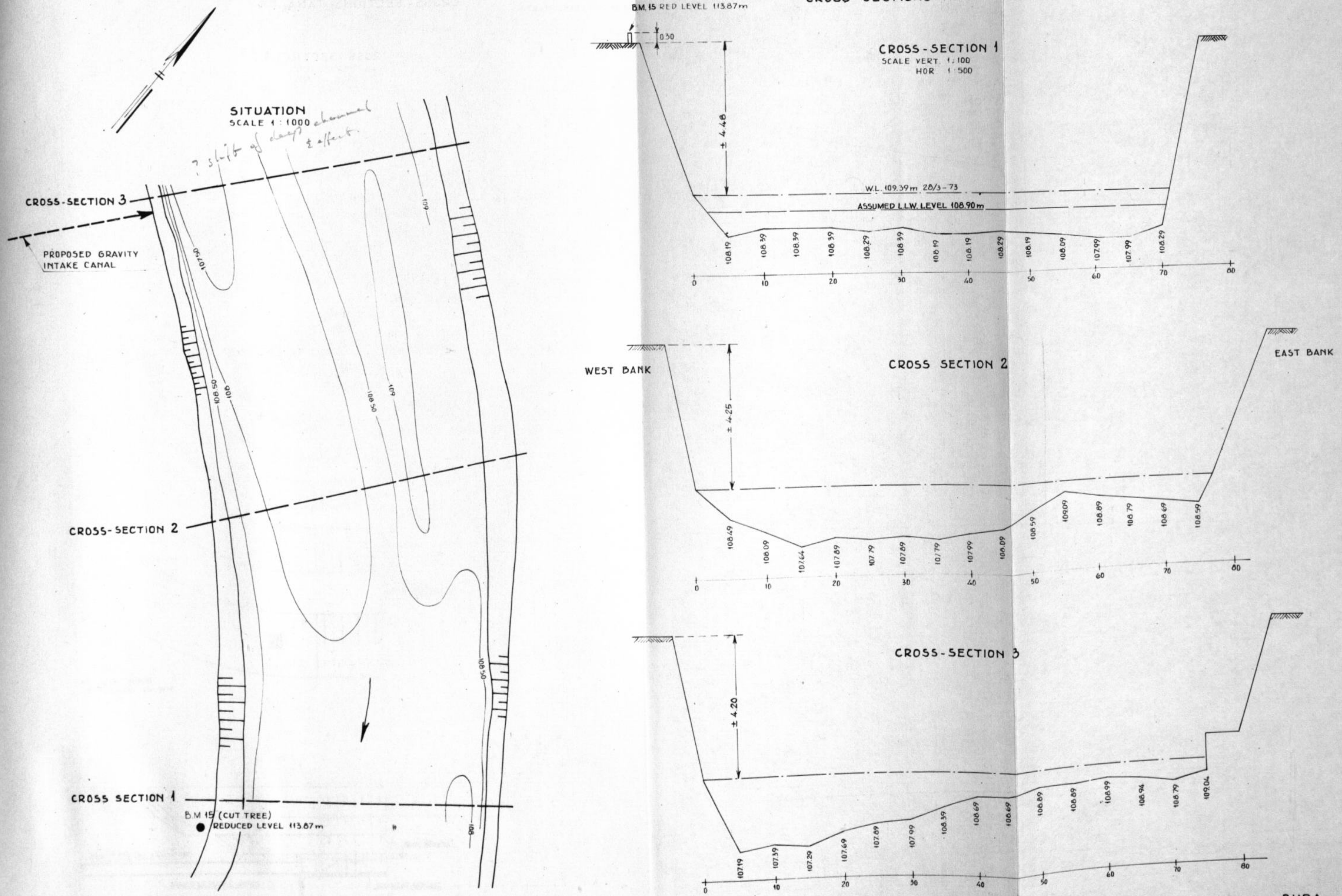
CROSS-SECTIONS TANA RIVER AND SITUATION GRAVITY INTAKE



BURA

ALL LEVELS ARE DEDUCED FROM TOPOGRAPHICAL MAP
ALL LEVELS ARE IN METERS

FIG. E.2

GRAVITY INTAKE WORKS
SCALE 1:400

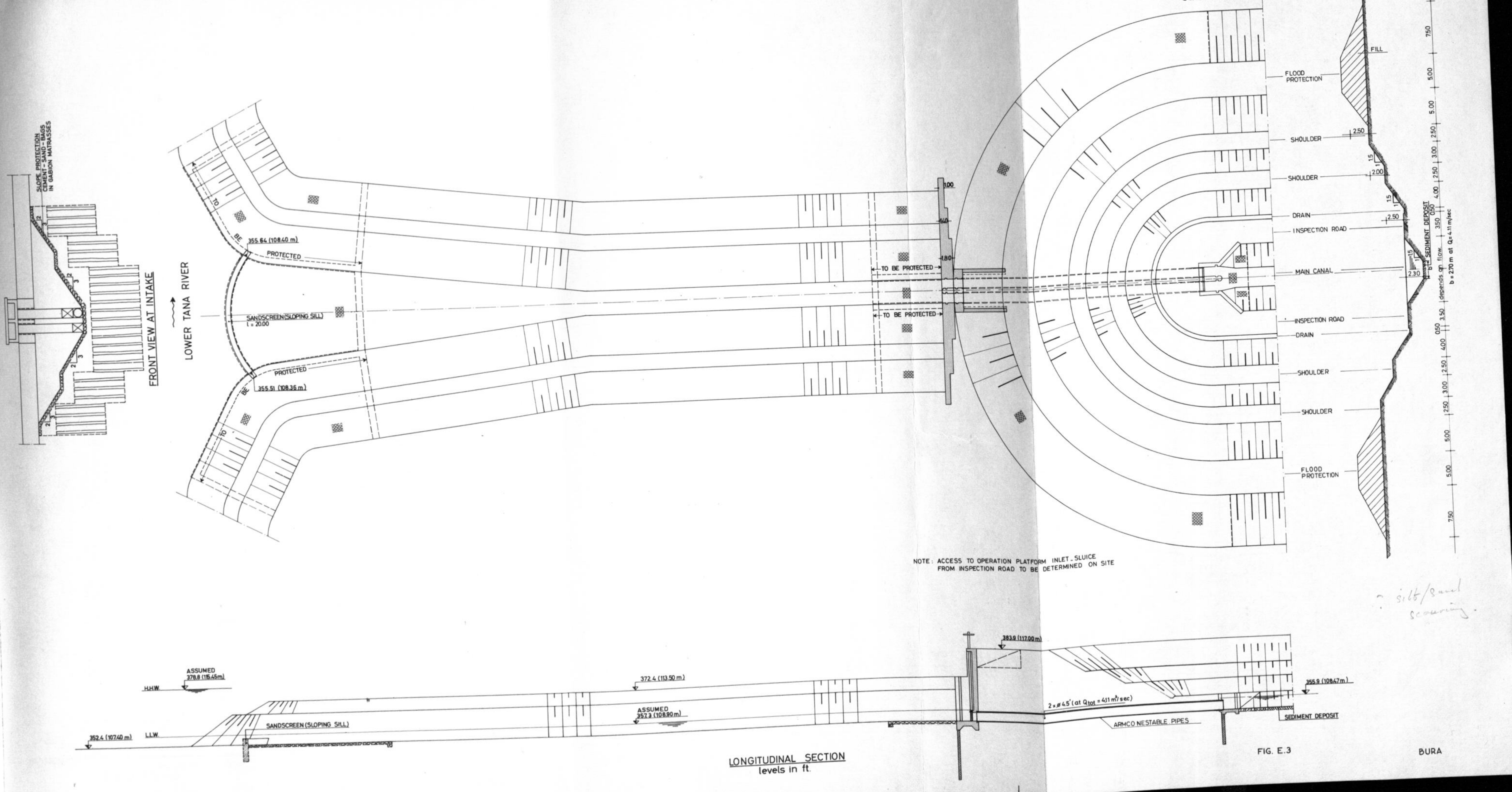
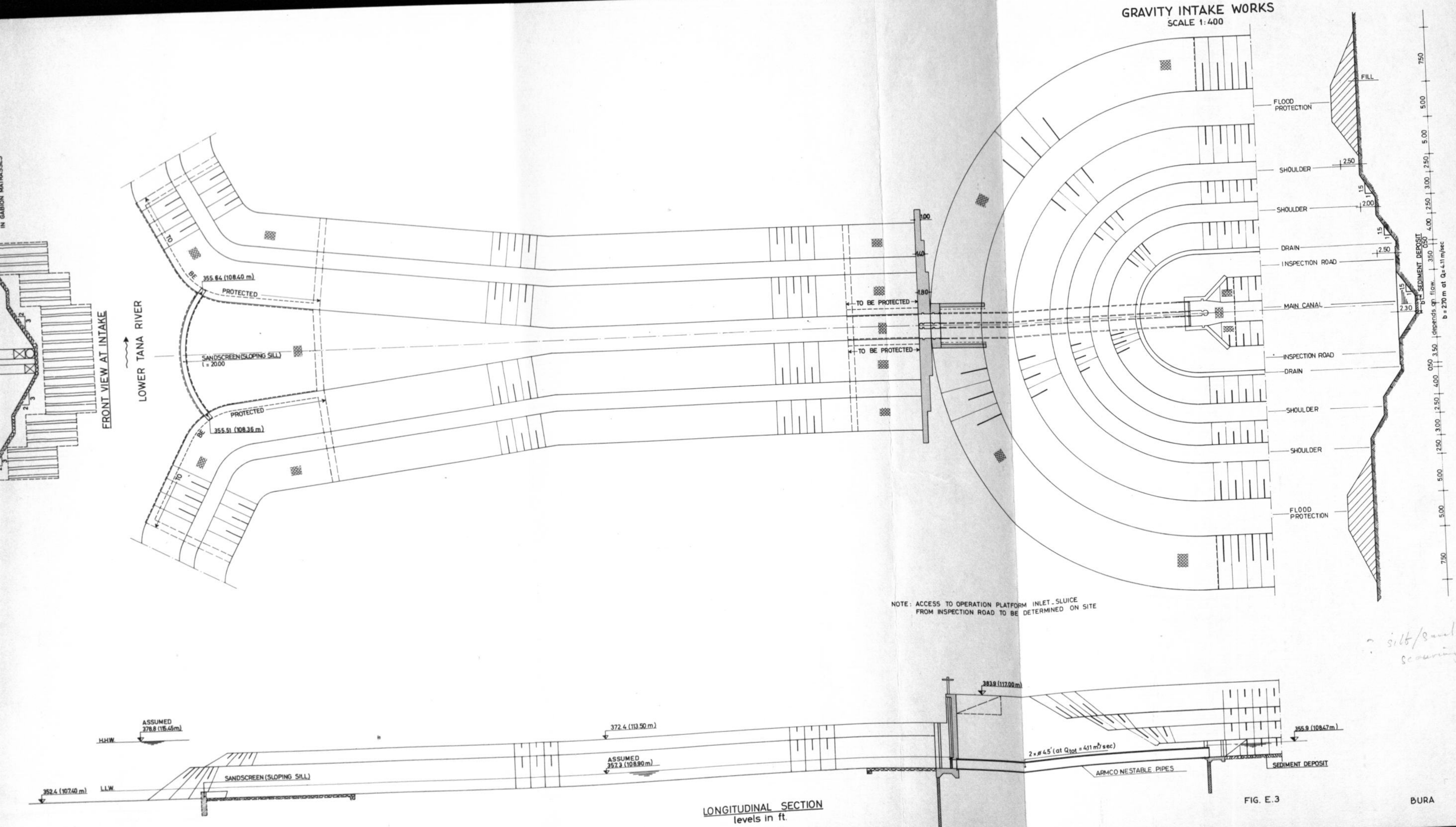


FIG. E.3

BURA


GRAVITY INTAKE WORKS
SCALE 1:400
FRONT VIEW AT INTAKE
LOWER TANA RIVER
TO
BE
PROTECTED
355.64 (108.40 m)
355.51 (108.36 m)
SANDSCREEN (SLOPING SILL)
l = 20.00
TO BE PROTECTED
1.00
1.40
1.80
FLOOD PROTECTION
SHOULDER
DRAIN
INSPECTION ROAD
MAIN CANAL
FILL
SEDIMENT DEPOSIT
b depends on flow
b = 2.70 m at Q = 4.11 m³/sec
7.50
5.00
2.50
3.00
4.00
3.50
0.50
2.00
2.30
NOTE: ACCESS TO OPERATION PLATFORM INLET-SLUICE FROM INSPECTION ROAD TO BE DETERMINED ON SITE
ASSUMED 378.8 (115.45m)
H.H.W.
372.4 (113.50 m)
ASSUMED 357.3 (108.90 m)
352.4 (107.40 m)
L.L.W.
383.9 (117.00 m)
2 x ⌀ 4.5' (at Qtot = 4.11 m³/sec)
ARMCO NESTABLE PIPES
355.9 (108.47m)
SEDIMENT DEPOSIT
LONGITUDINAL SECTION
levels in ft.
FIG. E.3

BURA

GRAVITY INTAKE WORKS

SCALE 1:400

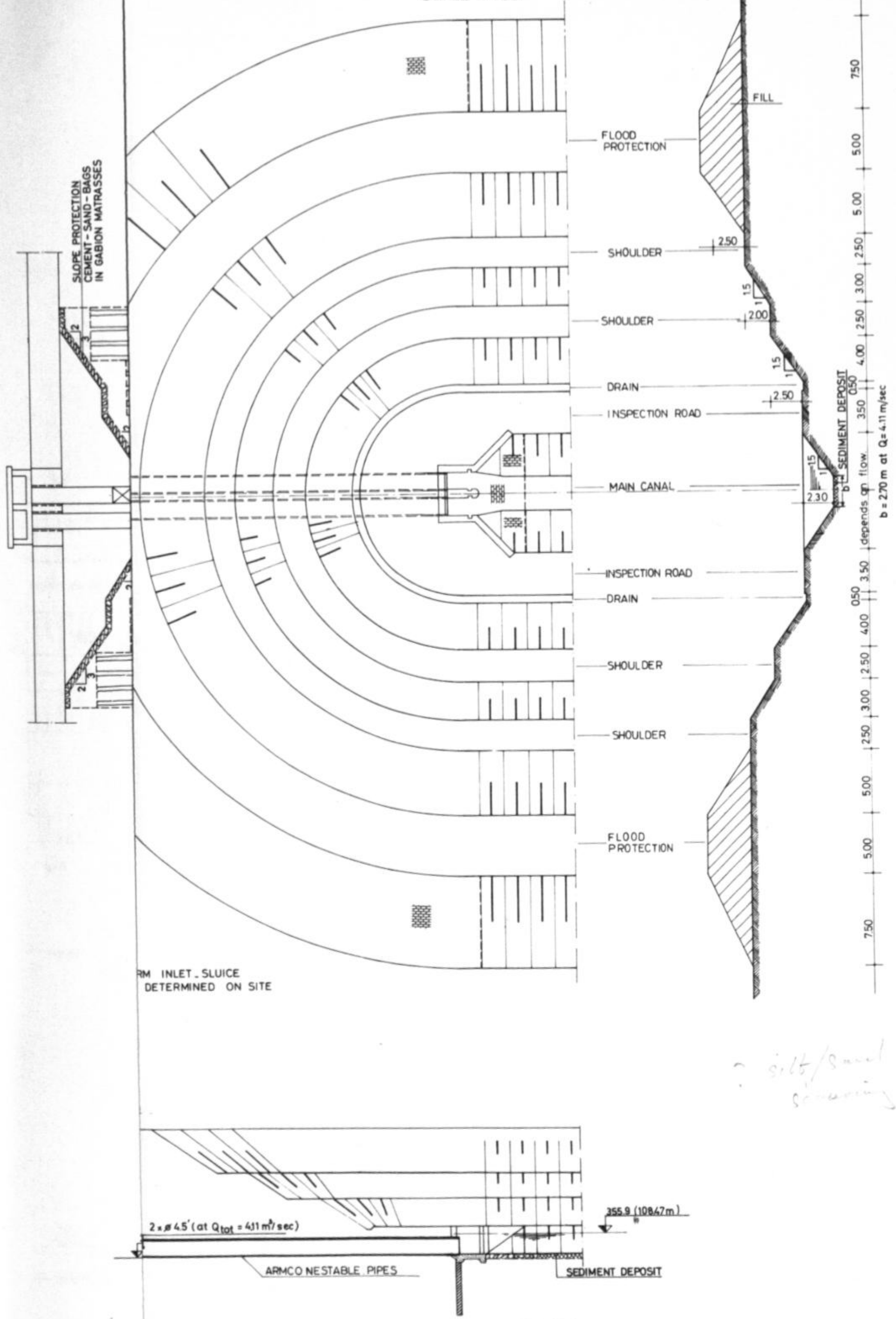
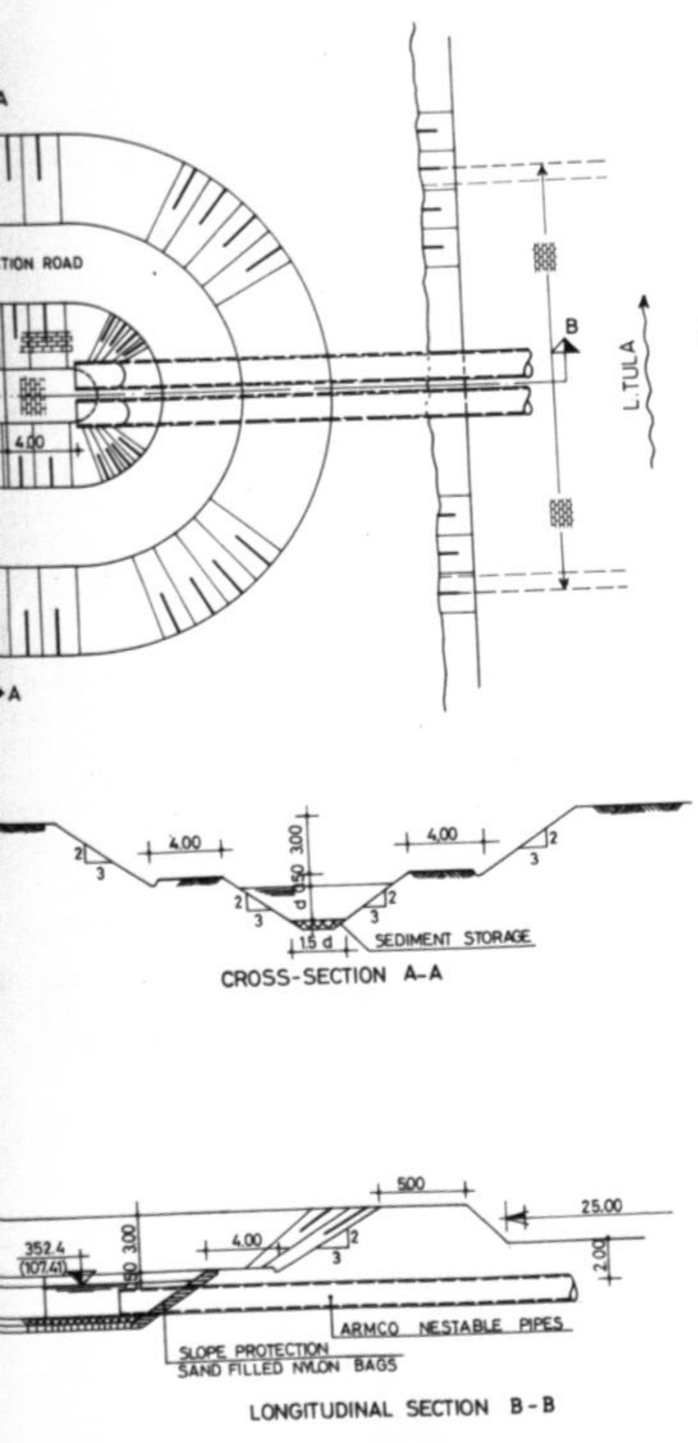


FIG. E.3

MAIN CANAL STRUCTURES

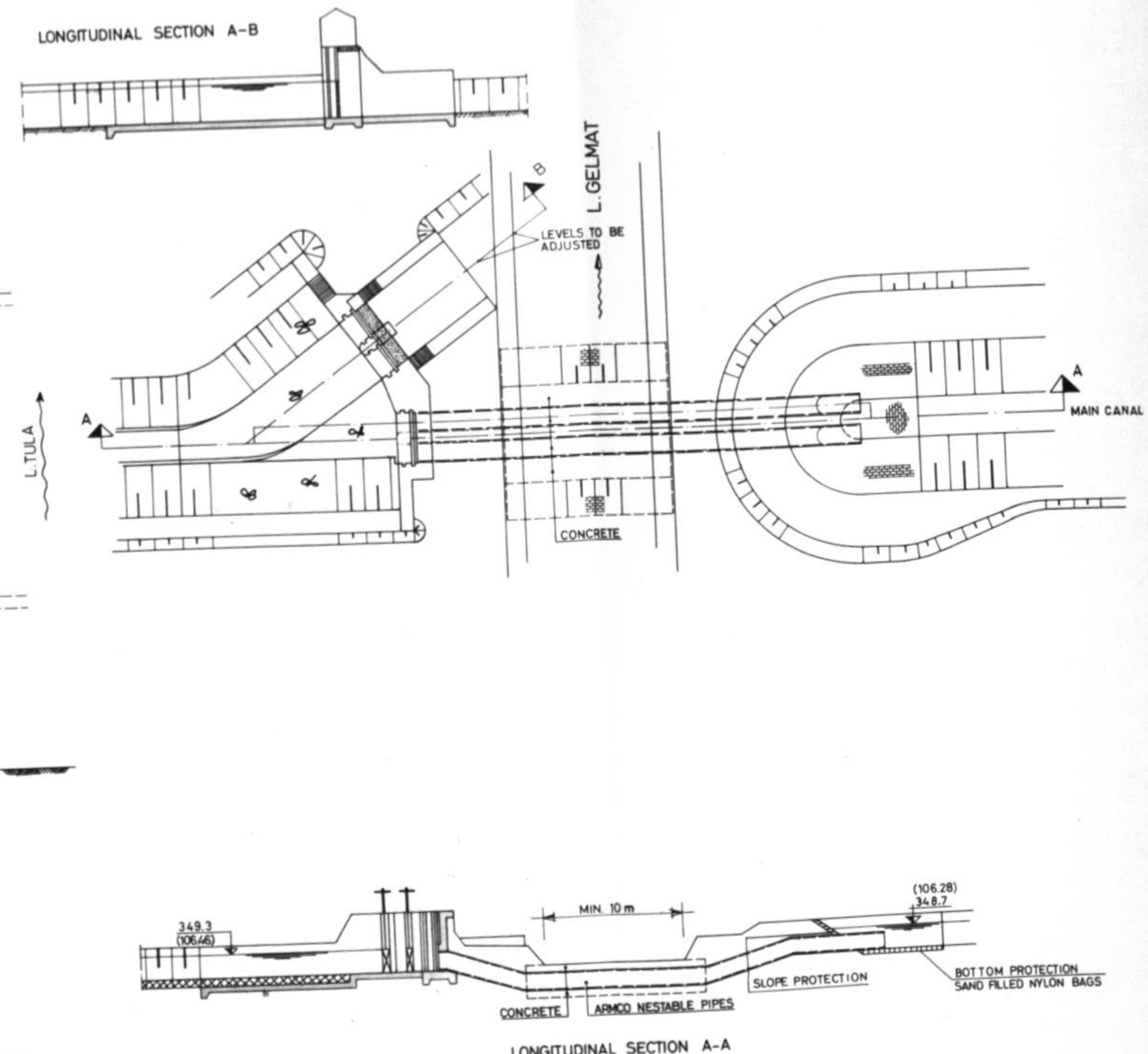
[OUT]LET OF CULVERT ACROSS L.TULA

SCALE 1 : 400



L. GELMAT CROSSING
SIPHON, FLUSH-SLUICE/OVERFLOW

SCALE 1:400



DIVERSION STRUCTURE I

SCALE 1 : 400

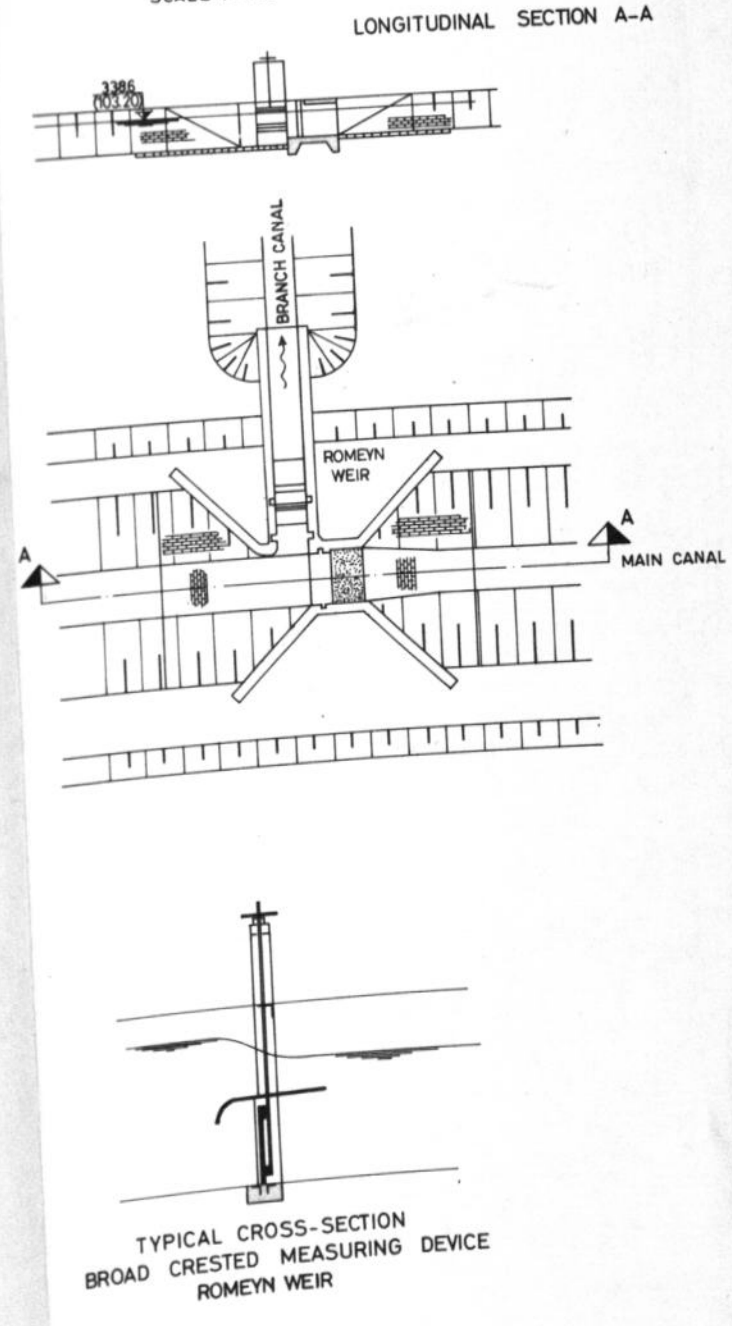
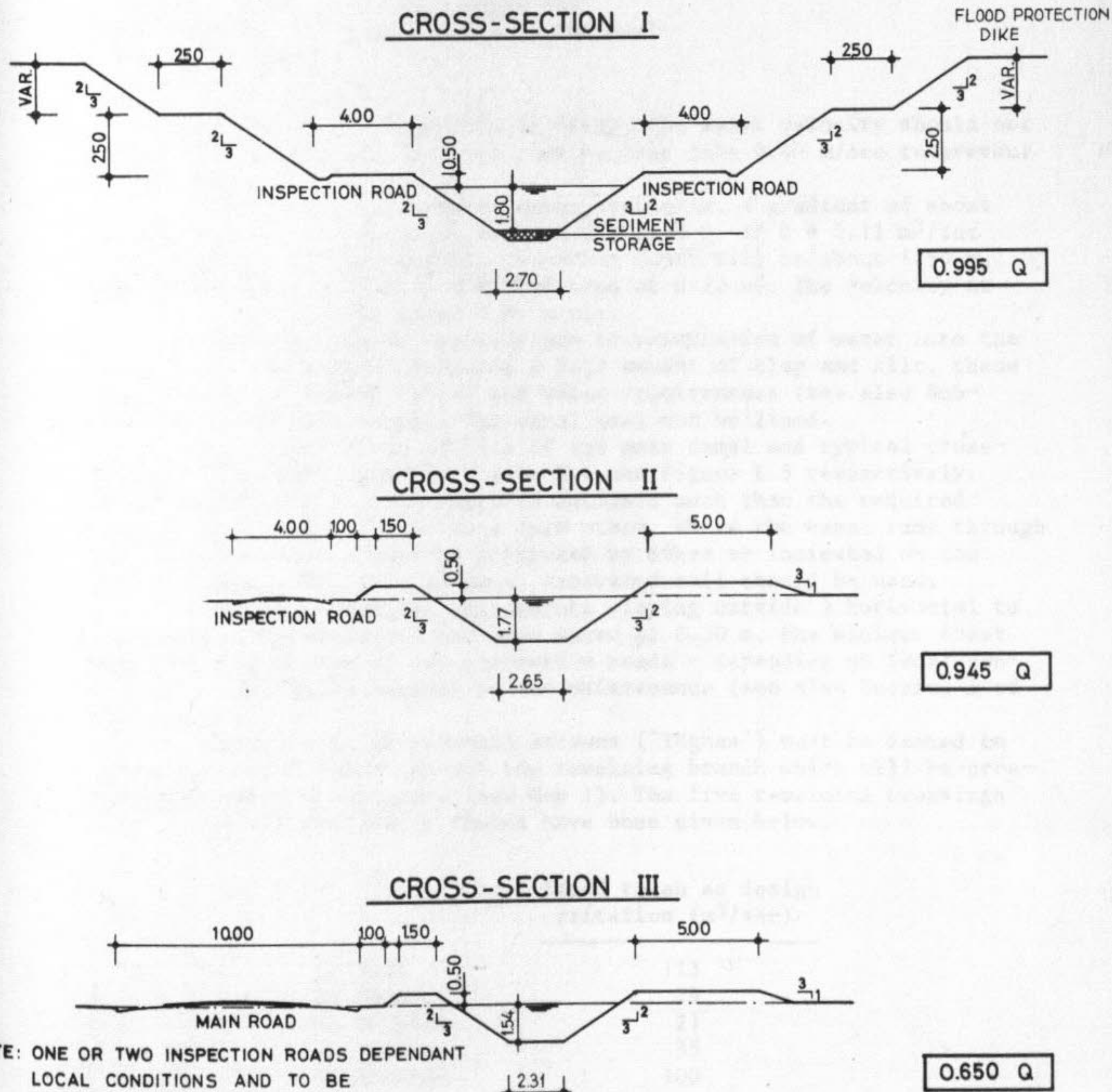


FIG. E.4

BURA

STANDARD CROSS-SECTIONS MAIN CANAL

VIEW IN UPSTREAM DIRECTION



ALL MEASURES IN m.

FIG. E.5

BURA

3.2 Canal profile

To calculate the profile of the main canal, Manning's formula and the following assumptions have been used:

- bottom width = $1\frac{1}{2}$ x water depth (d)
- side slope = 3 horizontal to 2 vertical
- roughness coefficient n = 0.025.

With a view to possible scouring, the water velocity should not exceed 0.60 m/sec, and it should not be less than 0.40 m/sec to prevent sedimentation.

Considering the head of water available, a gradient of about 0.1 ‰ has been recommended, hence $d^{\frac{8}{3}} = 1.19\ Q$. If Q = 4.11 m^3/sec (see Section 1 of this Annex), the water depth will be about 1.80 m, the bottom width 2.70 m at a wetted area of 0.72 m^2. The velocity at this discharge will be about 0.41 m/sec.

Some loss can be expected due to penetration of water into the subsoil. As the subsoil contains a fair amount of clay and silt, these losses will not exceed 10% of the water requirements (see also Subsection 1.7 of this Annex). The canal need not be lined.

The longitudinal profile of the main canal and typical cross-sections have been shown in Figure E.1 and Figure E.5 respectively. Where possible, the canal has been designed such that the required volumes of cut and fill balance each other. Where the canal runs through the flood plains, it must be protected by dikes as indicated on the layout drawing. For this purpose, excavated soil should be used.

The main canal has embankments sloping outside 3 horizontal to 1 vertical. The freeboard has been taken at 0.50 m, the minimum crest width at 1.50 m. One or two inspection roads - depending on local conditions - will serve inspection and maintenance (see also Section 5 of this Annex).

Two branches of seasonal streams ('laghas') must be dammed to guide the runoff water through the remaining branch which will be crossed by means of a structure (see Map 1). The five remaining crossings with laghas and the design floods have been given below.

	Flood taken as design criterion (m^3/sec)
L. Tula	113
L. Gelmat	29
L. Bilbili	21
L. Walesa	35
L. Hiraman	100

The floods based on rainfall, drainage area and infiltration rates have been taken from the Lower Tana report (1).

To cope with the expected runoff of the L. Tula and the L. Hiraman, the minimum passage must be 25 m wide and 2 m deep, while the other laghas require passages of 10 m wide and at least $1\frac{1}{2}$ m deep.

3.3 Structures

The intake structure has been shown in Figure E.3. In order to prevent sand from entering the canal as much as possible, a sand screen has been planned at the intake. The vortex action caused by the hydraulic slope at the entrance to the canal may disturb the normal regime of silt transportation and allow coarse sediment to rise and to be carried over the sill. To prevent this, the sill has been provided with a sloping crest, thus neutralizing the hydraulic slope of the centrifugal flow. Hydraulic tests of similar screens have proved that they will reduce the sediment intake considerably.

The slope of the sill has been calculated at 4 cm over a length of 20 m (downstream 4 cm higher than upstream). The depth of overflow over the sill at the low design water level must be about one-third to one-fourth of the depth of the water at the intake canal (3).

Moreover, temporary storage of sediment has been provided for by the excess depth of the canal between the intake and the Gelmat structure, consisting of a flush sluice cum spillway and siphon.

The maximum flow, which is 4.11 m^3/sec at the intake, will be diverted through 2 pipes, Ø 4.5 ft (1.37 m). The flow can be adjusted by means of movable gates. To prevent the pipes from silting up, their dimensions have been projected such that the water velocity in the pipes will exceed 1 m/sec. Armco nestable pipes are recommended as they are easy to transport and to be installed and do not require any foundation.

Two crossing structures and a diversion structure have been shown in Figure E.4. In view of topographical conditions, the crossing with L. Tula must be built as a culvert. No head for flushing is available here. Inverted siphons are required for crossing the other laghas. The culvert and all siphons will be made of Armco nestable pipes 2 x Ø 4.5 ft (1.37 m), while for the crossing with the L. Hiraman 2 x Ø 4.0 ft (1.22 m) pipes are to be used.

Building materials of good quality are scarce in the vicinity of the canal. If no good gravel layers are found nearby, crushed rock must be used for concrete aggregate. The hauling distances for rock are long (Kandelongwe Hill, granite, good concrete aggregate). It is, therefore, recommended that slopes and bottoms of the canal near inlets and outlets of the crossings should be protected with sand/cement-filled bags of a nylon texture. For the outer slopes of the intake, gabion mattresses could be used, filled with such bags.

4 LAYOUT OF THE PROJECT

4.1 General design considerations

In this section, the preliminary design for the Bura project as presented in Map 3 will be discussed. For the area south of the Hiraman the design map, scale 1 : 10,000, included in the Lower Tana Report (2) has been used. As this area covered only 3,000 ha net and the terms of reference refer to 4,000 ha, another 1,000 ha had to be found. The remaining 1,000 ha have been projected just north of the Hiraman, for which area only a 1 : 50,000 map was available. The 1 : 50,000 map and the 1 : 10,000 map have been photographically enlarged and reduced respectively to a 1 : 20,000 scale map. As the results did not fit in with each other, the ultimate 1 : 20,000 scale layout map must be considered as an approximation only. If a definitive design is to be made, the whole area must first be surveyed properly.

Explanation of some terms used in this section:

	primary system	secondary system	tertiary system
irrigation	branch canal	block feeder	unit feeder
drainage	main drain	block drain	unit drain
roads	main road	block road	unit road

As discussed in Annex C, certain areas in the project area are unsuitable for cultivation (soil classes 4A and 4B). These soils have been left out in the layout, which means that sometimes only part of a unit will be used for crop growing. The largest area of unsuitable soils has been reserved for the administrative and technical centre. Small areas of soil group 5 near the Hiraman have been included. These areas should be protected by a low bund built from the excavated soil of the drain.

The layout has been designed for furrow irrigation in relation to the crops to be grown. The furrows have been projected under a slight angle with the contours as far as possible, so that an acceptable grade for the fields will be obtained. Three low ridges in the terrain have been used for the three branch canals. These two factors have largely determined the layout. A much more regular pattern could be arrived at than in the layout for the Masinga area.

A sketch of the layout of a unit is presented in Figure E.6; the length of the furrows in the fields has been fixed at about 300 m, since this has proved advantageous on the Hola Scheme. The furrows have been projected under a small angle with the contours providing a grade of some 0.1 to 0.4%; like at Masinga, 0.2% is the most recommended grade.

A farmer's holding of 1.2 ha will consist of a 40 x 300-m field, with an irrigation channel at the upper end and a drain at the lower end. The unit road will run between the feeder and the drain.

4.2 Irrigation schedules and frequencies

The available moisture in the soils at Bura has been determined during the present study (see Annex C: Soils) and previously during the Lower Tana Survey (2). On an average, the available moisture in the root zone depends on the depth of the non-saline topsoil, which varies for the different soil classes. Roots will penetrate into an alkali layer but not into a saline soil layer. On the basis of the analyses and on experience gained elsewhere, the average root zone has been estimated at 40 to 50 cm. This results in a quantity of available water in the soil of about 80 to 100 mm.

The highest demand for water at Bura is in May, when almost 180 mm is required at the root zone, or 90 mm for a fortnightly period. This can just be stored in the root zone of soil group 3, and easily in the root zone of the other soil groups. Experience at Hola has shown that a 70-mm gift every 12 to 14 days is sufficient.

The unit feeders will have to supply enough water to cover the net requirement and the losses, i.e. 110 mm per irrigation gift for a 20-ha unit, or 36 l/sec/ha.

4.3 Irrigation canals

4.3.1 Branch canals

The main supply canal enters the area in the north-western corner of the project, and the branch canals take off from the main canal by structures. Longitudinal profiles of the three branch canals have been drawn for the design. A new design has been made for the northernmost branch no 1, (Drawing No 1). For the other two, the Lower Tana designs have been used with some alterations. The most important revision has been the reduced size of branch no 2; this has been done since the flood plain lands are not expected to be irrigated in view of their high grading requirements. Cross-sections are shown in Figure E.7.

Drop structures have been projected in the branch canal wherever an offtake for the night storage reservoirs has been planned. If not all the water is needed in a specific branch canal, the excess can be discharged through tail escapes. For the drop structures, the same type of prefabricated unit can be used as for Masinga (see Figure E.8).

Water measurements will be made at the three intake structures with permanent water level recorders, and a Cipoletti weir can be built into the tail escapes.

The body of the branch canals will be formed by bulldozer; where they are constructed in fill, they will be excavated mechanically in the larger sections, by hand in the smaller sections. An area on both sides along the branch canals has been reserved for night storage reservoirs and to provide soil for the embankments of the branch canals.

LAYOUT OF A UNIT, SHOWING THE SITUATION OF A NIGHT STORAGE RESERVOIR

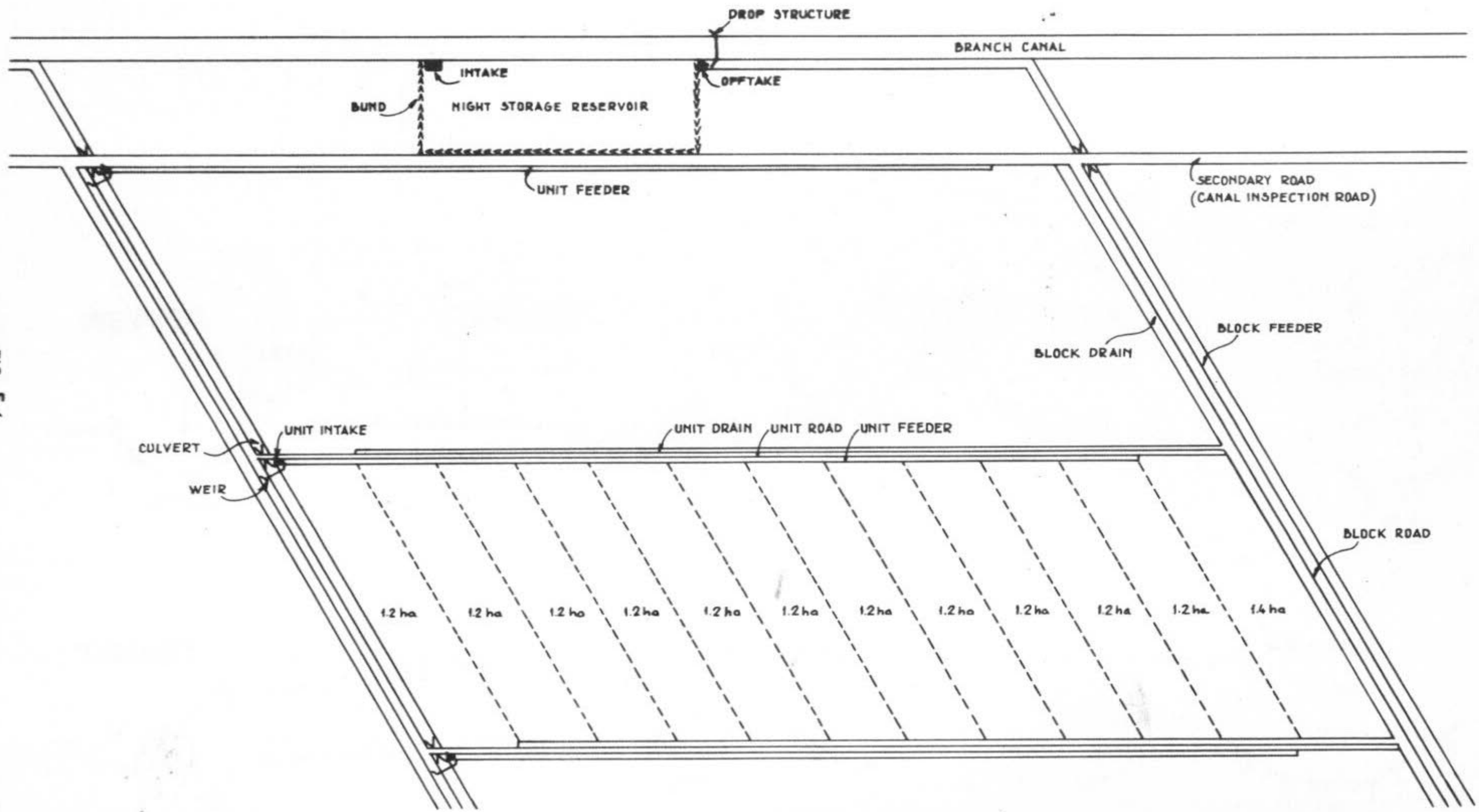


FIG. E.6

SOME CROSS-SECTIONS

SCALE 1 : 100

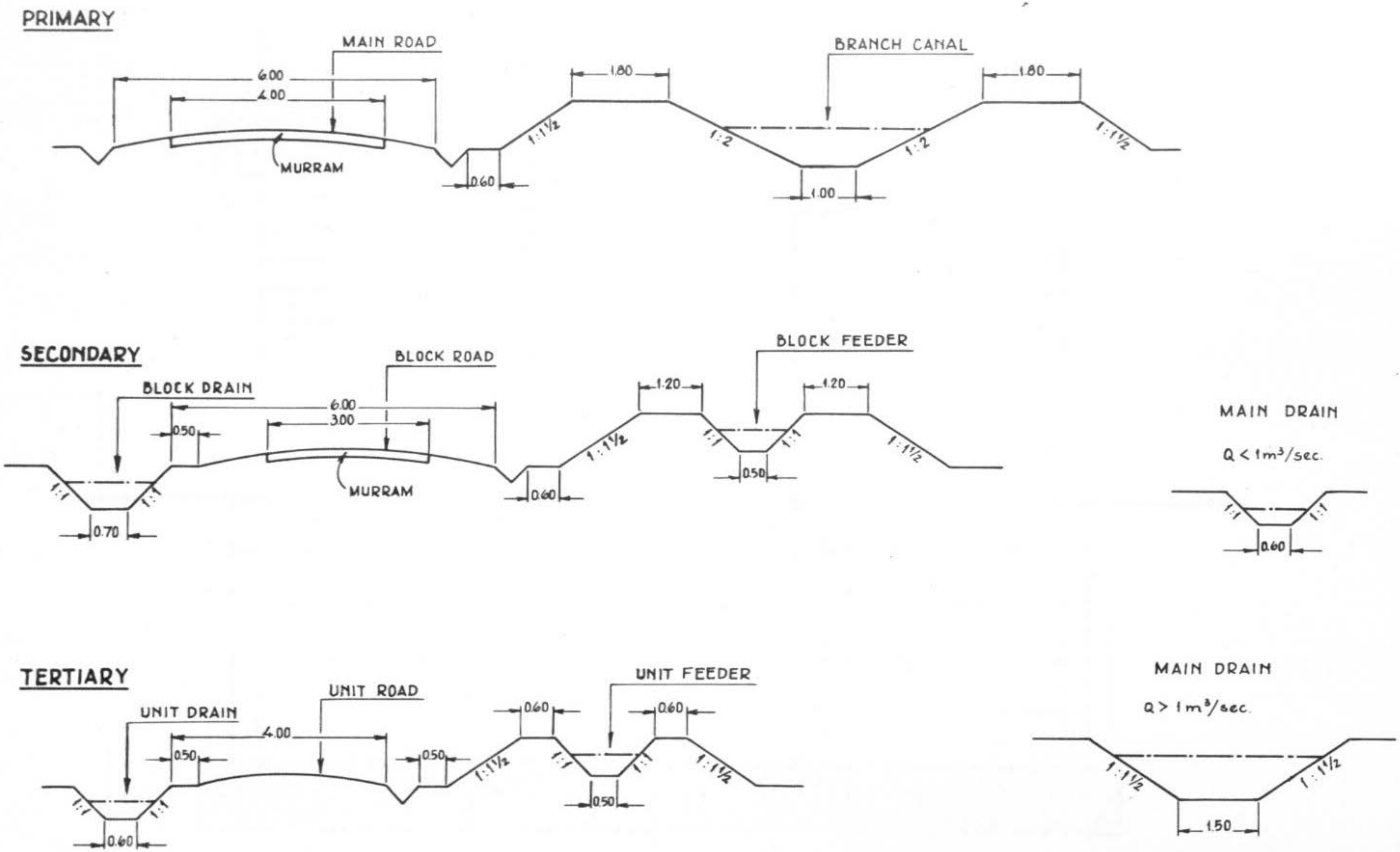


FIG. E.7

BURA

CHECK/DROP STRUCTURE MADE OF PREFAB UNITS

SCALE 1:20

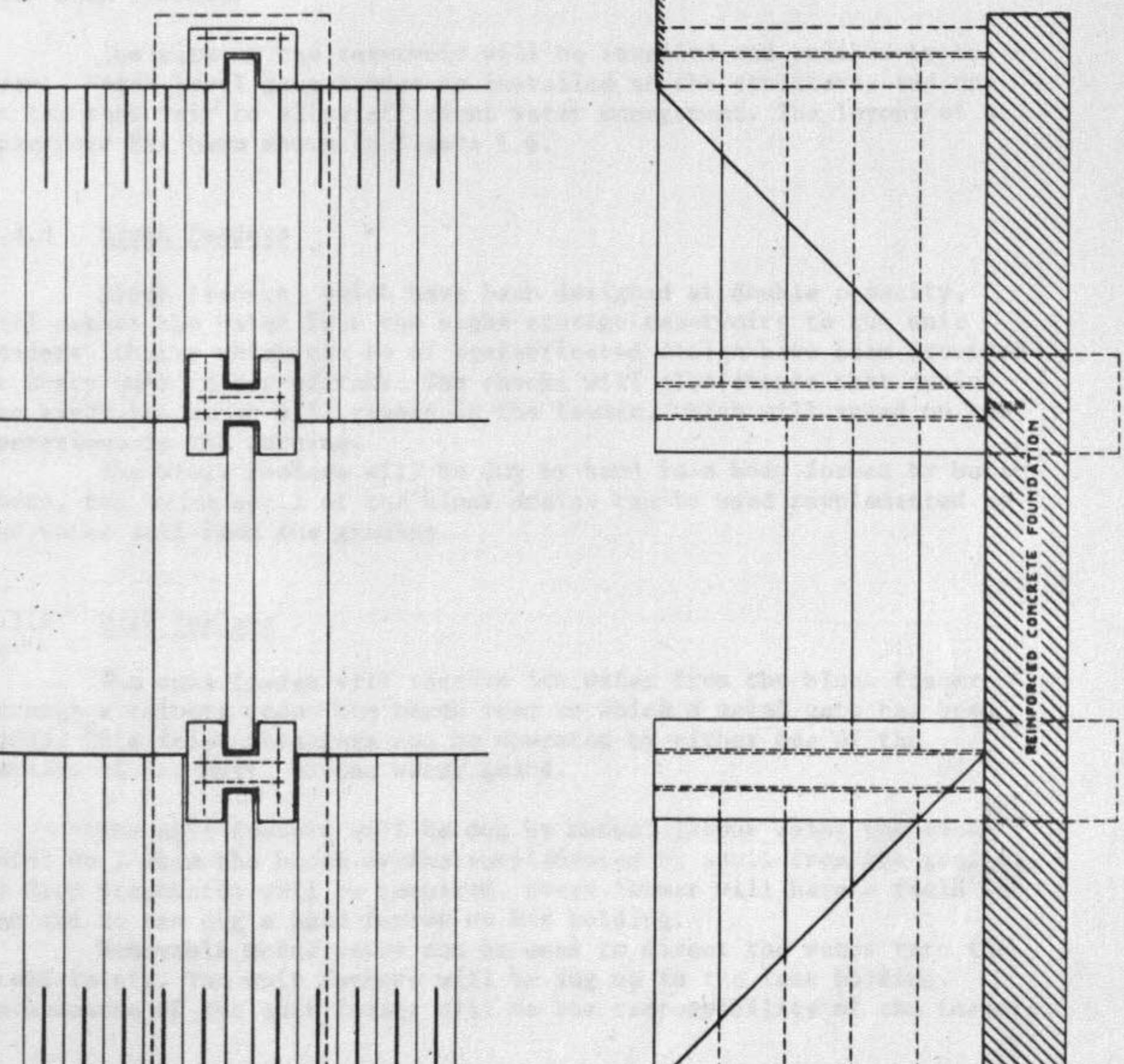


FIG. E.8

4.3.2 Night storage reservoirs

? seepage.

Night storage reservoirs have been planned so that the lands can be irrigated at daytime only. The night storage reservoirs have been projected at the head of the block feeders, with an inlet from the branch canal and a double-capacity outlet to the block feeders. Standard-type adjustable gate structures, which are easy to construct, have been planned.

The site of the reservoir will be levelled and endiked by bulldozer. Water level gauges must be installed at the structures and one in the reservoir to allow efficient water management. The layout of a reservoir has been shown in Figure E.6.

4.3.3 Block feeders

Block feeders, which have been designed at double capacity, will convey the water from the night storage reservoirs to the unit feeders. Checks which can be of prefabricated design have been provided at every unit feeder offtake. The checks will also ensure that during the night the water will remain in the feeder, which will speed up the operations in the morning.

The block feeders will be dug by hand in a body formed by bulldozer, for which spoil of the block drains can be used supplemented by excavated soil from the grading.

4.3.4 Unit feeders

The unit feeder will receive its water from the block feeder through a culvert under the block road to which a metal gate has been added. This inlet structure can be operated by either one of the farmers of the unit, or the water guard.

The unit feeders will be dug by manual labour using the excavated soil from the block drains supplemented by spoil from the grading. No drop structures will be required. Every farmer will have a field inlet and he can dig a head furrow on his holding.

Removable metal weirs can be used to direct the water into the field inlets. The unit feeders will be dug up to the last holding. Maintenance of the unit feeder will be the responsibility of the farmers.

4.4 Drains

4.4.1 Main drains

A total of 5 collector drains have been planned, which discharge via the flood plain lands into the Tana river. Cross-sections are shown in Figure E.2. These drains need only few drop structures; the majority of them will be necessary where the project area slopes away into the flood plain lands. The drop structures can be prefabricated units. Cipoletti weirs should be built in each of the main drains; they could be incorporated into one of the drop structures.

The larger sections of the drains at the lower end will be dug by excavator, the smaller sections by hand.

4.4.2 Block drains

Water from the unit drains will be collected in the block drains, which, in turn, will convey the water to the main drains. No drop structures will be required due to the slight grade and the low discharge.

The block drains will be dug by hand and the spoil will be used to form the body of the block feeders.

4.4.3 Unit drains

All the fields will be bordered by a unit drain at their lower end. The unit drains will be hand-dug, the spoil is to be used for the unit feeder. The drains will start at the border line of the first and second holdings; the first tenant can dig a small drain for himself. At the lower end, the unit drains discharge directly into the block drains.

The unit drain is to be maintained by the tenant.

4.4.4 Reuse of drainage water

The drainage water supplemented by excess irrigation water may be used in the flood plain lands for irrigation of gardens and pastures in areas that are not subject to flooding. The soils in the flood plain lands are excellent, only levelling and grading are expensive. The farmers should be assisted and stimulated to lay out a small shamba in this area, which will have a supply of irrigation water most of the time. Crops which could be grown here are bananas and vegetables, or the land could be used as irrigated pasture.

4.5 Roads

4.5.1 Main roads

The main roads in the project area will be discussed in Annex H: Buildings and Infrastructure.

4.5.2 Secondary roads

Several types of secondary roads are distinguished, i.e. a section road along the collector drain, a canal service road along the branch canals and the block roads along the block feeders. They will be all constructed similarly, have a width of 6 m and should be surfaced.

At present, no murram pits are available in the area, but they may be surfaced with coral limestone, of which a quarry is available nearby.

4.5.3 Unit roads

The unit road will run between the unit feeder and the unit drain; thus many culverts can be saved in every unit, but it does not improve the accessibility of the fields.

The unit road will be connected with the block road on one side only. Connection on the other side would call for an extra culvert, which is not considered to be necessary.

The unit roads will be constructed by motor grader, they will be 4 m wide and will not be surfaced.

4.6 Land clearing and grading

Land clearing will meet very few difficulties; the area is relatively barren and only some bush and tree stumps have to be removed. This can be done simultaneously with the land grading.

Grading will not be very difficult either; the area is gently sloping and the slopes are fairly regular. The grade of the fields should be as close to the actual grade as possible, not only to minimize excavation and hence costs, but also because in soil group 3 the non-alkali topsoil is in places only 20-30 cm deep (see Annex C).

On the basis of the layout it has been estimated that only some 20% of the area will need grading with excavation of some 1,000 m^3 per ha on an average.

The remaining area has the required slope and has only to be planed to equalize small uneven spots. It will not be necessary to make slanted furrows. They can all be parallel.

The grading will be done by bulldozers, the planing by a tractor and a land plane.

5 PLANNING AND METHOD OF CONSTRUCTION

5.1 Planning

Construction has been planned to take 4½ years. If it is started on 1st March 1975, the scheme can be fully operational on 1st September 1979.

The main canal outside the scheme has been planned to be completed about 1½ years after the construction work has started, i.e. on 1st September 1976. Simultaneously with the main canal, an area of 700 ha will be ready for cultivation. The remainder of the scheme will be implemented in the next three years, in line with the following planning:

1st September	1976 -	700	ha	ready	for	cultivation	
1st "	1977 -	1,800	"	"	"	"	
1st "	1978 -	2,900	"	"	"	"	
1st "	1979 -	4,000	"	"	"	"	

Figure E.9 indicates the sequence of construction, while Figure E.10 shows the schematic work plan for the construction of the scheme.

5.2 Outside the scheme - main canal

5.2.1 Earthwork

In view of the amount of earth to be moved, the main canal will be excavated mechanically. Excavators with a 1,000-1 capacity are to be used. The excavated soil will be dumped along the main canal by D6-type bulldozers and serve to construct the embankments. Motor scrapers with a capacity of about 20 m^3 will be used in digging the section of the main canal up to some 10 km from the intake. Bulldozers of the D6-type will serve to handle the soil at the excavation and dumping sites. The soil excavated from this part of the main canal will be used for constructing the flood protection dam.

5.2.2 Inspection roads

An unsurfaced inspection road, 10 m wide, has been planned along one side of the main canal; the section of the main canal up to some 10 km from the intake will be provided with inspection roads on both sides. Use will be made of 150 h.p. motor graders.

5.2.3 Main roads

The following main roads, all of them surfaced, have been planned:

- 17½ km main road Hola-Garissa, 6 m wide, a diversion of the present road because of the construction of the main canal;
- 1.3 km main road, 4 m wide, to the centre of the scheme;

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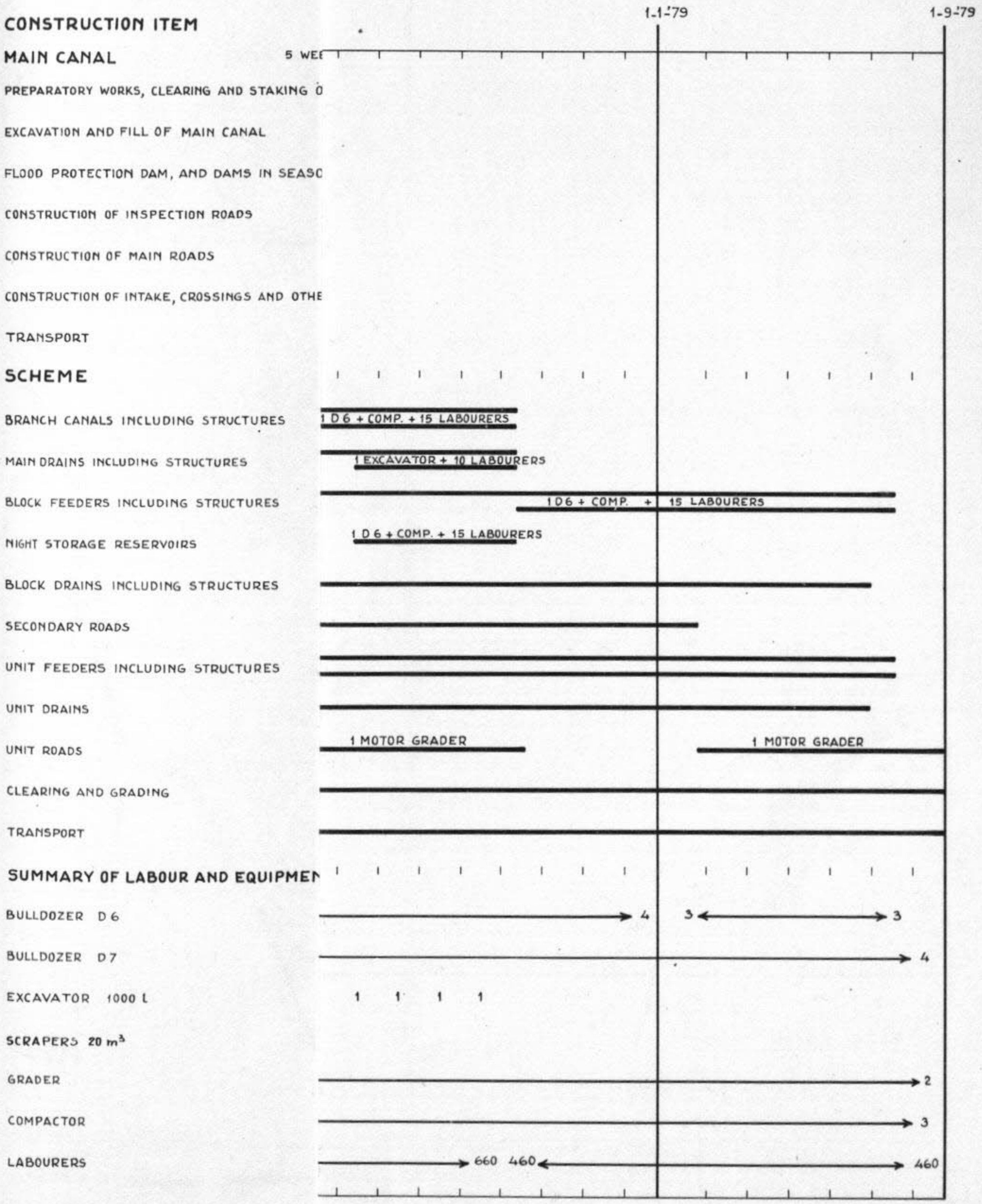


FIG. E.9

BURA

SCHEMATIC WORK PLAN FOR THE CONSTRUCTION OF THE BURA IRRIGATION SCHEME

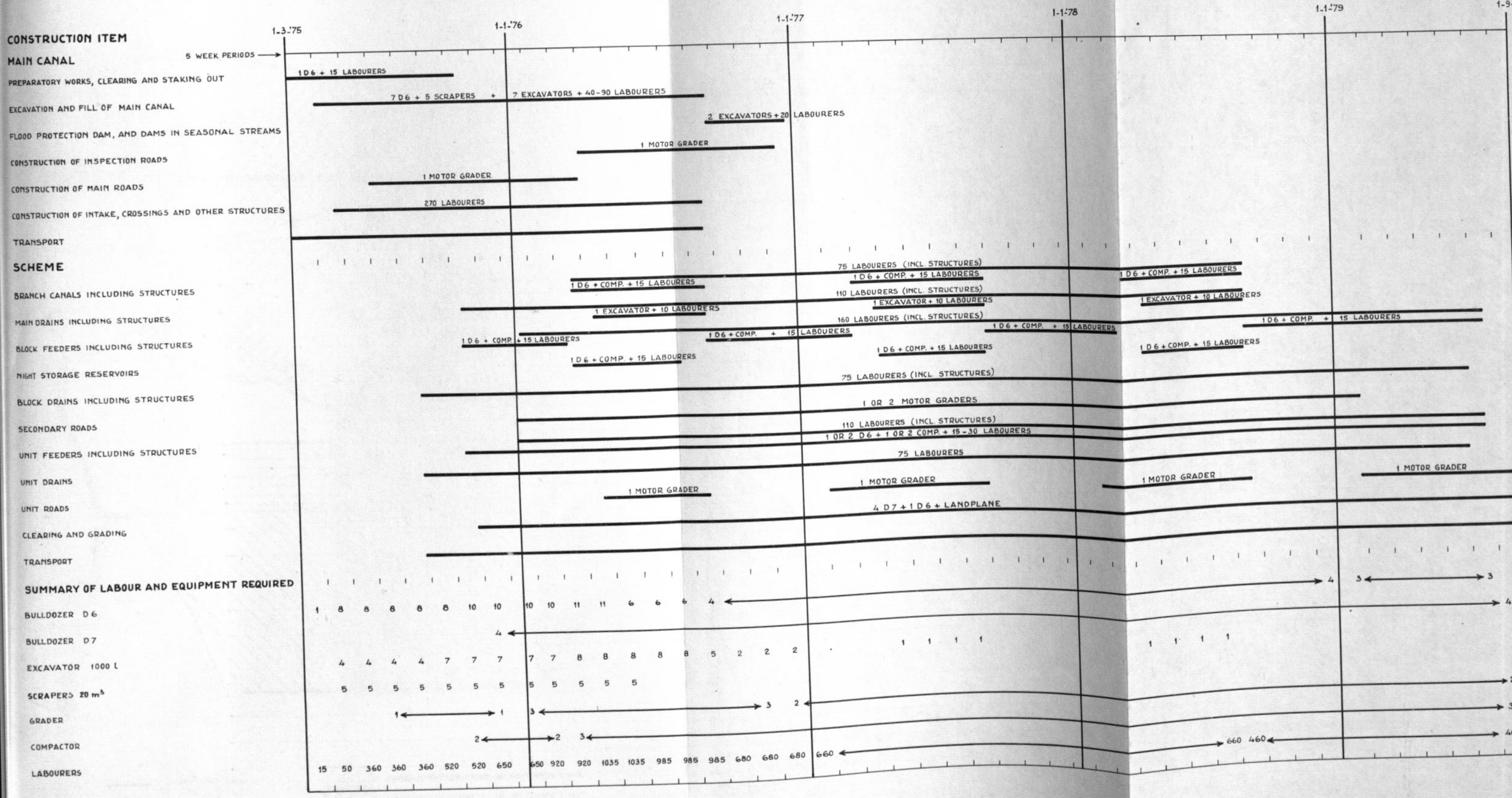


FIG. E.9

BURA

SCHEMATIC WORK PLAN FOR THE CONSTRUCTION OF THE BURA IRRIGATION SCHEME

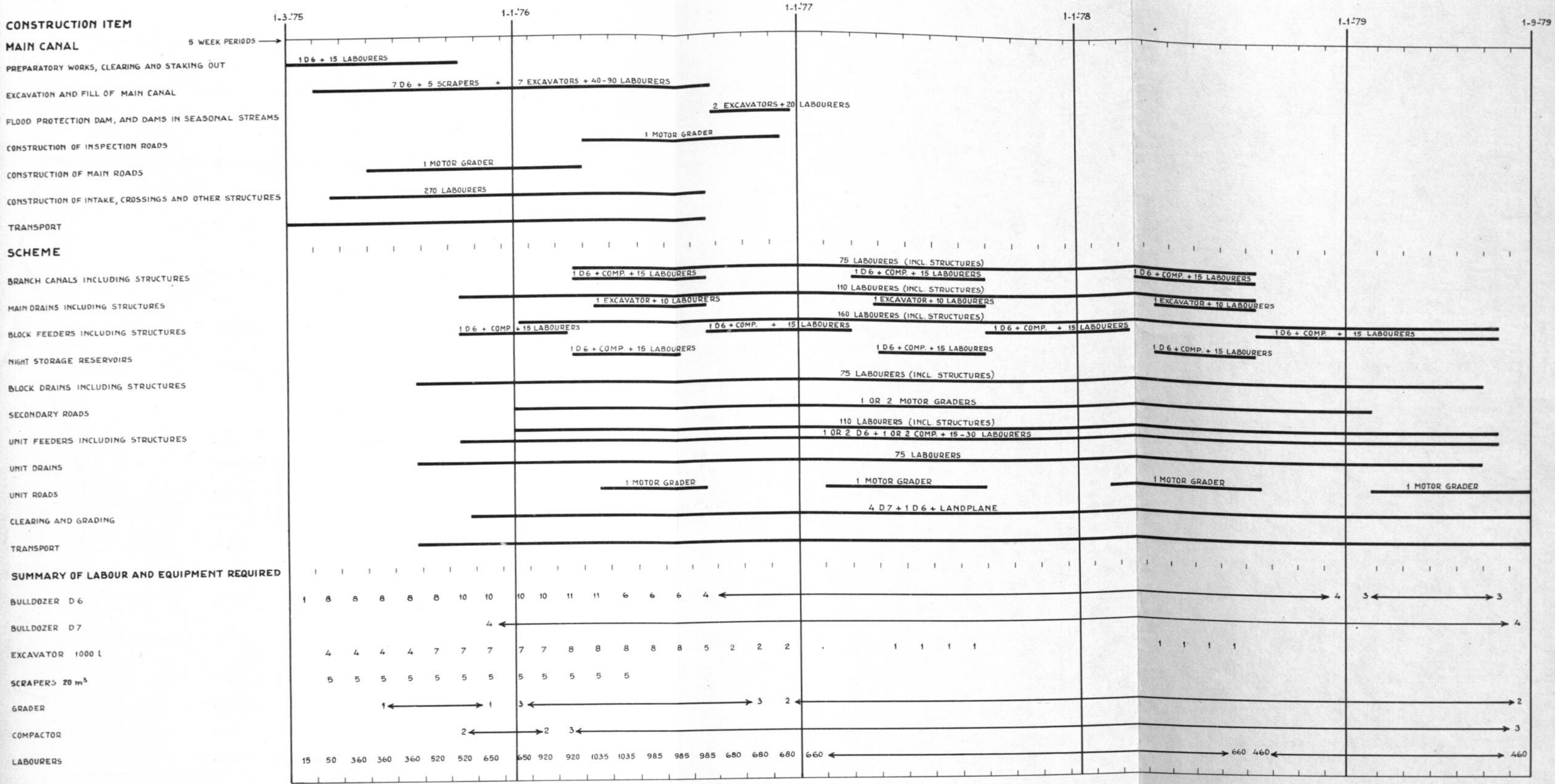


FIG. E.9

BURA

SEQUENCE OF CONSTRUCTION

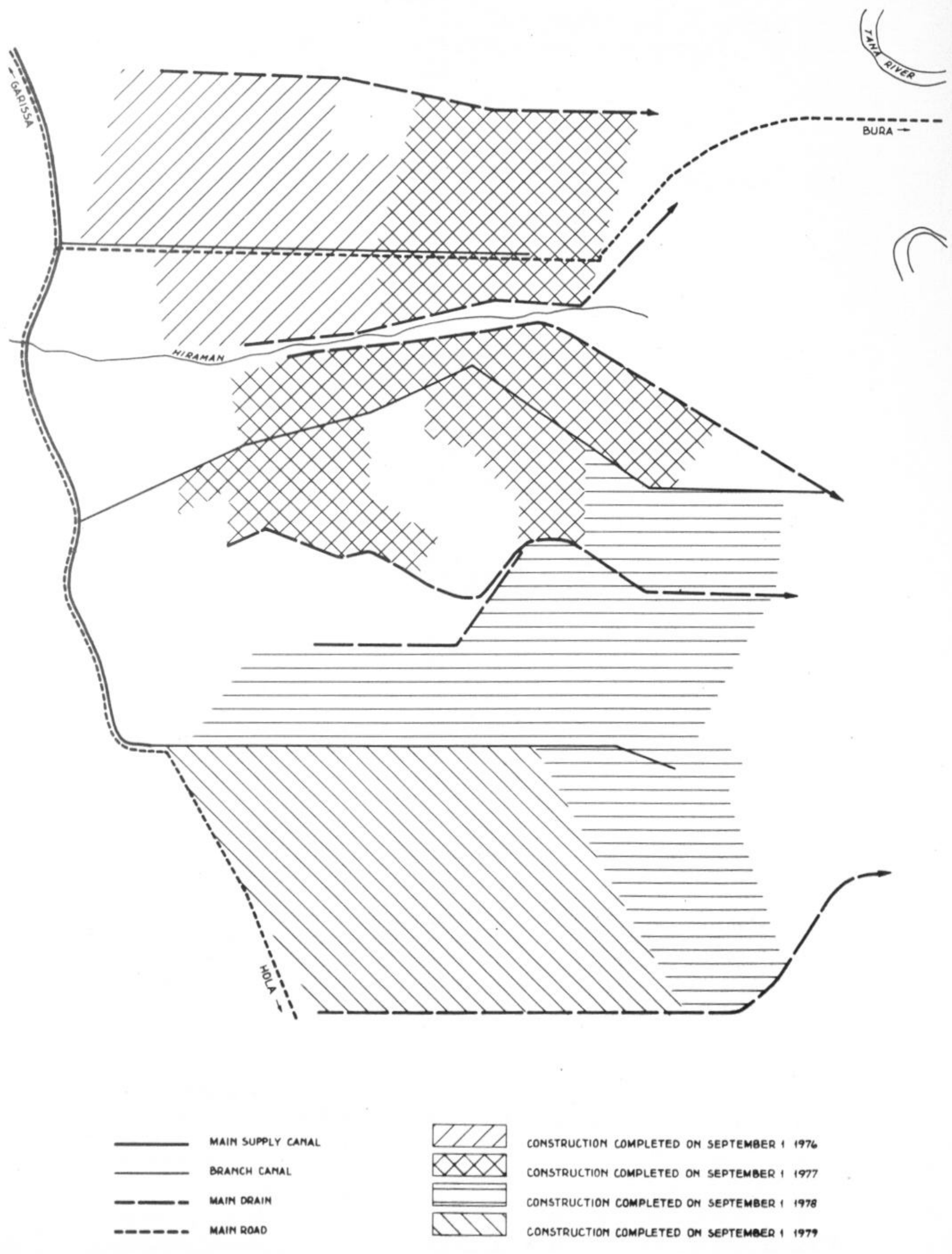


FIG. E.10

- 5 km main road to Bura Town;
- 4.75 km of the existing main road Hola-Garissa will be surfaced using a 150 h.p. motor grader; the surfaced layer will consist of 0.10 m coral lime stone.

5.2.4 Structures

The following structures have been planned in the main canal:

- intake near the Tana river;
- Tula crossing
- Gelmat crossing
- Bilbili crossing
- Walesa crossing
- Hiraman crossing
- Offtakes with water-measuring devices
- Bridges across the Walesa and Hiraman rivers.

Armco pipes will be used for the intake and the different crossings. For the inlets and outlets of these pipes reinforced concrete and masonry will be applied. The canal bottoms and slopes in front of and behind the offtake structures will be protected by nylon bags filled with stabilized sand. The bridges will be constructed in reinforced concrete.

5.2.5 Required machinery and estimated hours of operation

For the construction of the main canal, the following machinery will be needed:

- D6-type bulldozers	:	19,150 hours
- 20 m^3-capacity motor scraper	:	12,000 "
- 1,000-l-capacity excavator	:	20,000 "
- 150-h.p. motor grader	:	3,020 "
- 5 to 7-ton truck	:	30,000 "

5.3 The scheme

5.3.1 Branch canals

Fill for the branch canals will be provided mechanically, using D6-type bulldozers. Compaction of the soil will also be done mechanically (compactors). Excavation of the branch canals and construction of their embankments will take place manually.

5.3.2 Main drains

These drains will be constructed partly mechanically and partly by hand labour (for 50% by a 1,000-l-capacity excavator and for 50% manually).

5.3.3 Block feeders and unit feeders

The fill for the block and unit feeders is to be provided by D6-type bulldozers. The soil will be compacted mechanically. Digging of the block and unit feeders and construction of their embankments will be done manually.

5.3.4 Night storage reservoirs

D6-type bulldozers will be used to construct the dikes of the night storage reservoirs. They will be compacted mechanically and finished by hand labour. The bulldozers will be also used to level the bottom of the storage reservoirs.

5.3.5 Block and unit drains

These drains will be constructed by hand labour.

5.3.6 Secondary roads

The road base will be constructed by a 150-h.p. motor grader. The roads are to be surfaced with a 3 or 4-m wide coral lime stone layer, having a thickness of 0.10 or 0.07 m respectively. The surfacing material is to be spread by the motor grader.

5.3.7 Clearing and grading

In levelling, the soil will be loosened up to a depth of 0.30 to 0.50 m with a D6-type bulldozer to which a ripper will be attached. The rough levelling will be done by D7-type bulldozers having a low and wide blade; in the final levelling, a landplane drawn by a D6-type bulldozer will be used.

5.3.8 Required machinery and estimated hours of operation

The following machinery will be required in constructing the scheme:

- D6-type bulldozers	: 29,300 hours
- D7-type bulldozers	: 32,000 "
- 1,000-l capacity excavator	: 3,600 "
- 150-h.p. motor grader	: 13,880 "
- 5 to 7-ton truck	: 27,700 "
- landplane	: 9,200 "
- compactor	: 20,000 "

5.3.9 Total machinery and labour requirements

The total machinery requirements for construction of the main canal and the scheme are as follows:

Type	Number
D6-type bulldozers	11
D7-type bulldozers	4
20-m^3 capacity motor scrapers	5
1,000-l capacity excavators	8
150-h.p. motor graders	3
compactors	3
landplane	1

Per period of six months, the following number of skilled and unskilled labour will be needed:

March	- September	1975	:	250
September 1975	- March	1976	:	720
March	- September	1976	:	930
September 1976	- March	1977	:	800
March	- September	1977	:	665
September 1977	- March	1978	:	650
March	- September	1978	:	650
September 1978	- March	1979	:	465
March	- September	1979	:	450

6 COST ESTIMATES

The cost estimates presented in this section have been based on bills of quantities derived from the preliminary designs and unit rates. The unit rates are shown in Table E.12; they have been based on actual costs in Kenya at the time of the field survey.

The cost estimates for construction have been presented in Table E.13. It has been assumed that the main canal and its structures will be built by contractors, and that the scheme will be constructed under supervision of the N.I.B. or another Government agency.

As a result the overhead percentages for the main canal are higher than those for the scheme; contingencies are also higher, because the construction costs of the scheme have been considered to be estimated more accurately.

The cost estimates have been summarized in Table E.14, which also shows the different categories making up the construction costs. Finally, Table E.15 shows the annual cost of maintenance, excluding the labour and supervision involved which have been accounted for under management.

Table E.10 - Unit costs and unit rates

1. Machinery				
Caterpillar D6	(or equivalent machine)	K.Sh.	100	per hour
" D7	(" " ")	"	120	" "
Motor scraper	(450 h.p., 20 m^3 capacity)	"	250	" "
Excavator	(1,000-1 capacity)	"	120	" "
"	(750-1 ")	"	100	" "
Motor grader	(150-160 h.p.)	"	120	" "
Truck	(5-7 tons)	"	50	" "
2. Labour				
Skilled labour		K.Sh.	15-20	per day
Unskilled labour		"	4.50	" "
3. Materials (all-in)				
Concrete		K.Sh.	300	per m^3
Reinforced concrete		"	600	" "
Masonry		"	300	" "
Slope and bottom protection	(outside)	"	100-150	/m^2
" " " "	(inside)	"	40-80	/m^2
Armco pipes	(Ø 4.5 ft)	"	670	/m

Table E.11 - Cost estimates (in K.Sh.) of construction of main canal and scheme

Main canal	
Preparatory work, clearing and staking out	135,000
Excavation and fill of main canal	6,525,000
Flood protection dam and dams in seasonal streams	136,000
Inspection roads	148,000
Main roads (diversion Hola-Garissa and on scheme)	192,000
Construction of intake	677,000
Construction of Tula crossing	130,000
Construction of Gelmat crossing	132,000
Construction of Bilbili crossing	102,000
Construction of Walesa crossing	102,000
Construction of Hiraman crossing	158,000
Construction of offtakes and water measuring devices	124,000
Bridges across branch canals (3)	150,000
Bridge across Walesa	50,000
Bridge across Hiraman	130,000
Transport	516,000
Sub-total	9,407,000
Contingencies 20%	1,881,000
	11,288,000
Contractor's overhead and profit 25%	2,822,000
	14,110,000
Engineering and site supervision 10%	1,411,000
Grand total	15,521,000

Scheme	
Branch canals	
- excavation and fill	472,000
- structures	183,000
Main drains	
- excavation	486,000
- structures	180,000
Block feeders	
- excavation and fill	968,000
- structures	493,000
Night storage reservoirs, grading and bunding	390,000
Block drains	
- excavation	252,000
- structures	76,000
Secondary roads (including surfacing)	1,009,000
Unit feeders	
- excavation and fill	1,683,000
- structures	298,000
Unit drains	
- excavation	330,000
Unit roads	471,000
Clearing and grading	4,320,000
Transport	1,283,000
Sub-total	12,894,000
Contingencies 15%	1,934,000
	14,828,000
Overhead and miscellaneous 20%	2,966,000
	17,794,000
Engineering and supervision 5%	890,000
Grand total	18,684,000

Table E.12 - Summarized cost estimate (in K.Sh.) per category, including contingencies, overheads and engineering

	Machinery	Labour		Materials		Total
		skilled	unskilled	foreign	local	
Main canal	12,842,000	463,000	633,000	529,000	1,054,000	15,521,000
Scheme	14,481,000	519,000	2,694,000	213,000	777,000	18,684,000
Total	27,323,000	982,000	3,327,000	742,000	1,831,000	34,205,000

Table E.13 - Estimate of annual maintenance cost of intake, main canal and scheme

Item	Type of machine	No of days required	Cost estimates (K.Sh.)		
			machine cost	materials	Total
Canals and drains	excavator	690	510,000		510,000
Night storage reservoir and regrading	bulldozer	200	115,000		115,000
Roads	motor grader	160	143,000		143,000
Transport of limestone	tipper lorry	90	30,000		30,000
Structures				30,000	30,000
Transport of materials	lorry	13	5,000		5,000
Total					833,000
					or K.Sh. 208/ha

Notes:

1. Prices are exclusive of labour; machinery rates excluding driver's wages.
2. Material cost: K.Sh. 15,000 local and K.Sh. 15,000 foreign currency.
3. Machinery days required include 30% unproductive days.
4. Machinery required: 2 excavators 750-1 capacity
   1 motor grader 150 h.p.
   1 bulldozer D4-type
   1 tipper lorry 5 tons
   1 lorry 5-7 tons

   Labour required : 3 foremen
   2 masons
   50 canal labourers
   6 drivers

7 INTAKE BY PUMPING

7.1 General

The most suitable site for a pumping station - taking also construction costs into consideration - is indicated in the layout, Map 1. This site has also been suggested in the Lower Tana Survey (1). It is located on the western bank of the Tana river, 33 km upstream Bura Town, 23 km downstream the location suggested for the gravity intake.

In March 1973, three cross-sections of the river were measured near the intake of the supply canal for the pumping scheme during low river flows. The location and cross-sections have been shown in Figure E.11. The levels given have been derived from a contour line and may deviate in practice.

The intake has been projected at the end of an outer bend of the Tana river. This will help prevent sand from entering the canal as much as possible. Furthermore, a sloping sill as mentioned in Section 3 of this Annex will be constructed at the beginning of the canal.

The canal will lead the water over 1,400 m through the Flood Plains to the pumphouse where it will be pumped into a canal which is constructed in fill over the first 600 m. This canal is to run perpendicularly to the contour lines over these 600 m, after which it will more or less follow the contours. The last part of the main supply canal will have the same course as the canal leading the water from the gravity intake to the scheme. For details of the canal, we refer to Section 3 of this Annex. The only difference is that at the Bilbili crossing, next to a siphon also a flush sluice cum spillway has been projected (see also longitudinal profile in Figure E.1).

Figure E.12 shows the pumping station. Design levels are: LLW-level (return period 10 years) 318 ft (96.93 m), HHW-level (return period 100 years) 337 ft (102.72 m). For these levels we refer to Annex B. As mentioned earlier, additional measurements of river stages at the proposed site of the intake must be taken as soon as possible. Furthermore, additional topographic measurements will be necessary.

7.2 Pumping station

The pumphouse is of simple construction, built in concrete. The water intake is outside the house to keep the pump room dry. In the pump room, 4 diesel-driven pumps have to be installed. Furthermore, a spare pump and engine must be available. For more technical details about the pumphouse and raising main, inclusive of the different provisions, we refer to the design drawing Figure E.12. For cost estimates, see Table E.16.

The total maximum output of the pumps must be 4 m^3/sec (see Section 1 of this Annex; the total losses are somewhat less than in the longer canal of the gravity intake). The maximum statical head to be pumped is 8.93 m (1 : 10 years LLW).

Four diesel engines of 230 BHP each will have to be installed. For the pumps, mixed flow pumps or centrifugal pumps are recommended.

To meet the water requirements, the pumping hours mentioned in Table E.1 have to be taken into consideration. From the hours mentioned, 10% can be deducted because of effective rainfall, which leads to an annual fuel consumption of about 900,000 litres.

Table E.14 - Cost estimates (in K.Sh.) for construction of pumping station and main canal

1. Preparatory work, clearing and staking out	88,000
2. Construction of supply canal from river to pumping station	363,000
3. Sand trap, slope and bottom protection	210,000
4. Excavation and fill of new part of main canal (from pumping station to alternative course)	237,000
5. Excavation and fill remainder of main canal	1,440,000
6. Inspection roads	180,000
7. Main roads (diversion Hola-Garissa and on scheme)	192,000
8. Construction of pumping station	354,000
9. Purchase and installation of 5 diesel engines and pumps	1,925,000
10. Construction of Bilbili crossing	128,000
11. Construction of Walesa crossing	102,000
12. Construction of Hiraman crossing	158,000
13. Construction of offtakes and water measuring devices	124,000
14. Bridges across main canal (3)	150,000
15. Bridges across Walesa, Bilbili and Hiraman seasonal streams	230,000
16. Transport	505,000
Sub-total	6,386,000
Contingencies 20%	1,277,000
	7,663,000
Contractor's overhead and profit 25%	1,916,000
	9,579,000
Engineering and supervision 10%	958,000
Grand total	10,537,000

NA RIVER AT LOCATION OF SITUATION
LY CANAL (PUMPED SUPPLY)

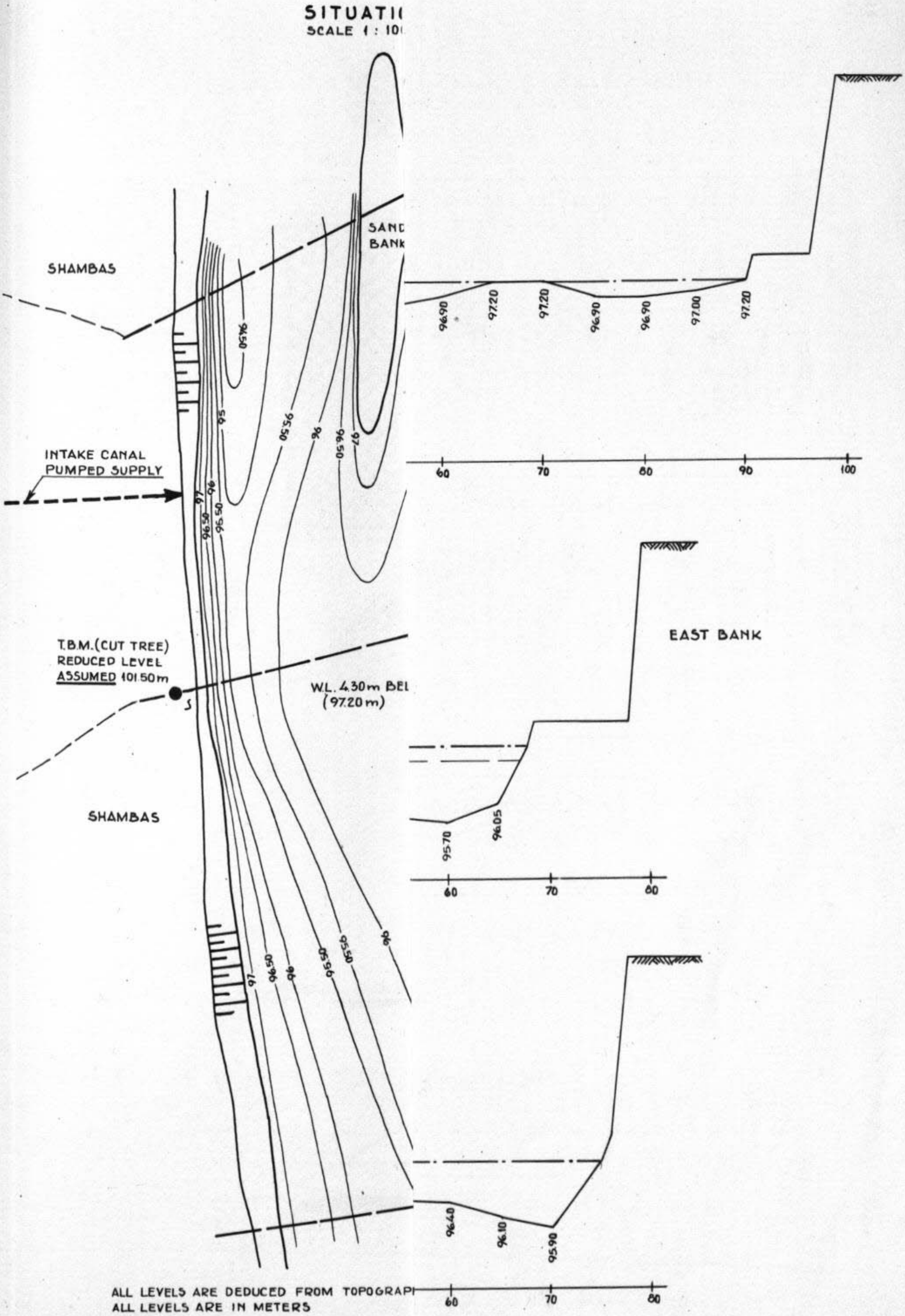
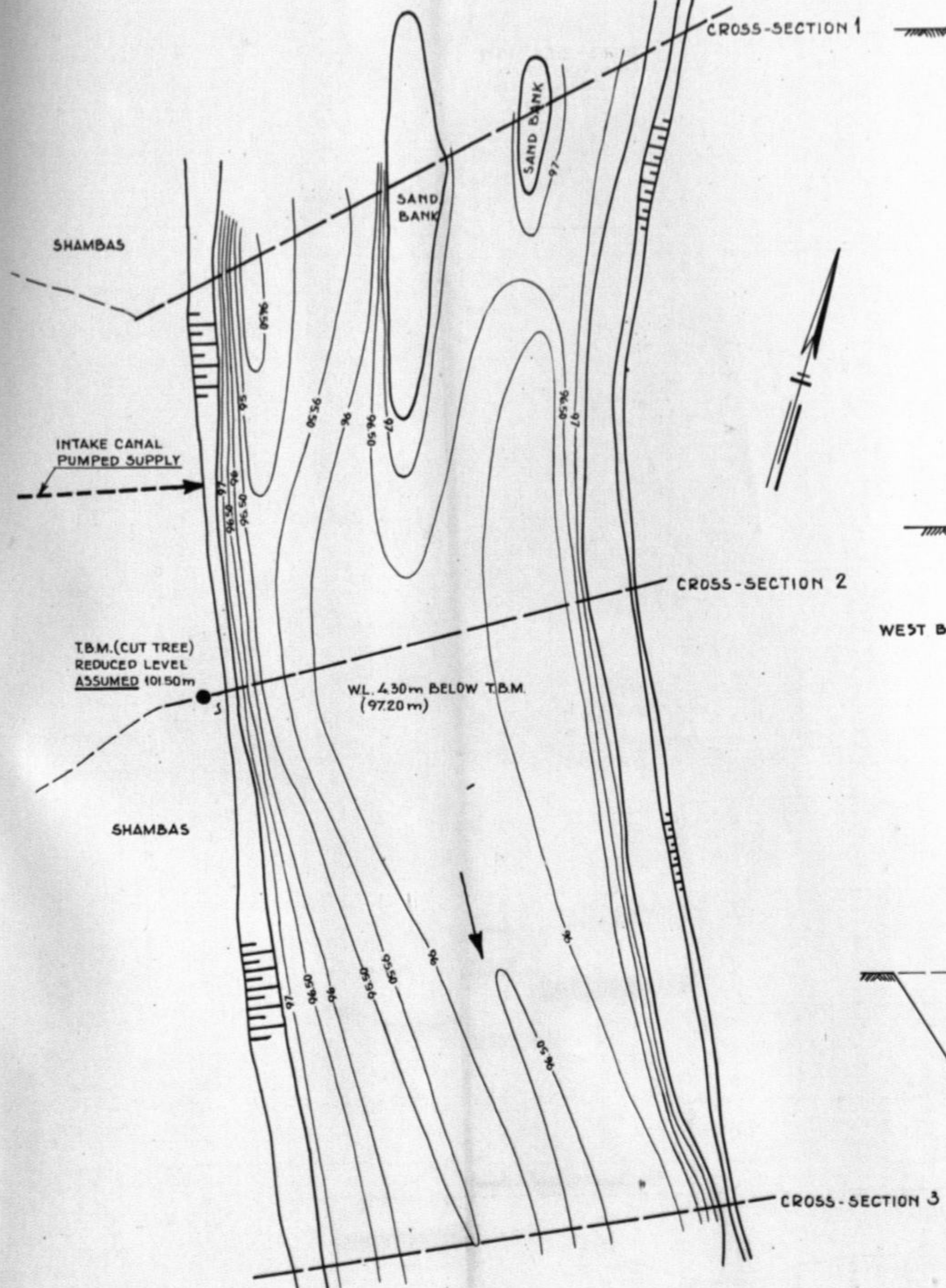


FIG. E.11

BURA

CROSS-SECTIONS TANA RIVER AT LOCATION OF SITUATION INTAKE SUPPLY CANAL (PUMPED SUPPLY)

SITUATION
SCALE 1 : 1000



ALL LEVELS ARE DEDUCED FROM TOPOGRAPHICAL MAP
ALL LEVELS ARE IN METERS

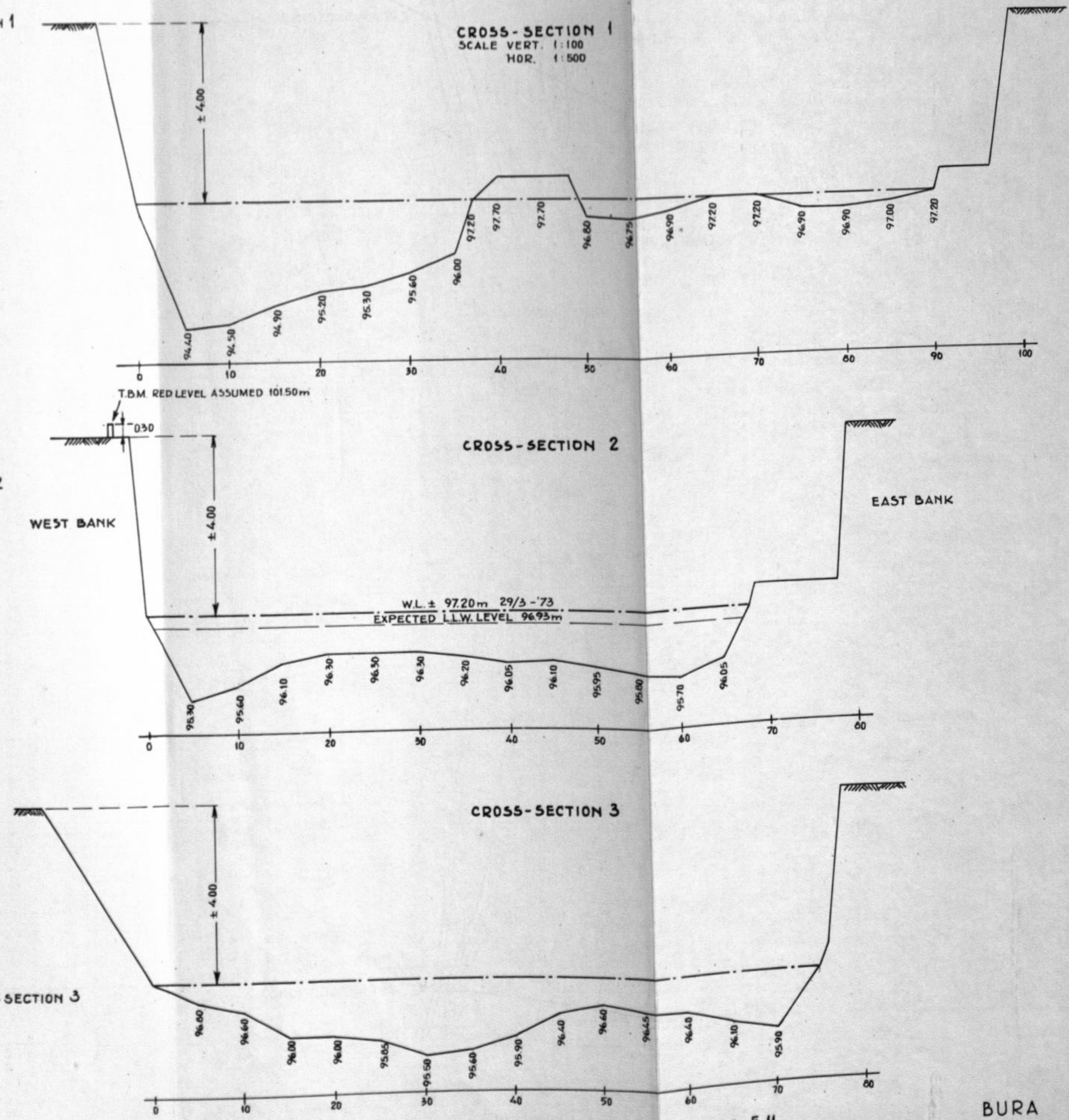


FIG. E.11

BURA

PUMPING STATION

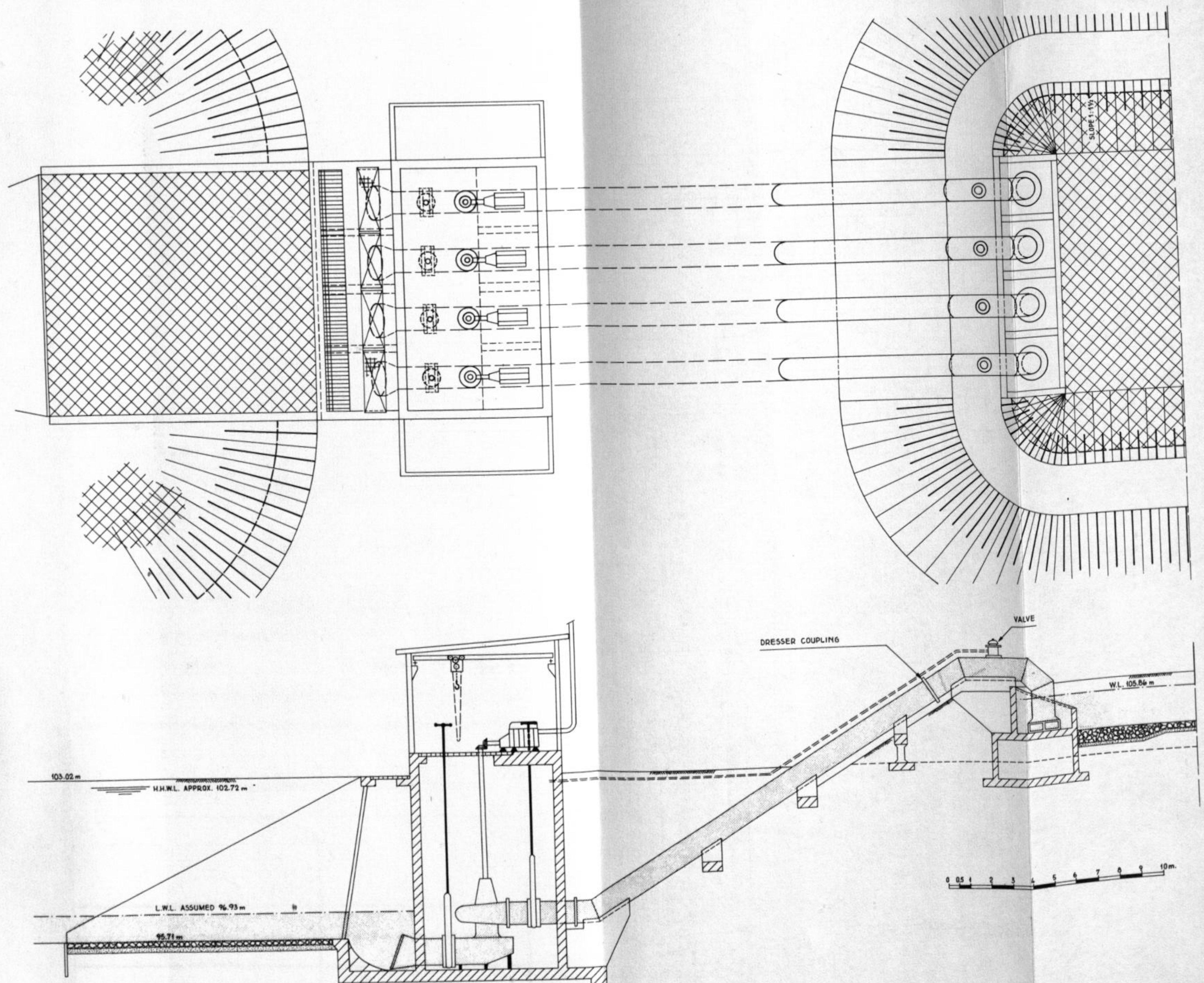


FIG. E.12

BURA

SCHEMATIC WORK PLAN FOR THE CONSTRUCTION OF THE BURA IRRIGATION SCHEME (PUMPING ALTERNATIVE)

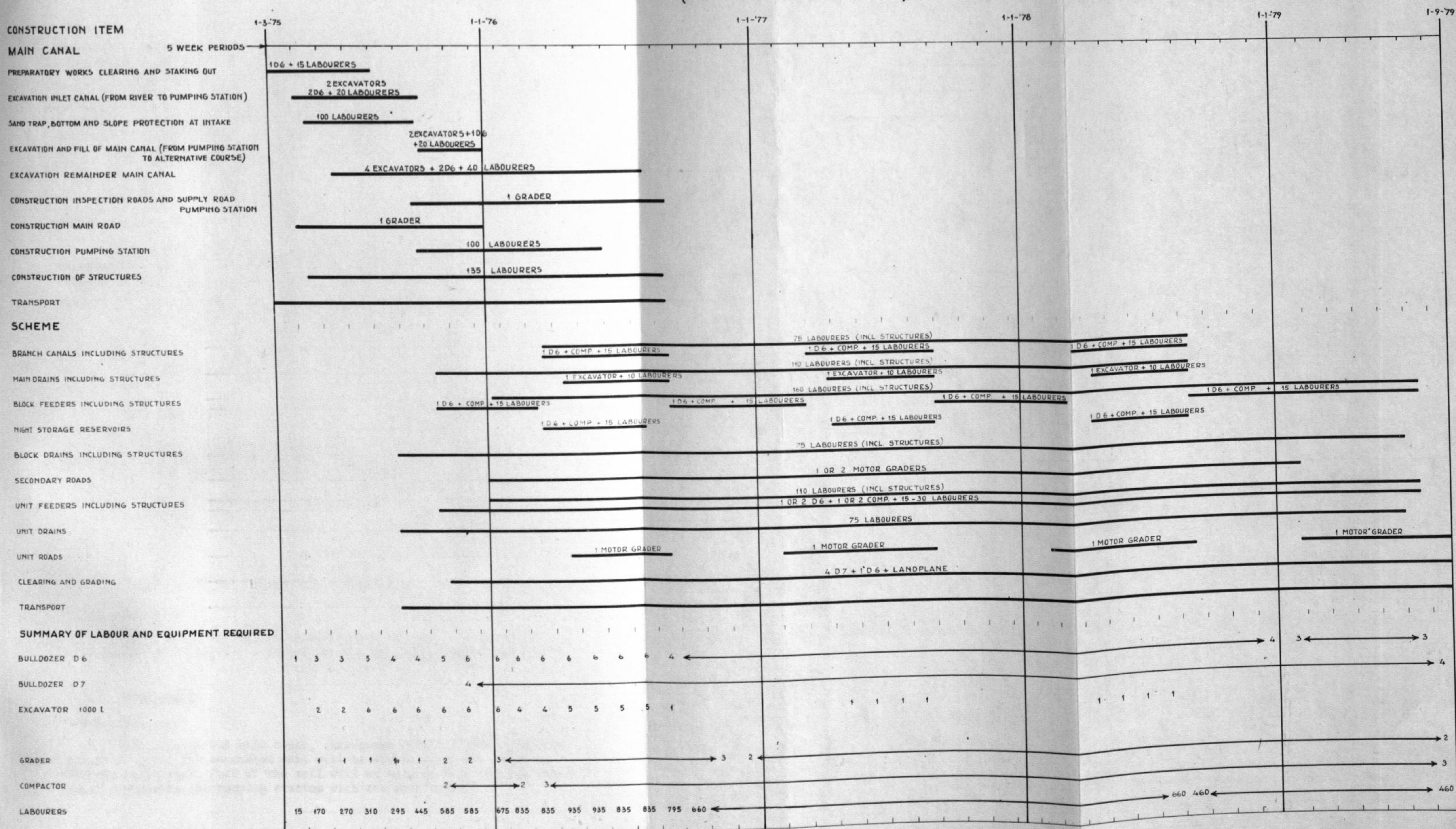


FIG. E.13

BURA

Table E.15 - Number of pumping hours at intake

Month	Pumping hours	Month	Pumping hours	Month	Pumping hours
January	1,440	May	2,880	September	1,440
February	1,440	June	2,880	October	2,160
March	1,440	July	1,440	November	2,160
April	2,160	August	720	December	1,440
				Total	21,600/ hrs/year

In Table E.18 the cost estimates for the annual operation and maintenance costs of pumps and engines based on a fuel price of K.Sh. 0.827 per litre, have been presented.

Table E.16 - Annual operation and maintenance costs (in K.Sh.) for pumps and engines

Fuel	744,300
Attendance (24 hours a day)	50,000
Lubricants	37,200
	831,500
Contingencies 10%	83,000
Total annual operation costs	914,500
Annual maintenance costs for pumps and engines (including contingencies)	58,000
Total annual operation and maintenance costs	972,500

7.3 Planning, method and cost of construction

7.3.1 Planning

Under this alternative, planning and sequence of construction will be identical to that proposed for the gravity intake alternative.

7.3.2 Main canal

7.3.2.1 Earthwork

For digging the main canal, excavators with a 1,000-l capacity are to be used. The excavated soil will be dumped along the canal by D6-type bulldozers. Part of the soil will be used as fill for the supply canal connecting the pumping station with the main canal.

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ANNEX F

SOCIAL ASPECTS OF THE PROJECT AREA

CONTENTS

LIST OF TABLES

1 SUMMARY

The project area is almost uninhabited; it is only used for grazing by some Orma pastoralists. Alongside the Tana River outside the project area, Pokomo cultivators grow maize, rice, bananas and pulses, mainly as subsistence crops.

Demographic data of the Orma and Pokomo are scarce; there seems to be some migration of Pokomo population surpluses to towns along the coast. The urbanization rate and migration trend of this tribe are substantially higher than those of the Orma.

The level of education in the project area is extremely low. Hardly any services and activities are available.

The Tana Irrigation Scheme at Hola has shown that establishing such a scheme in almost uninhabited areas offers good opportunities for high-density settlement of up to 400 people per sq.km, for good incomes, for substantial improvement of the quality of rural life and for development of all kinds of secondary activities.

The Bura area being almost uninhabited, no vested interests of local population groups will be disturbed when a settlement scheme is set up there. Such a project would create employment opportunities, good incomes and many social benefits for those who are going to work on the scheme. Besides, it will act as a centre for rural development in all its aspects for those living outside the scheme, who have a relatively low to very low stage of development at present.

2 GENERAL

The Bura project area, lying north and south of the L. Hiraman, is only very sparsely populated. The population density is estimated at 1 person per sq.km, but this may vary with the seasons. For, Orma pastoralists move through the area, seeking for pasture grounds and water and sometimes the area may be not or almost not inhabited, another time several groups may live there for a short period.

In this and the following sections some data will be supplied about the Pokomo, living outside the project area proper, but having some economic relationships with the Orma. Not only will these data give some indications about the conditions in a larger area, but if the scheme were implemented the Pokomo are expected to be strongly affected by it.

The Orma mainly rely on their cattle for their living. Occasionally, they exchange some cattle against agricultural products with the Pokomo.

At least since the last century they have been living in good friendship with the Pokomo.

The Pokomo/Riverine Bantu* are cultivators, growing their crops on the banks of the Tana river. They have grown rice for centuries. Maize and pulses are also cultivated by them as subsistence crops. In addition, the Pokomo engage in hunting and fishing.

Bura, after which the project is named, is a small village with some two to three hundred inhabitants. It is situated on the other side of the Tana River, north-east of the project area.

The adaptability to modernization of the Orma pastoralists is considered to be lower than that of the Pokomo cultivators. But the Orma do not take a negative view towards agriculture; on the Tana Irrigation Scheme (Hola) there are a few Orma tenants, but reportedly they hire others to cultivate their plots.

3 DEMOGRAPHY

This section deals with population growth, population density, sex ratios and age-sex distribution.

3.1 Population growth and population density

It is difficult to present growth rates for the Orma and the Pokomo. The figures of the 1969 Census deviate from those of the 1962 Census to such an extent that the resulting growth rates are unlikely. E.g. the growth rate or the Orma worked out at 5.0% between 1948 and 1962, which is too high, and at 2.1% in the years 1962 to 1969 which is felt to be a more reasonable approximation.

As regards the Western Hamitic tribes to which the Orma belong, these declined from 97,000 to 90,000, and the Eastern Hamitic tribes from 275,000 to 250,000, according to the 1962 and 1969 Censuses. These varying results may have been caused by various factors, such as enumeration errors in the 1962 Census, international migration and, to a slight degree, famines perhaps. Consequently, the growth rates had to be estimated. The growth rate for the Pokomo has been taken to be 2 to 3%, i.e. somewhat lower than the average for Kenya because of the lower state of health services in the area concerned. That of the Orma pastoralists has been set at 2 to 2.5%, since in view of their transhumant way of life the services available to them will be even lower than those for the sedentary Pokomo.

* The question whether the Coastal Bantu living north and south of Bura should be named Pokomo or Malekote has been left out of consideration in this study. In general, they are grouped as Upper Pokomo; in this report they will be referred to as Pokomo.

The population density in the small strips of land alongside the river banks outside the project area is probably between 10 and 15 persons per sq. km.

3.2 Sex ratios and age-sex distribution

The number of Orma in Kenya being very small (16,306 in 1969) and there being relatively few Pokomo and other Riverine Bantu (Pokomo/Riverine in 1969: 35,181), the ratios calculated (see Table F.1) are less reliable than those for the larger tribes as presented in the Masinga Feasibility Study.

Table F.1 - Sex ratios (male to female) for 'all ages' (1969 Census)

Kenya total	100.4
Coast Province	104.8
Tana River District	99.8
Orma tribe total	105
Pokomo/Riverine tribe total	95
Central Division	104
Zubaki location	111
Northern Division	93
Bura location	95

Note: Bura location is the southernmost part of the Northern Division of the Tana River District. It comprises an area of 1722 sq.km, including the river banks on both sides of the river, Bura village, the flood plains, the project area and vast areas to the West. Hola and the Tana Irrigation Scheme are part of the Zubaki location.
The name Galole was changed again to Hola in 1971.

The above figures can only result in rough indications, considering the low numbers of persons concerned. It would seem that for all ages the ratios between the sexes are quite reasonable.
Table F.2 shows the age-sex distribution and sex ratios for children and adults.

Table F.2 - Age-sex distribution and sex ratios

	Children: 0-15 y.		Adults: 16 and over	
	% of population	sex ratio	% of population	sex ratio
Kenya total	50.5	103.6	49.5	97.2
Coast Province	44.8	104.6	55.2	104.9
Tana River District	51	106	49	94
Central Division	51	106	49	101
Zubaki location	47	100	53	122
Northern Division	53	102	47	83
Bura location	54	103	46	87

Especially the Zubaki location shows an unbalanced sex ratio for adults, probably due to immigration of males.
In the Northern Division, there is some shortage of adult males.

The 1969 Census only presented the 5-year age groupings up to district level and for urban centres (see Table F.3, next page).
An analysis of these data only allowed to give some indications as to which age groups are disturbing the sex ratios in and around the project area on division and lower levels.
Compared with the total for Kenya, the Coast Province shows only a slight deviation. The sex ratios of the age groupings 20-50 years in the Coast Province are much more in balance than those of e.g. the Eastern Province.
The Tana River District shows a shortage of male twens.

Mombasa Town and Malindi Town have high sex ratios in the productive ages, though not as high as Nairobi City.
The sex ratios for Hola Town (mentioned Galole in the 1969 Census) are heavily unbalanced for the productive ages; they are in complete contrast to those of other small towns in Kenya.
This may be partly caused by the fact that males are working and living outside Hola Town, e.g. on the Tana Irrigation Scheme.

4 URBANIZATION AND MIGRATION

These aspects could not be studied for the project area either, but figures of higher administrative levels may provide some indications.

4.1 Urbanization trends

The Orma live in an area which is remote from large towns. Some distances from Bura are:

to Lamu (abt 7,500 inhabitants in 1969) via Garsen:	some 260 km
to Malindi(abt 11,000 inhabitants in 1969):	some 240 km
to Mombasa (abt 247,000 inhabitants in 1969):	some 350 km

As the road from Bura to Garsen is unmetalled, it may be impassable for weeks or longer during and after heavy rains.

The 1969 Census provides data which give a general idea of the urbanization rates of the different tribes in Nairobi and Mombasa, the two major towns (see Table F.4, page 140).

Table F.3 - Age groups in per cent of population and sex ratios

Age group	Kenya		Coast Province		Tana River District		Mombasa Town		Malindi Town		Galole Town	
	% of popu-lation	sex ratio	% of popu-lation	sex ratio	% of popu-lation	sex ratio	% of popu-lation	sex ratio	% of popu-lation	sex ratio	% of popu-lation	sex ratio
0- 4	19.2	101.1	17.1	101.1	18.8	101	14.6	107	) 26.6	104	) 35	97
5 -9	16.5	102.6	15.1	102.8	17.6	104	12.0	101	)		)	
10-14	12.6	107.7	10.6	112.2	12.6	117	8.8	122	9.6	123	11	123
15-19	10.1	102.8	9.9	98.4	8.6	89	11.6	131	11.5	157	9	77
20-24	8.0	95.1	8.7	92.3	7.3	74	12.3	142	10.0	133	9	66
25-29	7.0	85.0	8.7	92.5	7.2	79	11.2	153	10.4	133	8	62
30-39	10.0	94.5	12.5	108.6	10.8	92	15.0	198	13.9	140	10	90
40-49	6.7	100.2	7.4	118.1	6.7	107	7.8	195	8.2	140	7	76
50-59	4.5	102.4	4.7	119.2	4.9	118	3.7	174	4.6	132	5	120
65+	5.4	110.4	5.2	128.7	5.5	133	3.0	140	5.2	120	6	139
Average		100.4		104.8		99.8		139.1		127		92

Table F.4 - Percentages of some tribes living in the two major towns and sex ratios

	Nairobi			Mombasa		Nairobi and Mombasa *
	1962	1969		1969		1969
	% of total tribe	% of total tribe	sex ratio	% of total tribe	sex ratio	% of total tribe
Kikuyu	4.0	8.7	144	0.7	172	9.4
Luo	2.2	4.1	189	1.4	145	5.6
Luhya	2.4	4.5	161	1.0	153	5.5
Kamba	2.6	5.1	210	2.5	191	7.5
Pokomo/Riverine	0.1	0.3	157	6.0	122	6.3
Orma	0.1	0.04	abt 250	0.26	abt 139	0.3

* Totals may differ because of rounding off.

Unfortunately, figures for smaller towns in relation to tribes have not been presented in the 1969 Census; the relevant figures could have provided information about the urbanization rates of the Pokomo at Lamu and Malindi.
The above data show that the urbanization rate of the Orma is very low which is common for pastoralists. In 1969, only 7 Orma were recorded in Nairobi and 43 in Mombasa.
The urbanization rate of the Pokomo cultivators is high. Breakdowns for the Lower Pokomo (those in the regions near the sea) and the Upper Pokomo (those living halfway Garsen to Hola northward) are not available. The urbanization rates of the Upper Pokomo are assumed to be substantially lower than those of the Lower Pokomo.

4.2 Migration trends

Data about place of birth and residence give some indication about migration trends (see Table F.5).

Table F.5 - Relation (%) between birthplace and residence for some tribes

	Born and living:			Not stated
	in same district	elsewhere in Province	elsewhere in Kenya	
Kikuyu	72.5	6.4	20.4	0.6
Luo	83.6	3.8	11.6	0.5
Pokomo/Riverine	43.8	21.6	7.7	26.9
Orma	88.0	2.6	0.9	8.2

The Orma show a very low migration trend, both at district and at provincial level, unlike the Pokomo who show a very high interdistrictal migration trend. This refers mainly to the Lower Pokomo. It may be caused to a great extent by the fact that the Pokomo live along district borders; alongside the Tana runs the boundary between the Tana River District and the Lamu District.

Consequently, the above figures do not give a clear indication about the migration trend of the Pokomo. Given their relatively high urbanization rate, the migration trend is assumed to be relatively strong, at least among the Lower Pokomo.

5 EDUCATION

No data are available about the status of education in the Bura project area. Figures for the conditions at district and higher levels are presented in Table F.6.

Table F.6 - Percentages of population with completed forms of education

	Total Kenya	Coast Province	Mombasa Town	Tana River District
Standard 1-8	24.3	17.4	29.6	6.4
Forms I and II	1.5	1.7	4.3	0.2
Forms III and IV	0.9	1.4	4.2	0.2
Form V +	0.4	0.6	1.4	-

Note: In the Population Census 1969, Vol. II, the state of education for the urban centre of Galole (Hola) is given as "non or not stated" for all standards and forms at all ages. Because of this error, the figures for the Tana River District are somewhat distorted.

Even when taking into account reasonable figures for Galole Town, the state of education in the Tana River District is very low compared to that in the whole of Kenya.
The state of education among the pastoral Orma will be even much lower than the above district averages because of their transhumant way of life; for the sedentary Pokomo near Bura it will be somewhat better than for the Orma.

6 EMPLOYMENT

Agricultural and non-agricultural wage employment in the Bura area is very low to non-existent. Employment in the area consists for almost 100% of self-employment and family labour, both in cattle grazing in the area proper and in agriculture alongside the river.

7 SERVICES AND ACTIVITIES IN AND AROUND THE PROJECT AREA

7.1 Administration and protection

The state of services and activities in the Bura area is extremely low, and neither are there adequate services available in the surrounding area.

The District Commissioner is stationed at Hola, some 50 km south of the project area.
Judicial services at Resident Magistrate's Court level are available at Hola. There is a small Tribal Police Post at Masabubu, east of the project area across the Tana River.

7.2 Health services

The small Bura village north of the project across the river has a dispensary. The most nearby hospital is at Hola. Clearly, the transhumant Orma benefit only to a very low degree from these services. The accessibility of Bura is in general poor, especially when the river is in spate.

7.3 Educational facilities

Educational facilities are not available in the project area. Most nearby primary schools are across the river, e.g. at Chewere and Rhoka. Because of the poor accessibility of schools and of their transhumant way of life, the state of education among the Orma is very low.

The secondary school at Hola mainly serves the Hola population and those living nearby alongside the river.

7.4 Libraries and social halls

These services are non-existent in the project area.

7.5 Communications

Postal services, telephone or telecommunications are non-existent in the project area. The Bura Project is only to be reached by road. The road from Garissa through the Bura area to Hola and the coast is unmetalled. During the rainy season, the road may be impassable for weeks or even longer. Both Bura and Hola have airstrips.

7.6 Commerce and industry

Industry, shops, markets and the like are non-existent in the project area. Only a very limited number of cattle is sold or bartered.

7.7 Electricity and water supply, sanitation

No electricity is available in the project area.
Water is available in shallow water holes and some gullies in the rainy season; during the dry season, it can be obtained only from the Tana river and by digging in dry river beds.

7.8 Agricultural extension services

An Agricultural Officer is stationed at Hola. Mainly cultivators like the Pokomo will benefit from his services.
The Orma may benefit from the services of the veterinarian at Hola in the prevention and care of cattle diseases and the like, but in view of the vast area to be covered, the intensity of his services cannot be but low.
There are no cattle dips in the project area.

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ANNEX G

ORGANIZATION, MANAGEMENT, PERSONNEL

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1 ORGANIZATION

1.1 General

The organization as proposed for Bura is, in general, identical to that suggested for the Masinga Irrigation Scheme. For completeness' sake, the features discussed in the report on the Masinga Scheme will be reverted to again in this Annex.

To ensure that an irrigation scheme will function properly and its aims are fully achieved, it must be well organized. To this end, a structure must be provided that allows to apply all inputs, both physical and non-physical ones, most efficiently in order to achieve the best results. The available resources and inputs, i.e. land, water, capital, manpower, know-how, materials, machinery, etc. are to be used to an optimum extent which, in turn, can be realized only by efficient communication within the organization.

The organization of an irrigation scheme should be flexible so that it can be easily adjusted whenever unforeseen situations or constraints and the like occur.

Figure G.1.1 shows the organizational set up as proposed for the Bura Irrigation Scheme; the organigram has been based mainly on the organization of other irrigation schemes of the N.I.B. and on that of schemes in other countries.

1.2 Departments

The main departments of the scheme will be:

- Agricultural Department;
- Technical " ;
- Research " ;
- Accounting " ;
- Processing " .

1.2.1 The Agricultural Department (see Figure G.1.2)

This department is to be entrusted with all tasks in relation to crop growing. But since all departments are to serve the farmers, the manager of the scheme is to ensure that the activities are properly coordinated with those of the other departments.

The Agricultural Department will include two divisions:

- the Irrigation Division;
- the Pest and Disease Control Division.

1.2.1.1 The Irrigation Division

The Irrigation Division will be sub-divided into three sections:

- Crops Section;
- Water " ;
- Maintenance Section.

a) The Crops Section

The Crops Section is to deal with all aspects of crop growing from land preparation up to harvesting, including weeding, irrigation, pest and disease control, upkeep and maintenance of unit feeders, drains and roads.
The lowest echelon of the Crops Section will be headed by the field assistant, who is to maintain regular contact with the farmers. Hence, the field assistant will be the most important man in the communication channel between management and farmers, and vice versa. He is the one who has to disseminate all information from the management to the farmers, and to collect from the farmers for the management all information needed to have the scheme function properly. The field assistant has been called once: "the key-man in the field staff, he should be a well-known and trusted figure, a man with high qualities of leadership and personality".
He should be a man who is not only familiar with the agricultural problems of the farmers, but also with their personal circumstances and those of their families, with life in the villages, etc.

In the organization system one man has been proposed to maintain regular contacts with the farmer. In other systems there may be two or more specialized persons for this purpose, e.g. one for extension matters, another for credit supply, etc. We consider that sufficient information will reach the management via the field assistant and the representative councils of the farmers, and that no credit advice or the like will be needed. Moreover, credit requirements are not expected to differ very much among tenants and it is, therefore, felt that these matters can be dealt with more efficiently and at less cost centrally through the Accounting Department. Experience gained on other irrigation schemes in Kenya supports this system.

b) The Water Section

Although the field assistant will deal with all the work on the farms, he need not handle every aspect himself. Several tasks are to be performed by other divisions and sections.

The irrigation officer who is to head the Crops Section will also be in charge of the Water Section in which task he will be assisted by head waterguards and waterguards. He will organize the water distribution in the part of the scheme under his command. The waterguards have to report to their superiors when the farmers or the field assistants complain about water shortage. To arrive at an optimum use and distribution of the water, the relevant instructions of the irrigation officers have to be strictly adhered to by both farmers and field assistants.

c) The Maintenance Section

The irrigation officer will also head the Maintenance Section for his part of the scheme. The headman and labourers have to do the maintenance work that does not belong to the farmers' obligations, such as maintenance and repairs of irrigation canals, drains and roads.
Regular maintenance and repairs of canals, drains and roads are essential to guarantee adequate supply and drainage of water, and to ensure reliable communications.
In these tasks, the scheme should be assisted by a surveyor stationed at the N.I.B. Headquarters under the proposed management system (see Sub-section 2.4.1). But when it proves necessary for the scheme to employ a full-time surveyor, he should be stationed on the project.

1.2.1.2 The Pest and Disease Control Division

This division will comprise headmen, sprayers and eventually casual labourers. Aerial spraying is not to be done by them, but will be organized by the manager who will contact aerial spraying firms.

The division will also be charged with spraying of insecticides and moluscides against malaria and bilharzia.

1.2.2 The Technical Department

This department will be divided into four divisions, i.e.:

- Agricultural Machinery Division;
- Other Machinery Division;
- Buildings Division;
- Transport Division.

The Agricultural Machinery Division will deal with the wheel-tractors and implements used in land preparation, etc. in close coordination with the Agricultural Department.

The Other Machinery Division is to handle the remaining equipment, such as crawler tractors, excavators, draglines, generators, etc.

The Buildings Division will be charged with maintenance and repairs of the project buildings and the staff houses that are not privately owned.

The Transport Division is to deal with transport of personnel, materials, produce, etc.

1.2.3 The Research Department

This department will be divided into two divisions, i.e.:

- Research Division;
- Water and Meteo-recording Division.

The Research Division has to conduct research on all subjects which are of relevance to the scheme, in close coordination with the Agricultural Department. Another important task is scouting of pests and diseases in the crops by the Pest and Disease Control Officer and his assistant. Early information is necessary to enable the management to take adequate action through the Pest and Disease Control Division of the Agricultural Department.

1.2.4 The Accounting Department

This department will be sub-divided into several divisions:

- scheme administration, tenant affairs, advance payments, final crop payments, financial affairs, etc.;
- crops administration;
- labour administration;
- marketing, purchases and selling of materials, fertilizers and spare parts, etc.

The marketing activities will be limited, since the produce is expected to be handled via specified Marketing Boards of the Government.

1.2.5 The Processing Department

This department has been included in the proposed organigram, but it may well be that processing of produce will be done by an independent organization, either owned by the N.I.B., or by farmers' cooperatives, or jointly. We recommend that a system should be set up under which the farmers have an interest and a share in the processing, as is the case with the Mwea Rice Mills Ltd.

1.3 Organization of two-way communication

In the foregoing sections we have mainly discussed the communication of the management with the farmers through the channels of the organization echelons.

A very important channel of communication is, however, the direct line from the manager to the farmer, and vice versa. Based on experience gained on other irrigation schemes in Kenya, a tentative organigram has been drawn up for this most important line of contact (see Figure G.1.3). The organization of representative councils at all levels should be extensively discussed amongst farmers and between farmers, management and the ministries concerned. The most important function of these councils, in which both the management and the Government are to be represented, will be to promote an open and constructive two-way communication. This will enlighten the insight of the management into all problems and constraints of the farmers and will enhance the farmers' motivation and participation.

1.4 Organizational relationschip of N.I.B. Headquarters with the scheme

The N.I.B. has long experience in managing irrigation schemes and it is recommended that for Bura the same type of system should be applied.

Under this system, the General Manager of the N.I.B. is responsible for the overall management of the schemes.

In their respective fields of action, the N.I.B. staff of the Engineering, Agriculture and Accounts Divisions deal with all technical aspects related to the schemes. These divisions are in contact with the relevant departments on the schemes via the manager of the schemes.

2 MANAGEMENT

2.1 General

Management is one of the most important inputs and one of the most decisive factors for the success or the failure of an irrigation scheme.

Its objective is to promote successful farming as a means to improve the quality of rural life. To this end, it is to supply all services and inputs efficiently, thus enabling the farmers to achieve success in their crop growing activities as rapidly as possible. Rapidly increasing crop yields and thus reasonable to good incomes are important incentives for highly motivated crop husbandry for the farmers.

Moreover, high-standard management is a prerequisite to using the capital invested in the scheme most efficiently.

The Terms of Reference for the studies require that a management system should be recommended with particular reference to the National Irrigation Board. Consequently, function names as used on the N.I.B. schemes and the distinctions between senior staff, junior staff, subordinate staff, casual labour and contracts have been adopted in this report.

The proposed management system has been based mainly on that practised by the N.I.B. on their other irrigation schemes and on experience in other countries.

Like its organization, the management system of a scheme and its management intensity must be flexible, so that they can be adjusted when the need arises to do so. This must be evaluated regularly by both the scheme itself and by N.I.B. Headquarters.

2.2 Management intensity

As the farmers will have no or only limited experience in irrigation and they have to use modern cultivation methods, the management intensity, i.e. the number of field staff per ha at the lowest echelon, or the number of field staff in relation to a number of farmers, should be thoroughly defined.

When the management intensity is too low, crop failures are likely to occur because of insufficient guidance and extension. Too high an intensity, which means too high closeness of guidance and supervision will work adversely; it may deprive the farmers from their own initiative and may decrease their motivation and their satisfaction in the work.

The optimum degree of intensity or closeness depends on several factors such as the degree of experience of the farmers, farm size, degree of motivation, failures or successes experienced, degree of cooperation among the farmers, and between farmers and the management, social conditions in the farmers' families and in the villages.

The recommendations on management intensity at Bura have been based on the experience gained on other irrigation schemes in Kenya and abroad.

Cotton requires slightly more intensive farm management than rice because the cultivation of this crop poses more problems as regards irrigation, weeding and pest control, etc. Therefore, we recommend that the management intensity at farm level for this crop, i.e. the number of field assistants per ha and per farmer, should be somewhat higher than that for rice.

2.3 Decrease in management intensity

The intensity of the management, i.e. the closeness of guidance and supervision, can gradually decrease as the efficiency of the staff and the experience of the farmers increase. Therefore, a high intensity has been envisaged at the start of the project, which will gradually decrease until its final stage in reference years 5, i.e. the second year of full production.

Clearly, the management intensity at the start will vary for the different staff levels and per department. For example, the number of field assistants per ha in the early years will be higher than that of mechanics and welders when related to hectares.

Table G.1 shows intensity percentages based on an intensity of 100% when the scheme is fully operational. Hence, an intensity of e.g. 300% indicates that the coverage or closeness of guidance per ha is three times higher than that in the final year. The trainees have been included but their efficiency has been assumed to be 50% of that of the appointed and experienced employees.

Table G.1 - Management intensity in per cent at fully operational stage

Reference year	1	2	3	4	5
Cropped area (ha)	700	1,800	2,900	4,000	4,000
Senior staff	377	198	135	100	100
Junior staff	268	158	126	99.7	100
Subordinate staff	223	146	118	99.5	100
Casual labour and contracts	154	109	107	97	100

For labour, a higher intensity has been assumed in the first years. When the project will be in full swing, they are expected to have reached a good efficiency. In the second part of year 4, more man-years have been accounted for because additional tasks are presumed to emerge at that time, but the management has to ensure that the labour efficiency as well as that of the staff at higher levels increase from year to year. Regular evaluations should be made in order to try to lower the intensity whenever possible.

If tasks of the scheme management can be taken over by the farmers themselves, either through the establishment of farmers' cooperatives or other organizations without jeopardizing the farming results, it should be considered to do so. It is assumed that such organizations will be initiated by the farmers themselves and that they will be stimulated and promoted by the management. More intensive participation of the farmers through such cooperatives may increase their motivation. As cooperatives will also require management executives and employees at all levels to function smoothly, an increased participation of the farmers through cooperatives is not expected to lower the cost of management substantially.

2.4 Staffing

2.4.1 Senior staff

The proposed senior staff has been listed in Table G.2.1 at the end of this Annex.

For the Agricultural Department, two senior irrigation officers and five irrigation officers have been proposed. The whole scheme is to be divided into two main parts of about equal size and each part again into two or three sub-parts such that these parts will more or less coincide with large irrigation units.

In accordance with present practices of the N.I.B., some N.I.B. staff (surveyors and the like) who are operational for the scheme have been included in this echelon. The costs of their services have been estimated at some 20% of those of the senior staff of the scheme.

2.4.2 Junior staff

The proposed junior staff has been shown in Table G.2.2 at the end of this Annex.

For the Agricultural Department we recommend five head field assistants. The areas under their command should be the same as those of their supervising irrigation officers.

Each head field assistant is to be assisted by five field assistants which implies that one field assistant has to deal with 154 ha or 128 farmers. This is a somewhat lower intensity than at Masinga for which one field assistant per 140 ha has been proposed. Considering the topography in the Bura area, the irrigation system on this scheme is expected to require less intensive supervision and guidance of the farmers.

In the following table, the proposed management intensity at field assistant level has been compared for the two proposed and two ongoing schemes.

Table G.3 - Management intensity at field assistant level - proposed and ongoing schemes

Scheme	Crop	Farm size in ha	Average number of farmers per field assistant
Mwea	rice	1.6	150
Tana Irrigation Scheme	cotton	1.6-1.2	60 (Pilot Scheme)
Masinga	cotton	1.2	117
Bura	cotton	1.2	128

For the Technical Department, the numbers of drivers and plant operators required have been based on a fleet of 40 wheel-tractors and 5 other machines (crawler tractors, draglines, excavators, generators). It has been assumed that 10% of the wheel-tractors will be under repair and that 10% reserve drivers will be needed. Furthermore, the wheel-tractors have been assumed to work in one shift for the greater part of the year, the other machinery in three shifts. The calculations for the fleet of tractors as presented in Annex D have been based on a two-shift system during peak periods in land preparation. Drivers for these two-shift periods should be hired on a temporary basis.

Whenever necessary and possible, it is recommended that a three-shift system should be applied.

2.4.3 Subordinate staff

The proposed subordinate staff has been shown in Table G.2.3 at the end of this Annex.

2.4.4 Casual labour and contracts

The labour requirements per department expressed in manyears have been estimated in Table G.2.4 at the end of this Annex. They have not been specified per type of work. Casual drivers have also to be covered by this budget.

3 PERSONNEL - QUALIFICATIONS, TRAINING, COSTS

3.1 Qualifications

N.I.B. has gained adequate experience with personnel at all levels, and is fully conversant with the qualifications for all personnel to be employed at Bura. Therefore, only a few remarks will be made in this respect.

Manager

Most of the success or failure of the scheme will largely depend on the qualities of the scheme manager. High-standing personal qualities, leadership and pushing power are essential for this job. He should have long experience in managing large projects under difficult circumstances. He should have a good insight into agriculture in general; specific knowledge of cotton growing is not the most important requirement, because technical aspects will be covered by his subordinates, the Research Department, the N.I.B. Headquarters, and others.

Senior irrigation officers

The senior irrigation officers should have long experience in irrigation, preferably on other irrigation schemes. If possible, both but at least one of them should be fully familiar with furrow irrigation. Graduates are preferred, but experience is the prime requirement.

Irrigation officers

These employees should also have several years of experience in irrigated cotton growing. For this job, too, graduates or diplomaholders are preferred, but again experience is of more importance.

Head field assistants

These employees must have long experience, either as head field assistant or as field assistant in irrigated cotton growing.

Field assistants

We recommend that in the first few years, field assistants should be employed who have gained wide experience on other irrigation schemes. This is of paramount importance to prevent failures at the start.

Accounting and Administrative Department

The accountant must be fully qualified and preferably have gained experience on irrigation schemes.

Technical Department

The staff of this department must be fully qualified. The workshop staff and the tractor supervisors must have experience in handling agricultural machinery.

Research Department

This department must be headed by a university graduate.

3.2 Training and employment schedules

These semi-annual schedules have been presented in Tables G.4.1 to G.4.4, at the end of this Annex.

Senior staff

Next to their qualifications and previous experience as described under Sub-section 3.1, some of the senior staff should be trained in some aspects of their future jobs.

For the manager this will concern managing of large schemes and some aspects of cotton growing. The irrigation officers may have to be trained in some aspects of cotton irrigation and cotton growing.

The training in aspects like management and irrigation can be provided for on large schemes, e.g. Mwea; as far as the training in cotton growing is concerned, Hola is recommended.

Junior staff

No training has been envisaged for the junior staff of the Administrative Department.

If junior staff for the Agricultural Department is attracted who have gained experience on other schemes as recommended under Sub-section 3.1, the training periods as suggested in Table G.4.2 at the end of this Annex will suffice.

As soon as cotton is being grown at Bura, their training can be arranged for there; until such time the staff is to be trained at Hola.

For the post of tractor supervisor within the Technical Department, capable and experienced supervisors or drivers from other schemes might be considered. Although a licensed tractor driver cannot be expected to do the fieldwork up to standard right from the start, it is felt that a short period of in-service training by capable workshop staff and tractor supervisors will suffice.

Subordinate staff

No special training has been envisaged for this group of staff. For the post of head waterguards, experienced and capable waterguards from other schemes might be attracted.

Casual and contract labour

Table G.4.4 shows the estimated labour manyears specified per half year.

3.3 Costs of personnel

The costs of the various categories of personnel have been listed in Table G.2.1 to G.2.4 at the end of this Annex. The salaries for each group of staff and function have been based on the relevant salaries included in the N.I.B. Annual Budget for the year 1972/1973. In this Annex, the salaries have not been adjusted for annual increases in the coming years; this has been dealt with in Annex J: Economy.

To the salaries have been added the costs of gratuities and other social costs, including 5% for the National Social Security Fund (N.S.S.F.). The salaries are exclusive of the costs of housing, transport and other emoluments.

For casual labour and contracts, only the 5% N.S.S.F. have been included.

Table G.5 shows the summarized costs of all personnel.

Table G.5 - Summary of annual costs of personnel in £ per cropped ha

Reference year	- 1	0	1	2	3	4	5
Cropped area (ha)	*	*	700	1,800	2,900	4,000	4,000
Senior staff	7.76	22.67	29.57	14.36	9.35	6.83	6.83
Junior staff	1.54	14.77	32.54	19.35	15.09	11.84	11.88
Subordinate staff	-	1.98	8.58	5.61	4.54	3.83	3.85
Casual labour and contracts	-	1.10	4.05	2.86	2.80	2.51	2.63
Total	9.30	40.52	74.74	42.18	31.78	25.01	25.19

* Amounts calculated on the basis of 700 ha.

The costs of personnel in the fully operational stage have been estimated at £ 25.2 per ha. This is somewhat lower than our preliminary estimate presented in the Interim Report of October 1972.

As the calculations have been completed, more refined data are now available about the proposed farm size, required number of tractors, layout of fields and water distribution works, etc. This has resulted in a slight reduction in the proposed staffing, especially as regards junior and subordinate staff, compared to the figures in our October 1972 Interim Report.

The above figures also include the cost of training of the staff indicated under 'Training' in Tables G.4.1 and G.4.2. During their training the salaries of trainees have been estimated to be 70% in the first year, and 80% in the second year (when applicable) of that of their appointed colleagues.

The estimated costs of personnel compare favourably with those of Masinga. For Masinga, a total of £ 31.0 per ha has been arrived at. The following table specifies the costs per category.

Table G.6 - Comparison of personnel costs at Bura and at Masinga per ha

Category of staff	Number of staff		Ha per man		Costs per ha, £	
	Masinga*	Bura**	Masinga	Bura	Masinga	Bura
Senior staff	11	14	216	285	9.9	6.8
Junior staff	98	148	24	27	13.3	11.9
Subordinate staff	75	100	32	40	4.9	3.9
Casual labour and contracts	100	150	24	27	2.9	2.6
Total	284	412	8.4	9.7	31.0	25.2

* Masinga: 2,380 ha
** Bura : 4,000 ha

At Bura, the capacity per man is higher and the costs per ha are lower because:

- the topography poses less difficulties than at Masinga;
- the economy of scale has a favourable effect at all levels at Bura, but especially on the cost of senior staff.

4 N.I.B. HEADQUARTERS STAFF

When both the Masinga and the Bura project are implemented, the acreage currently managed by N.I.B. will increase from 7,250 to some 13,550 ha. Therefore, we recommend that the N.I.B. Headquarters staff should be further reinforced to handle the almost doubled acreage, both in the construction and in the operational period.

For the construction period, these aspects are dealt with in Annex E. For the operational stage, we recommend reinforcement of the Engineering Division and the Agricultural Division. For the Engineering Division beside the senior engineer present, a senior irrigation engineer should be attracted who is to deal with all aspects of irrigated agriculture, such as irrigation systems, water use, etc.
In addition, a senior civil irrigation engineer should be appointed, who is to deal with all civil engineering aspects of irrigation, like pumping plants, structures, canals, etc.

For the Agricultural Division we recommend that a second senior agriculturist be appointed, so that the tasks of the two agriculturists could be divided; one should deal with cotton, the other with other crops (rice, onions, etc.).

The Accounts Division should be further reinforced whenever the need arises to do so.

During the fieldwork in Kenya in 1972, we have understood that the N.I.B. is working out a programme for reinforcement of its staff with a view to the further development of irrigated agriculture.

Therefore, the above suggestions should be considered to be tentative, and they should be elaborated further at N.I.B. Headquarters.

If only one of the projects is implemented, reinforcement of the N.I.B. staff as recommended is still considered to be necessary. The 3 senior experts should be appointed some 6 months before the first crops are planted on the new project(s).

5 RECRUITMENT

A detailed recruitment schedule has to be worked out during the design period of the project. This has to be done in line with the training periods as recommended under Sub-section 3.2: Training and employment schedules, and shown in Tables G.4.1 and G.4.2.

Should the required high-level management capacity, especially for managers, senior irrigation officers, the research officer, and the recommended N.I.B. staff reinforcement not be available locally, then we recommend that expatriate experienced staff be employed for a limited period. Their task will be to set the projects going and to train local staff right from the start.

Table G.2.1 - Numbers and salary costs of senior staff

Department	No of staff	Average salary per annum (£)	Total annual salary costs (£)	No of hectares per man
General management, Administrative and Accounting Departments				
- Manager	1	3,000	3,000	
- Accountant	1	1,800	1,800	
- Assistant accountant	1	800	800	
Agricultural Department				
- Senior irrigation officer	2	1,550	3,100	2,000
- Irrigation officer	5	850	4,250	800
Technical Department				
- Senior officer for workshop	1	1,850	1,850	
- Workshop foremen	2	750	1,500	
Research Department				
- Research officer	1	1,200	1,200	
Sub-total A	14		17,500	285
Gratuities, N.S.S.F., etc., 30%			5,250	
Total A			22,750	
N.I.B. HEAD OFFICE STAFF,				
Operational for the scheme, 20% of sub-total A			3,500	
Gratuities, N.S.S.F., etc., 20%			1,050	
Total B			4,550	
Grand total			27,300	

Annual costs, exclusive of housing, transport, etc.: £ 6.83 per ha.

Table G.2.2 - Numbers and salary costs of junior staff

Department	No of staff	Average salary per annum (£)	Total annual salary costs (£)	No of hectares per man
<u>General management, Administrative and Accounting Departments</u>				
- Clerks, typists	14	270	3,780	
- Senior storeman	1	340	340	
- Assistant storemen	2	270	540	
<u>Agricultural Department</u>				
- Head field assistants	5	460	2,300	800
- Field assistants	26	250	6,500	154
<u>Technical Department</u>				
- Building foreman	1	460	460	
- Junior building foremen	2	330	660	
- Tractor supervisors	4	350	1,400	1,000
- Charge hands	4	350	1,400	1,000
- Mechanics, welders	15	270	4,050	
- Artisans	15	310	4,650	
- Drivers, plant operators*	53	260	13,780	80
<u>Research Department</u>				
- Head field assistant	1	460	460	
- Field assistant	1	250	250	
- Water/meteo recorder	1	260	260	
- Pest and disease control officer	1	350	350	4,000
- Assistant pest and disease control officers	2	250	500	2,000
Sub-total A	148		41,680	27
Gratuities, N.S.S.F., 14% of A			5,835	
Total			47,515	

Annual costs, exclusive of housing, transport, etc.: £ 11.88 per ha.

* Based on 40 wheel-tractors in one shift, and 5 other machines (draglines, etc.) in 3 shifts.

Table G.2.3 - Numbers and salary costs of subordinate staff

Department	No of staff	Average salary per annum (£)	Total annual salary costs (£)	No of hectares per man
General management, Administrative and Accounting Departments				
- Headman	1			
- Watchmen, messengers, labourers	15			
		140	2,240	
Agricultural Department				
- Headmen	2			
- Head waterguards	3			1,333
- Waterguards	20			200
- Watchmen	6			
- Sprayers for pest control	20			
		140	7,140	
Technical Department				
- Headmen	2			
- Greasers	10			
- Artisans mates	12			
- Attendants large equipment	4			
		140	3,920	
Research Department				
- Pests scouts	5			800
		140	700	
Sub-total	100		14,000	40
Gratuity, N.S.S.F., 10% of A			1,400	
Grand total			15,400	

All subordinate staff has been taken to earn an average annual salary of £ 140; of course, this will vary widely between different functions.

Annual costs, exclusive of housing and transport, etc.: £ 3.85 per ha.

Table G.2.4 - Cost of casual labour and contracts expressed in manyears

Department	No of man-years	Average salary per annum (£)	Total annual salary costs (£)	No of hectares per man
General management, Administrative and Accounting Departments				
about 20 manyears; average £ 70 per manyear	20		1,400	
Agricultural Department				
about 100 manyears; average £ 70 per manyear	100		7,000	
Technical Department				
about 25 manyears; average £ 70 per manyear	25		1,750	
Research Department				
about 5 manyears; average £ 70 per manyear	5		350	
Total	150		10,500	27
Casual labour and contracts: daily wages Sh. 4/ - Sh. 4/50, inclusive of 5% N.S.S.F., no gratuity, 309 working days per annum, average £ 70 per manyear				

Annual costs, exclusive of housing and transport, etc.: £ 2.63 per ha.

Table G.4.1 - Training and employment schedule - senior staff

Reference year		- 1		0		1		2		3		4		5	
Cropped area in ha		I	II	I	II	I	II	I	II	I	II	I	II	I	II
						700		1,800		2,700		4,000		4,000	
General management, Administrative and Accounting Departments															
- Manager	T	1	1	-	-	-	-	-	-	-	-	-	-	-	-
	E	-	-	1	1	1	1	1	1	1	1	1	1	1	1
- Accountant	T	-	-	-	-	-	1	-	-	-	-	-	-	-	-
	E	-	-	-	-	-	-	1	1	1	1	1	1	1	1
- Assistant accountant	T	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	E	-	-	-	1	1	1	1	1	1	1	1	1	1	1
Agricultural Department															
- Senior irrigation officer	T	1	1	1	1	1	-	-	-	-	-	-	-	-	-
	E	-	-	-	1	1	2	2	2	2	2	2	2	2	2
- Irrigation officer	T	-	1	1	2	2	1	2	2	1	-	-	-	-	-
	E	-	-	-	-	1	2	2	3	4	5	5	5	5	5
Technical Department															
- Senior officer for workshop	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	E	-	-	1	1	1	1	1	1	1	1	1	1	1	1
- Workshop foremen	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	E	-	-	1	1	1	1	2	2	2	2	2	2	2	2
Research Department															
- Research officer	T	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	E	-	-	-	1	1	1	1	1	1	1	1	1	1	1

T = Traineee
E = Employee

Table G.4.2 - Training and employment schedule - junior staff

Reference year		- 1		0		1		2		3		4		5	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II
Cropped area in ha						700		1,800		2,900		4,000			
General management, Administrative and Accounting Departments															
- Clerks, typists	E	–	–	2	4	6	8	10	12	14	14	14	14	14	14
- Senior storeman	E	–	–	–	–	–	–	–	1	1	1	1	1	1	1
- Assistant storeman	E	–	–	1	1	1	1	1	1	1	1	2	2	2	2
Agricultural Department															
- Head field assistant	T	–	1	1	1	1	1	2	2	1	–	–	–	–	–
	E	–	–	–	1	1	2	2	3	4	5	5	5	5	5
- Field assistant	T	–	–	4	8	8	10	12	6	2	–	–	–	–	–
	E	–	–	–	–	4	8	12	18	24	26	26	26	26	26
Technical Department															
- Building foreman	E	–	1	1	1	1	1	1	1	1	1	1	1	1	1
- Junior building foremen	E	–	–	1	1	2	2	2	2	2	2	2	2	2	2
- Tractor supervisor	E	–	1	1	2	2	3	3	3	4	4	4	4	4	4
- Charge hands	E	–	–	1	2	2	3	3	3	4	4	4	4	4	4
- Mechanics, welders	E	–	–	3	5	5	5	8	8	12	12	14	15	15	15
- Artisans	E	–	–	3	6	9	12	12	12	15	15	15	15	15	15
- Drivers, plant operators	E	–	2	5	10	15	25	30	40	40	50	53	53	53	53
Research Department															
- Head field assistant	T	–	–	1	1	–	–	–	–	–	–	–	–	–	–
	E	–	–	–	–	1	1	1	1	1	1	1	1	1	1
- Field assistant	T	–	–	–	1	1	–	–	–	–	–	–	–	–	–
	E	–	–	–	–	–	1	1	1	1	1	1	1	1	1
- Water/meteo recorder		–	1	1	1	1	1	1	1	1	1	1	1	1	1
- Pest and disease control officer	T	1	1	1	–	–	–	–	–	–	–	–	–	–	–
	E	–	–	–	1	1	1	1	1	1	1	1	1	1	1
- Assistant pest and disease control officers	T	–	–	1	1	1	1	–	–	–	–	–	–	–	–
	E	–	–	–	–	1	1	2	2	2	2	2	2	2	2

T = Trainee
E = Employee

Table G.4.3 - Training and employment schedule - subordinate staff

Reference year		- 1		0		1		2		3		4		5	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II
Cropped area in ha						700		1,800		2,900		4,000		4,000	
General management, Administrative and Accounting Departments															
- Headman	E	-	-	1	1	1	1	1	1	1	1	1	1	1	1
- Watchmen, messengers, labourers	E	-	-	2	3	6	9	12	13	14	15	15	15	15	15
Agricultural Department															
- Headmen	E	-	-	-	1	1	1	2	2	2	2	2	2	2	2
- Head waterguards	E	-	-	-	-	1	1	2	2	3	3	3	3	3	3
- Waterguards	E	-	-	-	-	4	4	10	10	15	15	20	20	20	20
- Watchmen	E	-	-	-	2	6	6	6	6	6	6	6	6	6	6
- Sprayers	E	-	-	-	-	5	5	10	10	15	15	20	20	20	20
Technical Department															
- Headmen	E	-	-	1	1	1	1	2	2	2	2	2	2	2	2
- Greasers	E	-	-	-	2	3	4	5	6	7	8	9	10	10	10
- Artisans' mates	E	-	-	-	2	4	6	8	10	12	12	12	12	12	12
- Attendants large equipment	E	-	-	-	2	2	2	2	3	3	4	4	4	4	4
Research Department															
- Pest scouts	E	-	-	-	-	2	2	3	3	4	4	5	5	5	5

E = Employee

Table G.4.4 - Employment schedule - Casual labour and contracts (expressed in manyears)

Reference year	-1 I	-1 II	0 I	0 II	1 I	1 II	2 I	2 II	3 I	3 II	4 I	4 II	5 I	5 II
Cropped area in ha					700		1,800		2,900		4,000			
General management, Administrative and Accounting Departments														
Number of manyears			1	3	4	6	10	12	16	18	20	20	20	20
Agricultural Department														
Number of manyears				10	20	30	40	50	70	80	90	100	100	100
Technical Department														
Number of manyears			2	5	7	9	12	15	18	20	22	25	25	25
Research Department														
Number of manyears				1	2	3	4	4	5	5	5	5	5	5

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National Irrigation Board	1972	Budget estimates for 1972/1973 for irrigation schemes of N.I.B., Nairobi.
Veen, J.J.	1969	De Mwea Irrigation Settlement, Landbouwkundig Tijdschrift, 81.1.

FIG. G.1.1 ORGANIGRAM FOR A COTTON IRRIGATION SCHEME

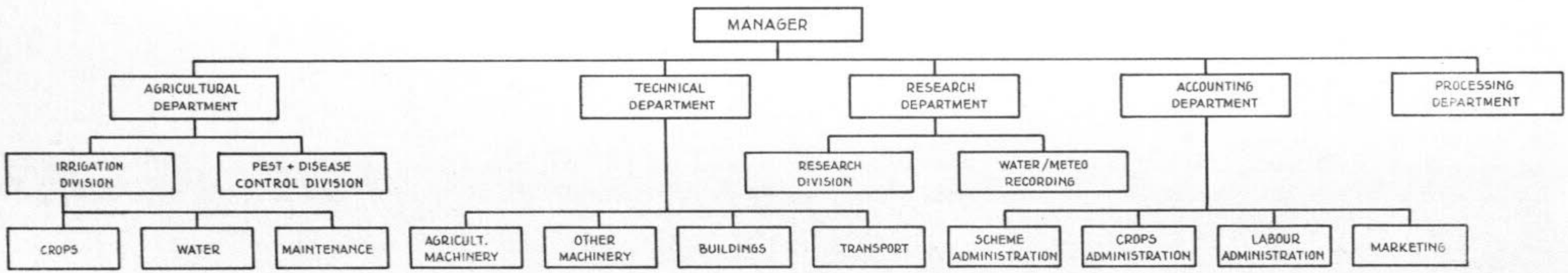


FIG. G.1.2 ORGANIGRAM FOR AN AGRICULTURAL DEPARTMENT

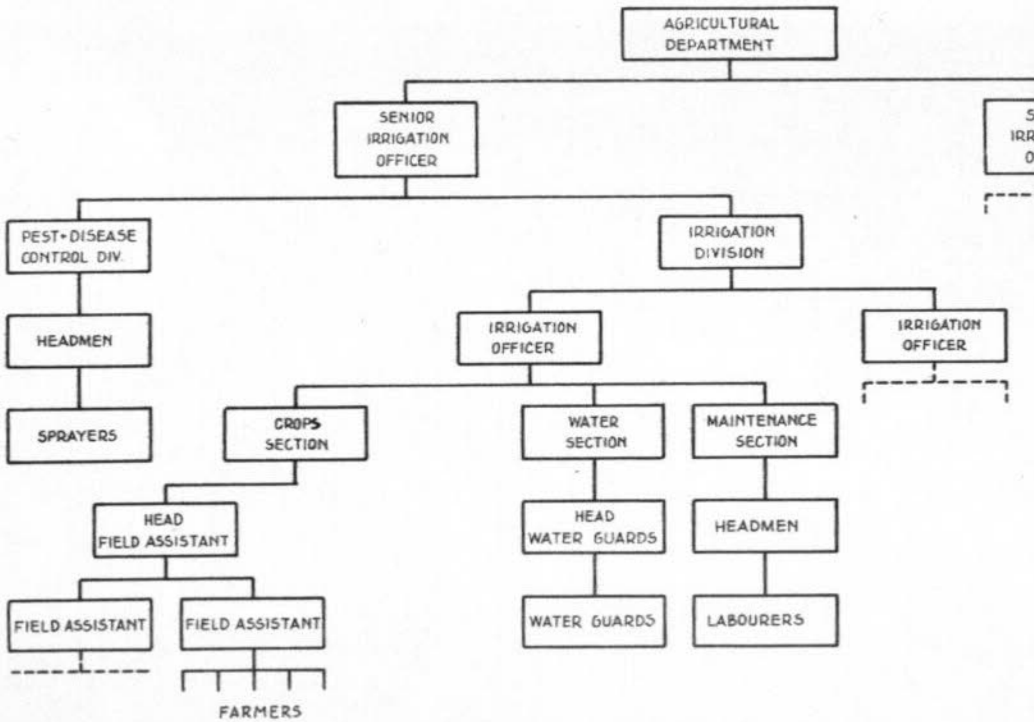
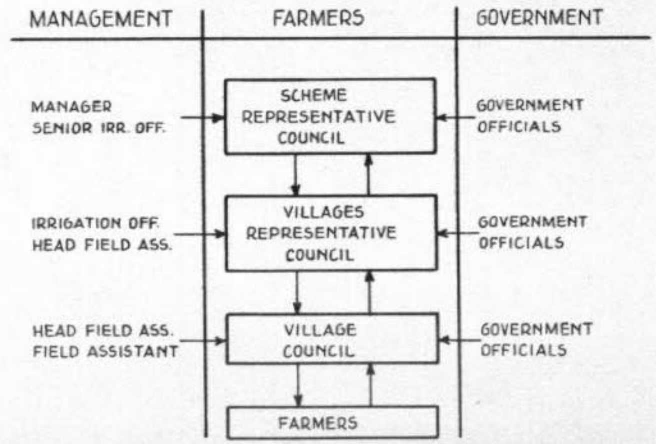


FIG. G.1.3 TENTATIVE ORGANIGRAM FOR FARMERS' REPRESENTATIVE COUNCILS



ANNEX H

BUILDINGS AND INFRASTRUCTURE

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 LAYOUT

On the scheme, a central compound and nine villages have been planned. For size and location of the villages we refer to the criteria mentioned in Annex K: Social aspects of the Bura irrigation scheme. All the villages have been planned on soils unsuitable for cropping (class IV).

The site for the stores, cotton ginnery, workshop etc., together constituting the technical centre, should meet the following requirements, which also apply to the administrative centre and, to a lesser extent, to the residential area:

- it should be situated as closely as possible to the centre of the production area to minimize traffic on the scheme, thus ensuring the utmost economy;
- it should be easily accessible from outside the project area;
- it should occupy as less valuable cultivable land as possible; preferably, land unsuitable for cropping should be used;
- future extension must be possible, preferably without reducing the cultivated area.

Based on the foregoing considerations, the site as indicated on map no 3 has been selected. The buildings have all been included in one compound. The soil map shows that a fairly large strip of land in the centre of the scheme is unsuitable for cropping. The central compound has not been planned in the middle of this area, but more to the west to minimize internal and external traffic.

The site suggested for the central compound lies along the existing Garissa-Hola road. Part of this road will serve as North-South connection within the scheme.

The road from Garissa to Hola will be deflected outside the scheme following the main supply canal. For the accessibility of the scheme from this road, three bridges have been planned across the main supply canal, the one in the North connecting a direct road through the scheme to Bura. Furthermore, some culverts have been projected in the eastern part of the scheme, providing a connection North-South in that area. Apart from the bridge on the main road no further bridges have been planned across the L. Hiraman, because the irrigable area north of the stream is relatively small and the cost of bridging it is high. Besides its bed can be easily crossed during the greater part of the year.

We have sketched a layout for a village in Fig. H. 1. It should be elaborated into a definitive design later on, as indicated in Annex K.

In Fig. H. 2, a structural plan for the central compound has been given. The layout shown offers a maximum of opportunities to extend the housing and technical facilities: to the East and the South housing can be extended, whilst in between the main irrigation canal and the Hola-Garissa road additional areas for industrial development are available.

The industrial centre consists of a technical centre for repairs, fuel, electricity power etc.; furthermore a cotton ginnery has been planned and 1,000-sq.m. covered storage space for fertilizers and pesticides. The industrial centre has been situated such that heavy traffic coming from the villages and from outside the scheme need not enter the compound proper.

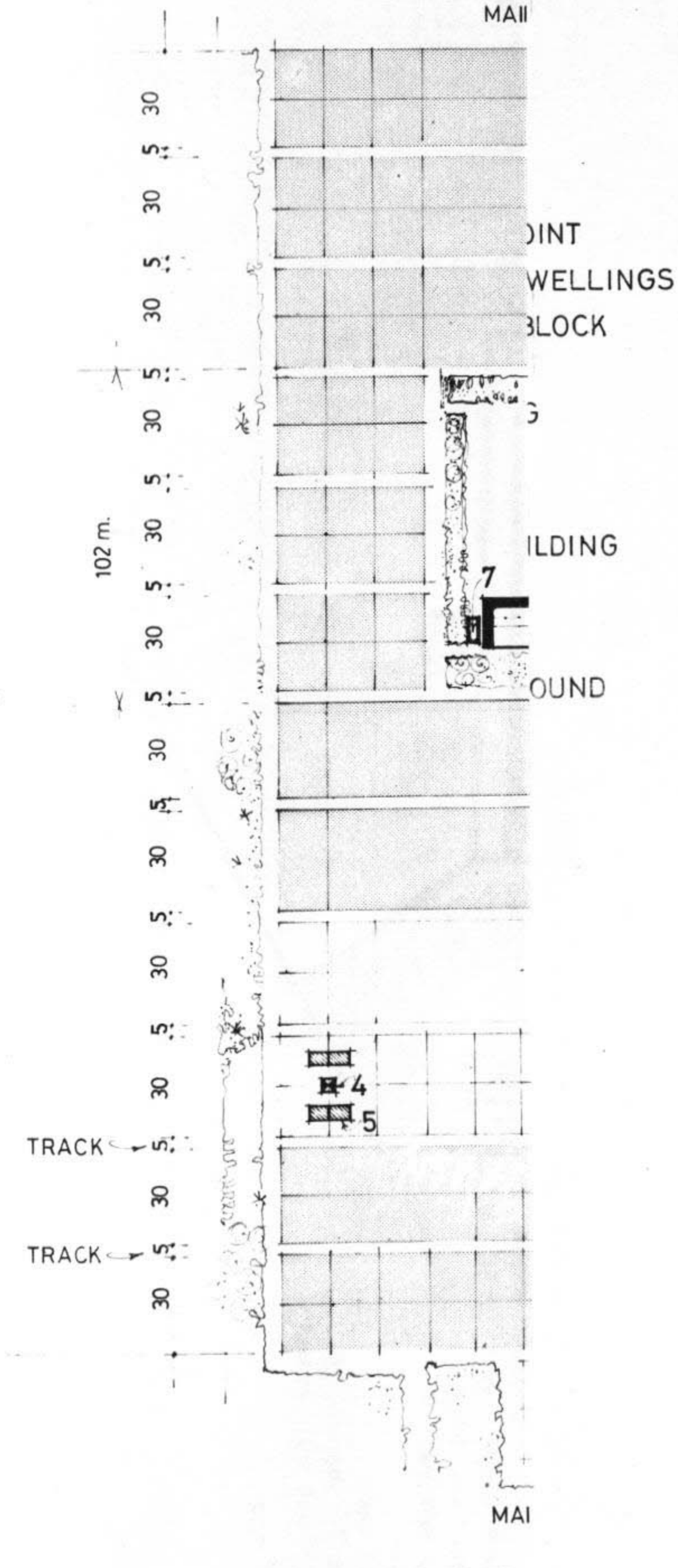
Two living areas have been planned: in the central compound, an area of 7 ha for about 100 labourers' houses, and 18 ha for about 280 staff houses (259 should be built initially). In between these areas, grounds have been reserved for schools, sports' facilities, religious activities and a hospital. Together with the industrial centre, these areas are all situated around a central area where the administrative centre, the civil centre and a shopping centre with marketing facilities have been planned. The civil centre includes space for a police post, post and telephone office, a governmental administrative office, fire protection post, cinema, social hall, shops and stores etc. This central area will be bounded by a ring road; adequate space should be provided to allow future growth of the area. Inclusive of roads, 65 ha is considered to be a reasonable size for the central compound.

To the east of the central compound, an air strip has been planned which is to serve external communication and aerial spraying.

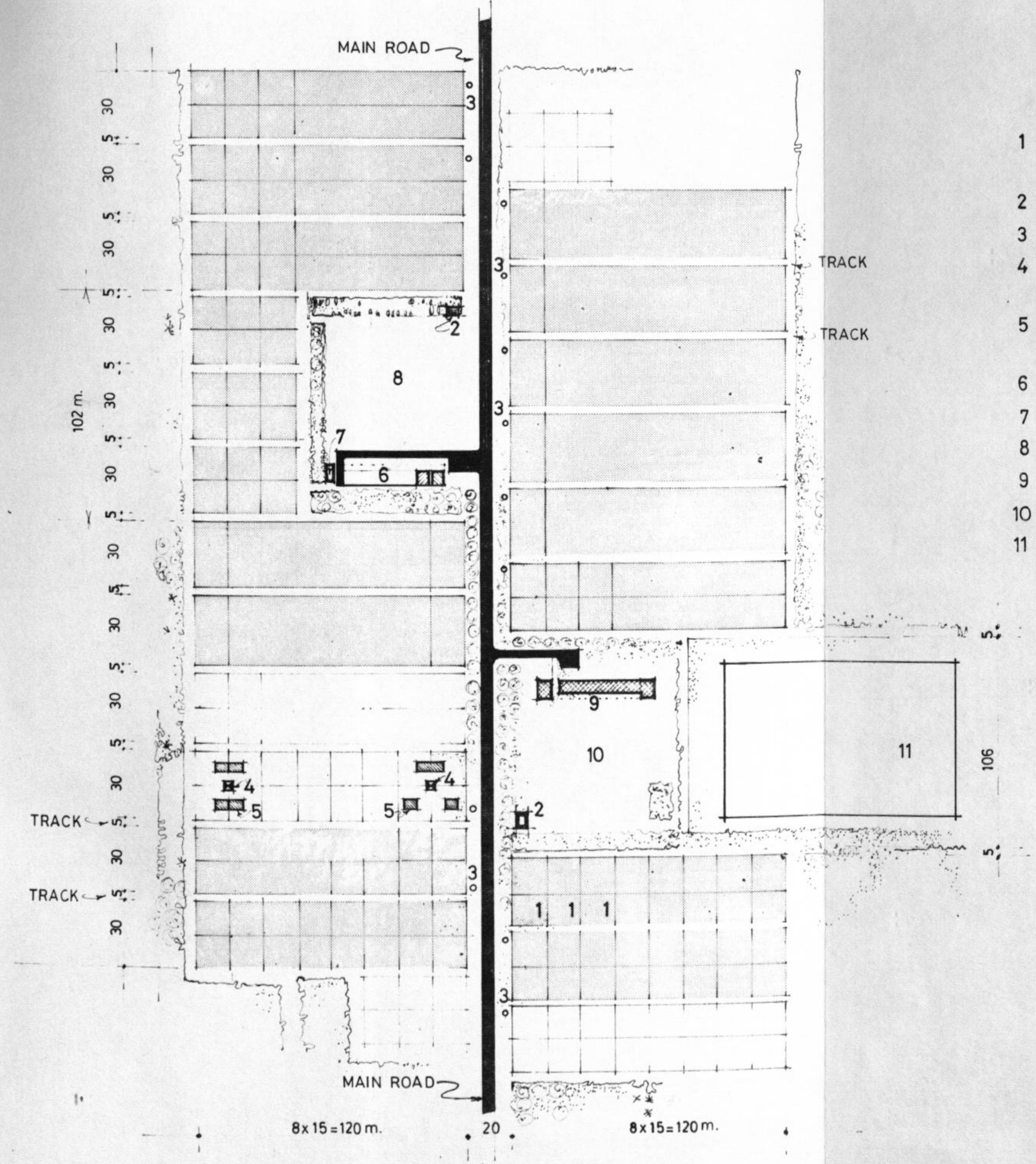
2 HOUSING

In Figure H.3, a sketch is shown of a tenant's house with a floor space of 30 m2. It is a tentative sketch, with only some details and specifications for our cost estimates. If these houses will not have a concrete but a mud floor, the floor area could be 38 m2 without increasing the total cost. For the other types of houses for the different categories of staff, we refer to drawings of the NIB, used for house-building on their schemes.

All staff houses are proposed to have electricity and their own waterpoint. Due to the poor foundation properties of the soil (swelling and shrinking), all types of houses and buildings must be provided with a reinforced concrete strip foundation. For sewerage purification, a septic tank with a French drain has been suggested. The types and numbers of houses and the relevant cost estimates have been given in Table H.1. The costs have been stated both exclusive and inclusive of contingencies (15%), overhead and profit (25%), cost of transport of building materials to the scheme (abt 12%) and the costs of design and supervision on site of the more expensive types of houses and buildings (7% on average). We have assumed that the houses for staff and labourers will be built under the supervision of the N.I.B. or another government agency, and not by contractors.



OUT OF A TENANT'S VILLAGE
SCALE 1:2000



1 TENANTS PLOT
SIZE 15 x 15 = 225 M^2

2 COMMUNAL WATERPOINT

3 WATERTAP FOR 16 DWELLINGS

4 CENTRAL LATRINE BLOCK FOR 4 HOUSES

5 TENANTS DWELLING

6 SOCIAL HALL

7 CENTRAL TOILET BUILDING

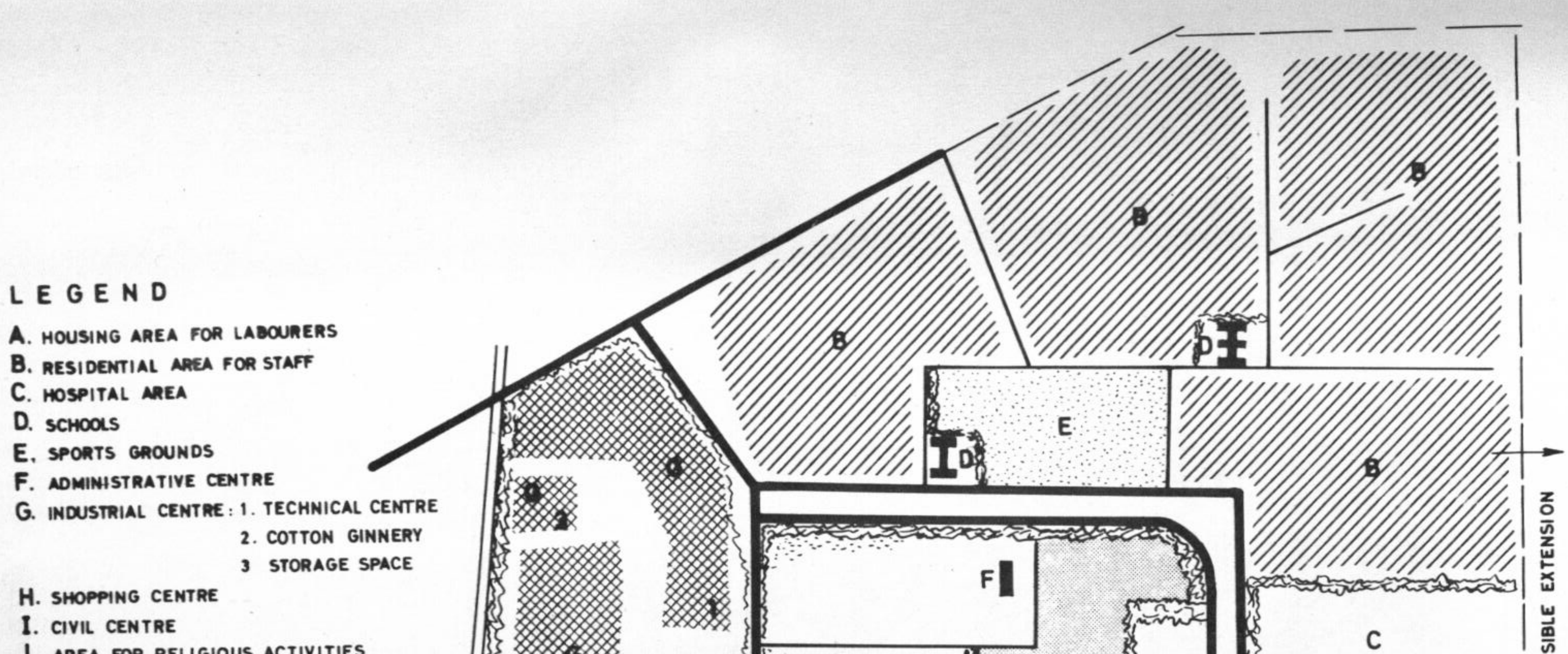
8 MARKET

9 SCHOOL

10 CHILDRENS PLAYGROUND

11 SPORTS GROUNDS

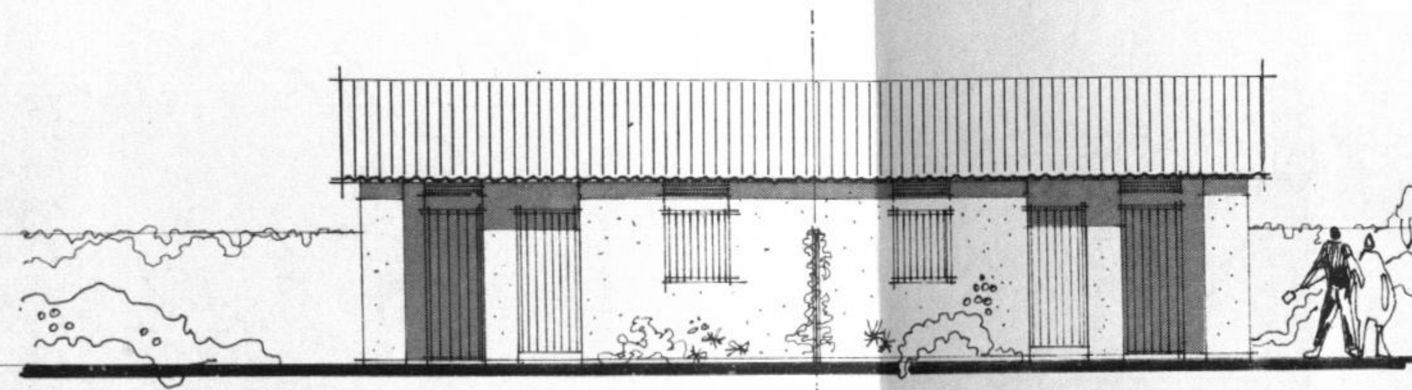
FIG. H.1 LAYOUT OF A TENANT'S VILLAGE
SCALE 1:2000



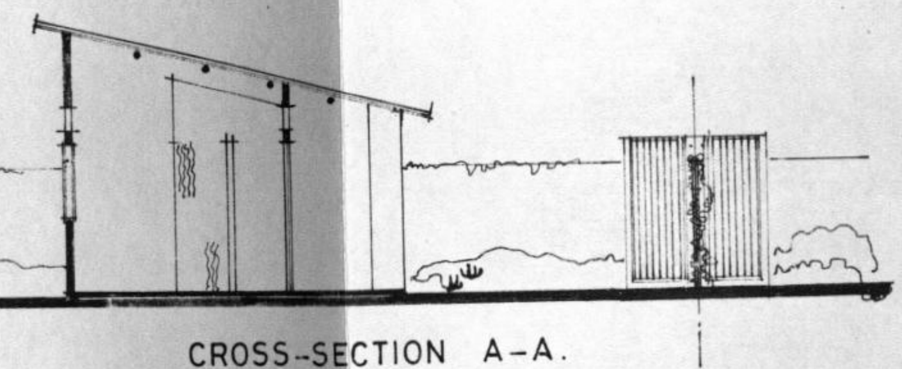
SKETCH LAYOUT OF CENTRAL COMPOUND BURA

SCALE 1:5000

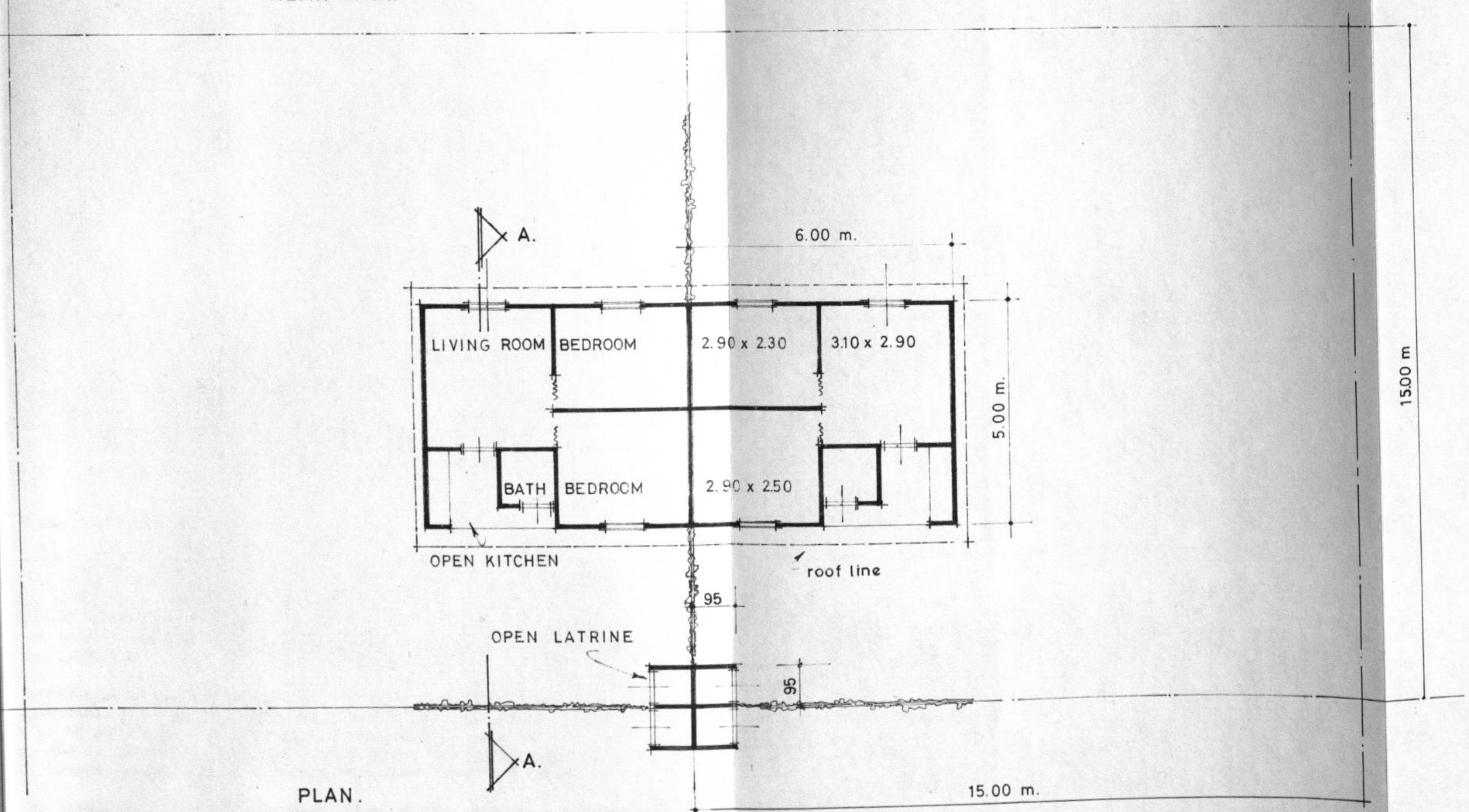
FIG. H.2



REAR VIEW



CROSS-SECTION A-A.



PLAN.

CONSTRUCTION METHOD

FOUNDATION : REINFORCED CONCRETE STRIP

FLOORS : CONCRETE

WALLS : CEMENT SAND BLOCKS 10cm THICK, WHITE WASHED

ROOF : WOODEN PURLINS COVERED WITH CORRUGATED ALUMINIUM

DOORS : WOODEN FRAMES AND LOCALLY MADE WINDOWS AND FLUSH DOORS

SEWER SYSTEM: LATRINES

FIG. H.3 TENANT'S HOUSE, BURA
SCALE 1:100

3 TECHNICAL CENTRE

This centre (see Fig. H.4) will consist of a workshop for repairs and maintenance of a tractor fleet of 40 and other machinery. A cost estimate has been presented in Table H.2 on page 186.

Separate space has been projected for:

- a store room for tyres;
- a store room for spares;
- welding works;
- steel structures;
- a carpenter workshop;
- office rooms and toilets;
- a pumping station for fuelling;
- a parking shed for long-term parking.

To provide power and electricity for the workshop and for the houses of staff, a diesel generator set must be installed. (See also Section 5).

We recommend that parking sheds should also be constructed in the north and in the south. The relevant costs have been listed in Table H.3 on page 187.

4 ADMINISTRATIVE CENTRE

Fig. H.5 shows a preliminary design of an administrative centre. The centre includes office space, which because of its nuclear function should have a prominent location in the total plan. The inventory should include furniture, filing cabinets, typewriters, a calculating machine and radio-telephone equipment. A special room should be provided for a research laboratory.

For cost estimates, see Table H.2 on page 186.

5 ELECTRICITY AND WATER

A diesel generator set is to be installed in the technical centre to provide electricity to the staff houses and to the workshop. Some extra power will have to be installed for ancillary buildings. Assuming that subordinate and junior staff houses will need 400 watt and senior staff houses 1,500 watt, and 20,000 watt will be required for the workshop etc., a 200-BHP diesel generator set has to be installed.

Potable water must be supplied to the villages and to the central compound. To limit the cost involved for the time being, communal water points will be installed in the housing area for labourers and in the villages at the beginning of the branch roads. The staff houses in the central compound will have their own water points.

No groundwater samples have been taken so far, but we recommend that this should be done as yet; using groundwater could be attractive if the water proves to be of good quality and need not be purified.

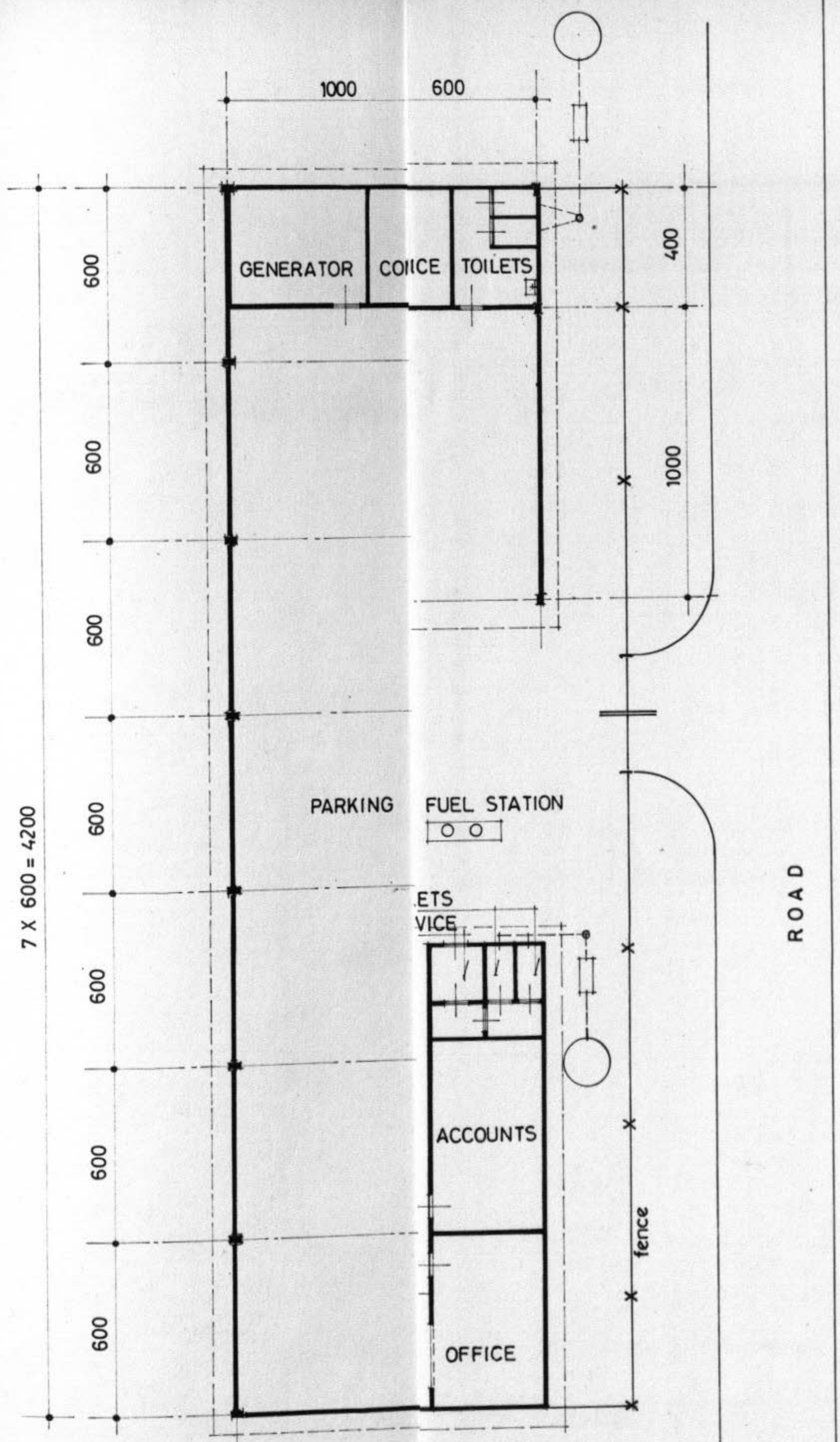
For the time being, the Tana river is considered to be the only source for drinking water. The water is of acceptable quality (see Annex B). Each village will have its own watertower. A combined sand filter and chlorification unit must be installed for purification of the water.

For budgetary purposes, the construction cost of the water supply system can be assumed to amount to K.Shs. 80 per caput, based on the experience gained on other water supply schemes in Kenya.

6 ROADS

The Garissa-Hola road, deflected over 17.5 km, is of paramount importance to communications outside and on the scheme. It must be an all-weather road, 9 m wide at least with a 6-m surfaced top layer. For surfacing, a 10-cm coral limestone layer is advised, no murram being available in the vicinity. The same dimensions and surfacing can be used for the connection between this road and the central compound, and for the main roads in the compound itself. The road around the centre of this compound has been planned to be partly double-laned.

A somewhat narrower road (6 m wide with 4-m surfacing) can be constructed to Bura; these dimensions can also be applied to the roads in the residential area for staff members and to the main roads in the housing area for labourers. It may be considered to surface the roads between the houseblocks in the villages and in the labourers' area of the central compound. In our cost estimates, only grading has been accounted for. All the roads must be cambered with drain ditches on both sides.



CHNICAL CENTRE BURA
SCALE 1: 200

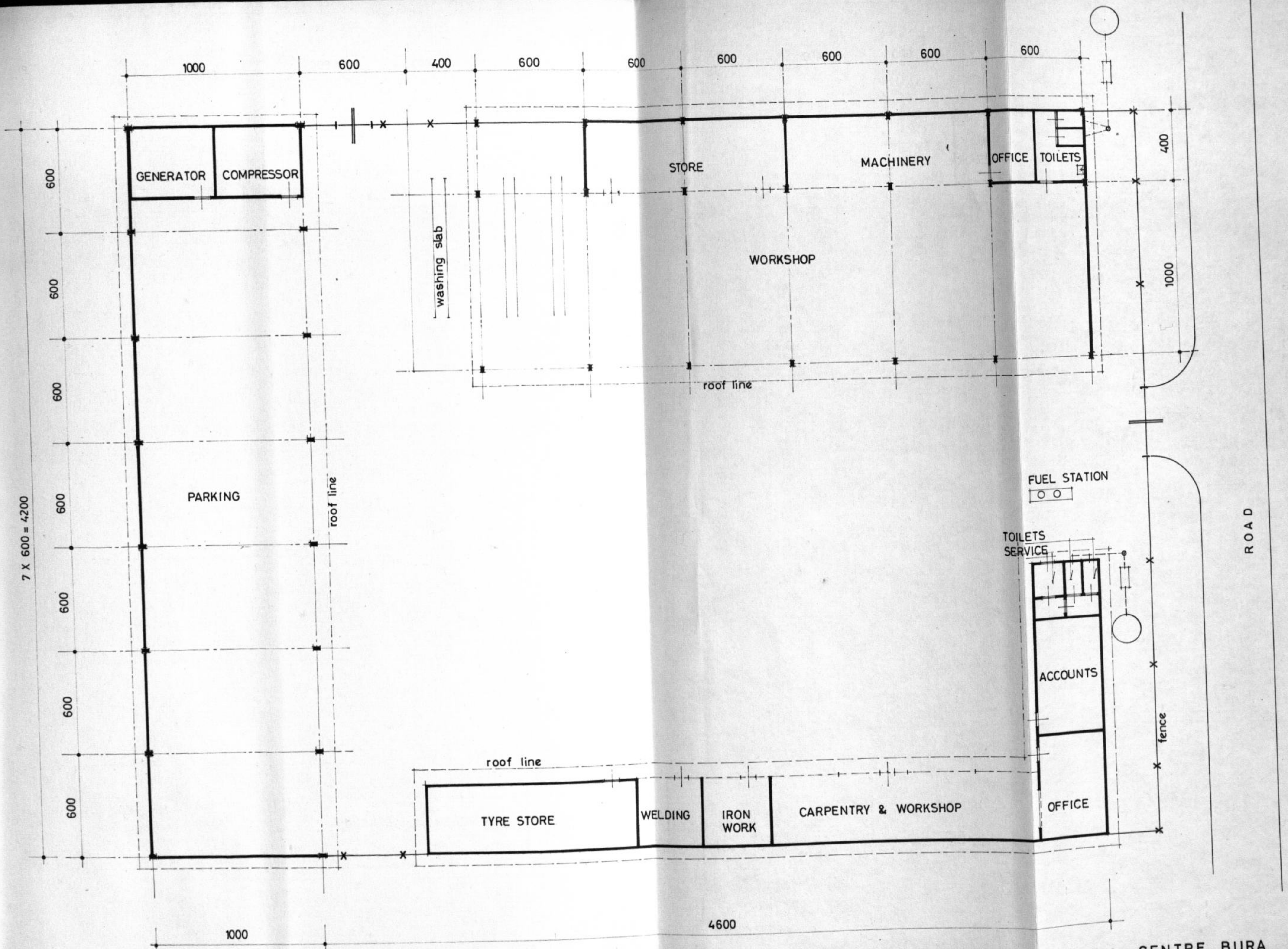
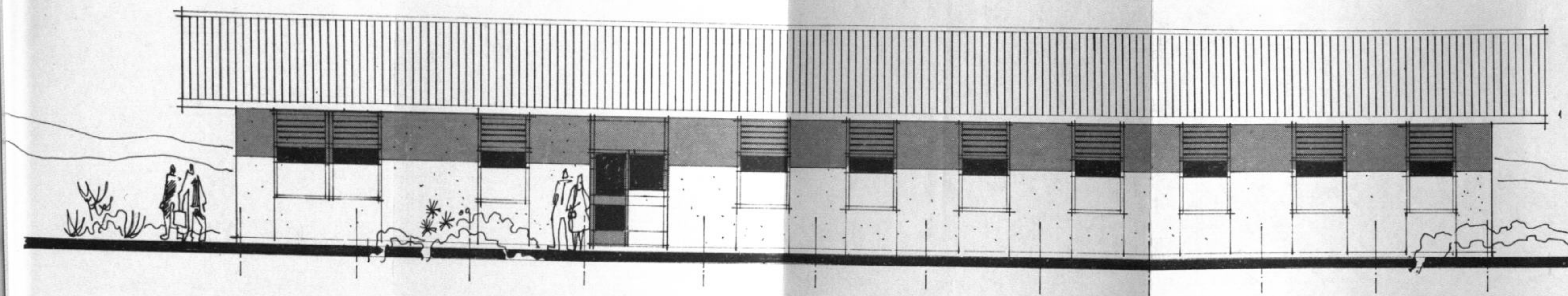
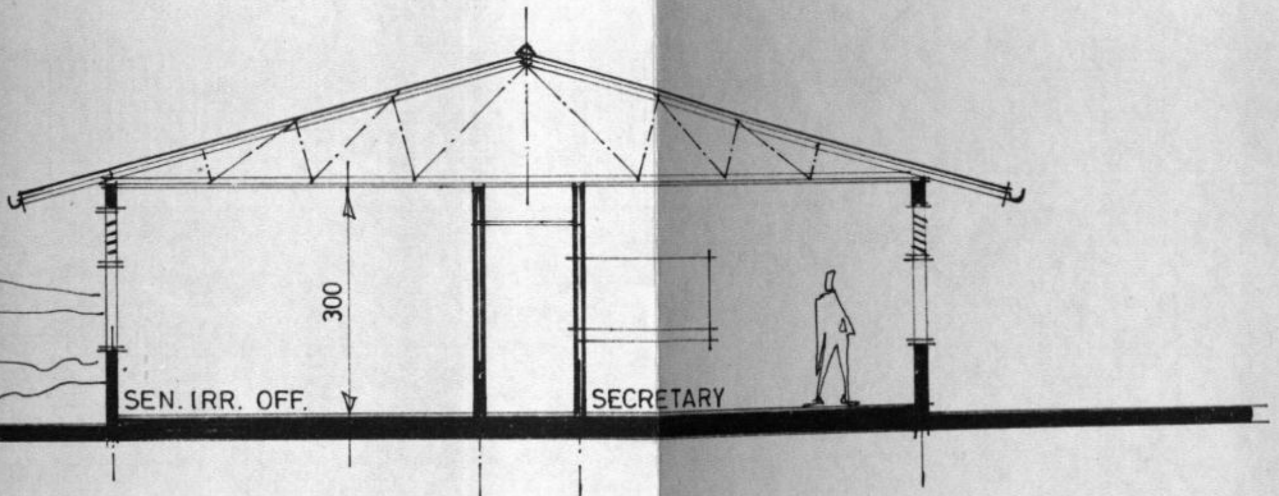


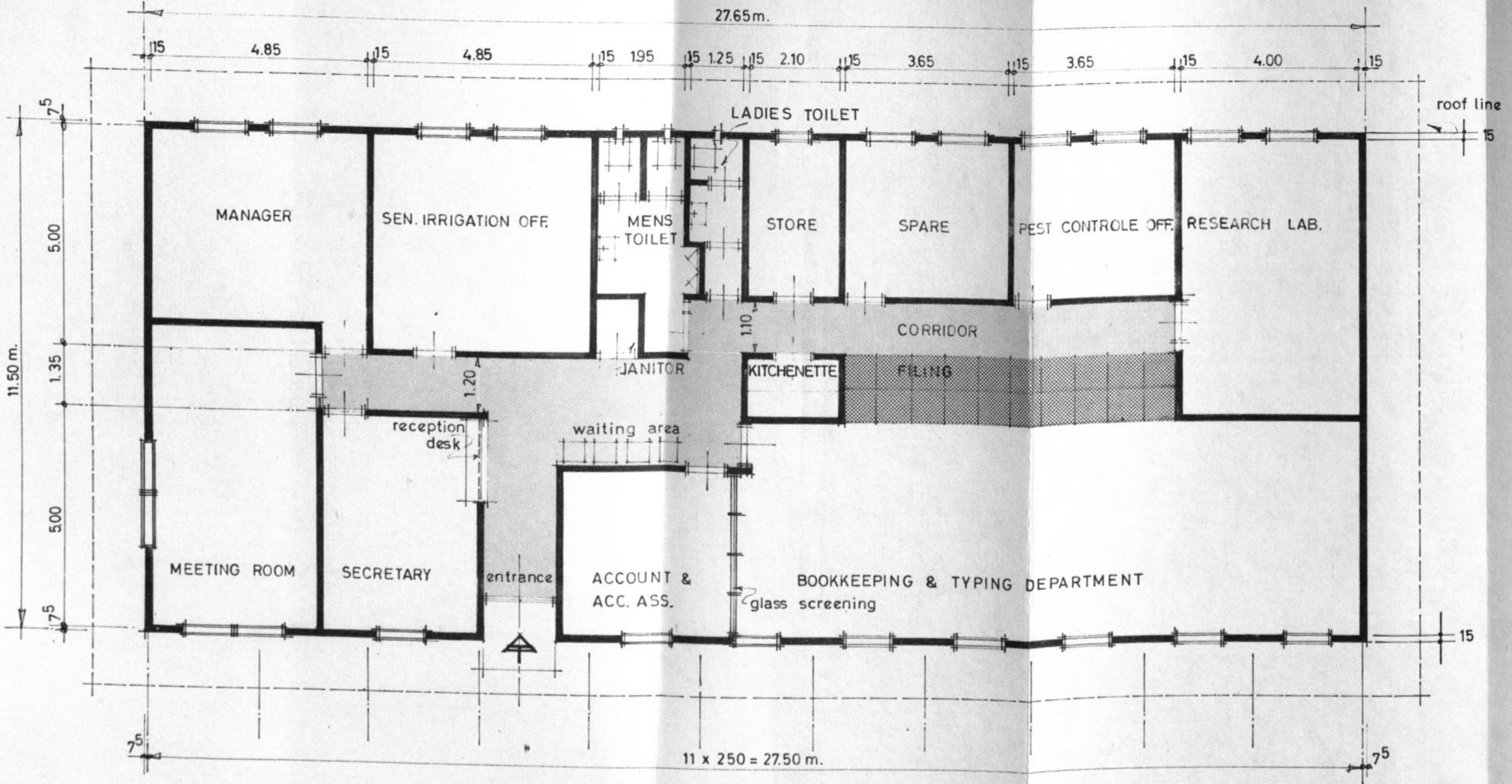
FIG. H.4 TECHNICAL CENTRE BURA
SCALE 1: 200



FRONT VIEW



TYPICAL CROSS-SECTION



PLAN

CONSTRUCTION METHOD

FOUNDATION : REINFORCED CONCRETE STRIP
FLOORS : CONCRETE, WELL PLASTERED
OUTER WALLS : 15 cm CEMENT-SAND BLOCKS, PLASTERED ON BOTH SIDES
INNER WALLS : 10 cm CEMENT-SAND BLOCKS, PLASTERED
ROOF : STEEL CORRUGATED SHEETS SUPPORTED BY STEEL TRUSSES
OUTER DOORS : IRON FRAME WITH GLASS
INNER DOORS : WOODEN, LOCALLY MADE
ALL WINDOWS SHOULD BE SCREENED
THERE IS ELECTRICITY PROVISION

FIG. H.5 ADMINISTRATIVE CENTRE, BURA
SCALE 1:100

Table H.1 - Cost estimates (in K.Shs.) of housing (excluding transport, contingencies, design, etc.)

	Number	Unit price	Total
Cost to be borne by occupant:			
tenant's house	3,330	4,700	
Cost chargeable to the project:			
house for casual labourers	100	4,700	470,000
subordinate's house	100	5,800	580,000
junior staff house	145	9,000	1,305,000
senior staff house	13	48,000	624,000
gen. manager's house	1	76,000	76,000
guesthouse	1	76,000	76,000
furniture for 15 houses			41,500
			3.172,500

Note:

When adding 12% transport cost, 15% contingencies, 25% overhead and profit, 7% for cost of design and supervision on site, the following unit prices are arrived at:

general manager's house	K.Shs	134,000
house-senior staff	"	85,000
house-junior staff	"	15,000
house-subordinate staff	"	9,700

These unit prices are in conformity with the ranges for the different categories of staff as discussed with the N.I.B. in 1972.

Table H.2 - Cost estimates (in K.Shs.) of administrative/technical centre (excluding contingencies, design, etc.)

	Floor space (sq.metres)	Unit price	Total
<u>Administrative centre</u>	316	600	189,600
furniture and equipment administrative centre			50,000
<u>Technical centre</u>			
workshop, offices and stores	710	300	213,000
parking shed	420	150	63,000
fence, septic tank, toilets			20,000
pavement (concrete)	1,200	30	36,000
ancillary equipment, compressor, compr. air circuit, overhead crane wiring, lathe tools, etc.			210,000
diesel generator			86,000
4 tanks (2 x 10,000 l. 2 x 50,000 l.), 1 on foundation			50,900
			918,500

Table H.3 - Cost estimates (in K.Shs.) of central compound, 9 tenants' villages and miscellaneous constructions

	Total (K.Sh.)
Central compound	
Clearing and landscaping	10,000
Roads + surfacing market place	300,600
Houses	3,172,500
Social hall	100,000
Administrative and technical centre	918,500
Water supply	390,000
Electric wiring	79,600
1,000 sq.m. storage space	150,000
Nine tenants' villages	
Clearing	10,000
Roads + surfacing market places	287,000
Water supply	2,105,000
Social halls (9x) + toilet buildings	450,000
Two enclosures with parking lots + fencing	146,000
Airstrip	70,000
	8,189,200
Transport costs of materials and personnel	896,660
Subtotal	9,085,860
15% contingencies	1,362,880
	10,448,740
25% overhead and profit	2,612,190
	13,060,930
7% cost of design and site supervision	914,270
	13,975,200

CONTENTS

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1 GENERAL

Essential elements in evaluating the economic feasibility of an irrigation scheme are the marketing opportunities for the products to be grown on the scheme and the prices that these products are able to fetch on the domestic or on foreign markets.

Information from various sources has been used in estimating the future domestic production and consumption, future imports and exports, future marketing cost and the corresponding prices.

This Annex deals with those crops that are suitable for cultivation on the Bura scheme based on agronomic and economic considerations. In calculating the economic prices, the true value of the crops to the economy has been estimated. These prices have been derived from import prices, export prices and from prices on the domestic market. For those products that are clearly linked to the world market, the domestic prices have been based on world market prices. The economic prices do not include subsidies, import and export levies and county council cess. The financial prices have been based on the prices actually paid to the producers.

2 COTTON

The domestic cotton production does not meet the demand for cotton products at all. Semi-final and final cotton products have to be imported. Raw cotton is being processed in Kenya to a small extent only. Hence, there are good opportunities for expansion of the raw cotton production and of the cotton processing industry. At present, consumers' demand does not tally with production. The quality of the raw cotton produced is excellent, but the domestic demand for final cotton products can be met with by cotton of an inferior quality. Consequently, the greater part of the Grade A cotton produced is being exported, only the Grade B cotton is used domestically (see Table I.1).

Table I.1 - Destination of cotton produced (in bales of 185 kg)

Year	Consumed locally		Exported		Total
	Grade A	Grade B	Grade A	Grade B	
1969	1,522	3,229	18,458	0	23,209
1970	3,590	4,288	18,834	1,040	27,752

The textile mills are increasingly importing Grade B cotton.

In view of the relatively low price fetched by Grade B cotton it is economically not justified to produce this type of cotton on an expensive irrigation scheme. On the long term the domestic demand for Grade A cotton is likely to rise because of the growth of the actual income per caput, the expected expansion of the cotton processing industry and its changing requirements as regards quality.

If it is decided to implement the Bura and Masinga irrigation schemes with cotton as the main crop, this will have a great impact on the current cotton production in Kenya, which amounts to some 30,000 bales annually. If the schemes are implemented rapidly, they will produce 20,000 bales of raw cotton a year by 1980 and 30,000 bales by the year 2000. The Cotton Lint and Seed Marketing Board is of the opinion that some 60,000 bales of raw cotton can be readily marketed at world market prices at present.

Kenya imports cottonseed and cotton oil; the amounts imported in 1970 were 8,300 and 8,400 tons respectively. In 1970, 3,000 tons of first-quality cotton cake were exported, while 2,000 tons second-quality were imported. The cottonseed to be produced on the schemes, i.e. 8,000 tons in 1980 and 11,000 tons in the year 2000, are expected to be readily marketable at world market prices.

The prices paid to the Cotton Lint and Seed Marketing Board for raw cotton and cottonseed are based on world market prices. Table I.2 shows these prices in K.Sh. per ton of lint and cottonseed in the years 1963-1972.

Table I.2 - Prices of raw cotton and cottonseed; period 1963-1972

Year	Raw cotton*		Cottonseed	
	Grade A	Grade B	Grade A	Grade B
1963	4,315	3,124	405	217
	4,725	3,131	335	200
1965	4,520	3,223	388	237
	4,111	3,076	388	237
1967	4,182	2,893	451	284
	4,522	2,982	490	301
1969	4,943	3,087	487	325
	4,635	3,088	487	348
1971	4,997	3,115	571	399
1972	5,394	3,986	626	426

* f.o.b. Mombasa.

The long term f.o.b. Mombasa prices for Kenya cotton have been based on:

- the average price of the last ten years, eliminating the lowest and the highest price levels;
- the average price of the last five years, eliminating the lowest and the highest price levels;

- weighing the average price level of the last five years at 75% as against that of the last ten years at 25%;
- the assumption that at least 90% of the seed cotton produced is Grade A quality.

Thus, f.o.b. Mombasa prices of K.Sh. 4,610 per ton of lint and K.Sh. 490 per ton of cottonseed have been arrived at.

In its Agricultural Commodity Projections 1970-1980 (27), FAO have accounted for a fall in the cotton world market prices of 5-8%. So far, this drop has not materialized, but for safety's sake we have included a 5% price decrease in our calculations.

Based on the foregoing, the following economic and financial producer's prices per ton of seed cotton have been arrived at.

Table I.3 - Economic and financial producer's prices (in K.Sh.) per ton of seed cotton in the different reference years

Year	1972		1982		1992		2002	
Price f.o.b. Mombasa/ton of lint	4,610		4,380		4,380		4,380	
Port charges	90		85		80		80	
Board expenses	150		135		130		130	
Transport costs	Masinga	Bura	Masinga	Bura	Masinga	Bura	Masinga	Bura
Masinga-Thika	38		35		35		35	
Thika-Mombasa	80		80		80		80	
Bura-Mombasa		138		135		132		130
Economic producer's price/ ton of lint	4,252	4,232	4,045	4,025	4,055	4,038	4,055	4,040
Extraction rates lint/seed cotton	(32%/65%)		(35%/62%)		(35%/62%)		(35%/62%)	
Revenues cottonseed corresponding with 1 ton of lint	995		868		868		868	
	5,247	5,227	4,913	4,893	4,923	4,906	4,923	4,908
Ginning costs	1,200		1,080		1,050		1,020	
Price at ginnery of 100/32 ton and 100/32 ton seed cotton respectively	4,047	4,027	3,833	3,813	3,873	3,856	3,903	3,888
Economic producer's price/ ton of seed cotton	1,295	1,285	1,340	1,335	1,355	1,350	1,365	1,360
Financial producer's price	1,350		1,335		1,350		1,360	

3 MAIZE

Maize is the main food crop of the population of Kenya. Supplies to the Maize and Produce Board range from 200,000 to 350,000 tons annually. The total maize production is estimated at about 1.6 million tons a year.

Climatic conditions have a great impact on the maize production; drought periods can reduce the yields substantially. The consequences of such drops in production are so serious that even in years of low production self-sufficiency in maize is aimed at. To this end, more maize is produced than consumed in years when favourable climatic conditions prevail. The overproduction is partly stocked to reduce or to make up for shortages when the yield results are disappointing in the next year. If no shortages occur in the following year, the stocked maize must be either exported or used as cattle feed.

As a result of this strategy, the domestic prices are relatively high compared to the world market price. But the high prices are needed in order to attain a high production allowing to meet the domestic demand also in years with unfavourable climatic conditions. The strategy of self-sufficiency is paid for on the one hand by the cost of stocking, on the other by the losses on exports caused by high economic producer's costs and high marketing costs.

So far, it has proved impossible to attain self-sufficiency in years of low production. The stocks have not sufficed to fully replenish the shortages. From 1959/60 to 1970/71, in five years 323,000 tons of maize were imported and in eight years 768,000 tons exported.

It is expected that by 1982 self-sufficiency in maize including stocking can be attained and surplus amounts can be exported without financial losses, if the following measures are taken:

- further introduction of hybrid seed varieties;
- improvement of cultivation methods;
- construction of new storage facilities and bulk handling;
- reduction in marketing cost.

Higher yields and lower production costs will allow to adjust the producer's price of maize to the economic price based on exports in the course of time without affecting the farmer's income. Provided that production at economic prices is feasible, maize growing on the schemes would fit in well with the strategy followed by the Kenya Government with regard to this crop.

The current economic price is based on both the import and the export price at a ratio of actual amounts imported to actual amounts exported (323,000 tons to 768,000 tons respectively) in the period 1959/60-1970/71. If the strategy of self-sufficiency in years of lower production plus stocking proves successful, the economic price should be derived from the export price.

The import price has been based on the prices c.i.f. United Kingdom and c.i.f. Japan (see Table I.4).

Table I.4 - C.i.f. import prices of maize (in K.Sh./ton)

Year	World market	United Kingdom	Japan
1965	477	471	481
1966	476	470	483
1967	475	452	489
1968	420	400	427
1969	443	426	431
1970	490	489	483
Average	464	451	466

The c.i.f. United Kingdom prices for maize originating from the United States in 1971 and 1972 were K.Sh. 478 and K.Sh. 442 per ton respectively; maize originating from Argentina was imported at K.Sh. 502 per ton in 1971 and K.Sh. 495 per ton in 1972. It has been assumed that on the long term the prices c.i.f. United Kingdom and c.i.f. Japan will range from US $ 65 to US $ 70 or K.Sh. 460 to K.Sh. 500 per ton. Considering the conditions under which maize is often imported, bag handling and transport, the c.i.f. Mombasa price is higher; based on figures of recent imports (in 1971 import prices c.i.f. Mombasa of K.Sh. 618, K.Sh. 680 and K.Sh. 630 per ton were quoted), the c.i.f. Mombasa price is expected to range from K.Sh. 540 to K.Sh. 580 per ton in the period 1972-1980.

The weighed average price of maize exported in the years 1961/62 to 1968/69 was K.Sh. 370 per ton f.o.b. Mombasa. The f.o.b. Mombasa export prices are significantly lower than the average f.o.b. prices in other countries exporting to the world market.

In its report on the storage and handling of wheat and maize in Kenya (10), a Working Party established by the Ministry of Agriculture in 1969 states that by adopting bulk handling freight rates can be reduced by about K.Sh. 50 per ton. In fixing the export prices for 1982 and 2002 we have assumed that by that time bulk handling will have been realized.

Economic producer's prices of maize in K.Sh. per ton have been established based on import substitution (Table I.5) and on exports (Table I.6); Table I.7 shows the economic producer's prices derived from those arrived at in Tables I.5 and I.6.

Table I.5 - Economic producer's price of maize (in K.Sh./ton) based on import substitution

	Masinga	Bura
c.i.f. Mombasa	560	
port charges	65	
administration	10	
	635	
	635	635
transport Mombasa-Thika	48	
" Mombasa-Garissa		195
price at store	683	830
transport Masinga-Thika	33	
" Bura-Garissa		57
economic producer's price	650	773

Table I.6 - Economic producer's price of maize (in K.Sh./ton) based on exports

	1972		1982		2002	
f.o.b. Mombasa	370		400		420	
port charges	65		55		45	
	Masinga	Bura	Masinga	Bura	Masinga	Bura
operation and administration charges	20	10	16	8	16	8
transport Thika-Mombasa	48		48		48	
transport Masinga-Thika	33		31		31	
transport Bura-Mombasa		138		135		130
economic producer's price	204	157	250	202	280	237

Table I.7 - Economic producer's price of maize (in K.Sh./ton) derived from those in Tables I.5 and I.6

1972	Masinga	$\frac{323^*}{1091} \times 650 + \frac{768^*}{1091} \times 204 = 335$
	Bura	$\frac{323^*}{1091} \times 773 + \frac{768^*}{1091} \times 157 = 340$
1982	Masinga	250
	Bura	200
2002	Masinga	280
	Bura	235

* weighing factor based on imports and exports in the period 1959/60 to 1970/71.

The following financial producer's prices (in K.Sh./ton) have been based on the current financial maize price and the expected development of the economic price.

Year	Masinga	Bura
1972	340	340
1982	250	200
2002	280	235

If maize is grown on the scheme, the crop will be largely consumed by the farmers. In defining the farmer's income, the amounts of maize consumed on the scheme have been valued at a financial consumer's price which has been based on a price (including transport cost) which the scheme would have to pay to the Maize and Produce Board if large amounts of maize had to be purchased. Thus, the following financial consumer's prices (in K.Sh./ton) have been arrived at.:

Year	Masinga	Bura
1972	565	595
1982	425	455
2002	370	400.

4 GROUNDNUTS AND SOY-BEANS: OIL AND CAKES

Kenya imports edible oils and exports cakes; the relevant figures for the period 1965 to 1972 have been presented in Table I.8.

Table I.8 - Imports of seeds and oil and exports of cakes (in tons); period 1965-1972

Year	Imports		Exports
	seeds	oil	cakes
1965	332	16.529	2,360
1966	3,848	16,210	3,000
1967	3,219	12,974	3,910
1968	1,180	14,738	3,950
1969	3,705	21,879	4,080
1970	5,031	16,124	4,680
1971	7,500	22,000	-

If 50% of both the Bura and the Masinga scheme are planted to groundnuts, 1,300 tons of oil and 1,900 tons of cakes can be produced in 1980 and 2,500 tons of oil and 3,800 tons of cakes by the year 2002. Selling these quantities at world market prices will not pose any difficulty. The oil can be sold on the domestic market, cakes will be exported although it may well be that the available quantities can be absorbed domestically by that time.

The c.i.f. Mombasa price of groundnut oil has been derived from the world market prices prevailing in the period 1965 to 1972 excluding the highest and the lowest values of the series.

The 1965-1972 price series on the world market was considerably lower than the c.i.f. Mombasa prices, one of the reasons being that bulk transport has not yet been introduced in Kenya. To make up for the difference, an amount of K.Sh. 200 per ton has been added to the basic price. We assume that by 1982 this additional amount will have become K.Sh. 50 as a result of improved transport. The same calculation method has been used for groundnut cakes, but the price has been derived from export prices and no correction has been applied.

Table I.9 shows the economic and financial producer's prices for groundnuts in the years 1972 and 1982.

Table I.9 - Economic and financial producer's prices for groundnuts (in K.Sh./ton) in 1972 and 1982

	1972		1982	
C.i.f. world market price				
1 ton of groundnut oil	2,490		2,490	
Correction for transport cost	200		50	
C.i.f. Mombasa	2,690		2,540	
1½ tons of cake	910		910	
Value of 1 ton of oil + 1½ tons of cake (= 2½ tons of groundnuts)	3,600		3,450	
Port charges	225		200	
Processing cost	225		200	
Transport cost Bura		345		335
Transport cost Masinga	250		250	
	2,900	2,805	2,800	2,715
Economic producer's price 1 ton of groundnuts: Masinga	1,160		1,120	
Bura		1,120		1,085
Financial producer's price:				
Masinga	1,140		1,100	
Bura		1,100		1,065

The same method has been followed in calculating the economic and financial producer's prices for soy-beans (see Table I.10, next page).

Table I.10 - Economic and financial producer's prices for soy-beans (in K.Sh./ton) in 1972 and 1982

	1972		1982	
C.i.f. world market price				
1 ton of soy-bean oil	2,080		2,080	
Correction for transport cost	200		50	
C.i.f. Mombasa	2,280		2,130	
4.56 tons of cake	3,032		3,032	
Value of 1 ton of oil + 4.56 tons of cake (= 5.56 tons of soy-beans)	5,312		5,162	
Port charges	500		445	
Processing cost	500		445	
Transport Bura		690		675
Transport Masinga	500		500	
	3,812	3,622	3,772	3,597
Economic producer's price				
1 ton of soy-beans: Masinga	685		675	
Bura		650		645
Financial producer's price:				
Masinga	665		655	
Bura	630		625	

5 AGRICULTURAL PRODUCTS MARKETED BY THE MAIZE AND PRODUCE BOARD

A large number of agricultural products is being marketed by the Maize and Produce Board. The prices paid at store usually follow the market trend. Table I.11 shows the 'at store' prices of a number of products paid by the Board in the period 1966 to 1973.

From these price series a basic price has been derived using the following methods.

1 - If the series is rising or falling uninterruptedly, the average of the last four years has been taken as basic price.

2 - If in the series the prices of the last four years are higher or lower than those in the first three years, the average of the last four years has been weighed at 75% and the average of the first three years at 25%.

3 - If both cases 1 and 2 do not apply, the average of the series after elimination of the higher and lowest values, has been taken as basic price.

Table I.11 - Prices paid by the Maize and Produce Board for different agricultural products in the period 1966-1973 (in K.Sh. per ton)

Product	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73
Mexican 142 beans	800	788	722	722	750	955	1,111
Canadian Wonder beans	633	633	555	577	844	944	722
Lima beans	1,600	1,052	922	944	1,011	1,033	1,033
Rosecco beans	716	730	666	666	844	1,000	722
Soy-beans	500	507	666	666	666	733	733
White haricots	672	672	622	622	666	833	666
Red haricots	500	507	444	466	622	777	722
Castor seed	664	685	685	716	700	707	715
Capsicum-grade I	1,844	1,716	1,716	1,944	1,850	1,950	2,000
Copra	1,371	1,371	1,371	1,371	1,200	1,305	-
Yellow grams	683	718	555	555	1,000	1,000	722
Groundnuts-Nyana	1,314	1,160	1,049	1,543	1,325	1,350	1,375
Groundnuts-Uganda	1,067	916	916	925	1,000	1,100	1,125
Cow peas	546	496	444	422	666	944	611
Pigeon peas	611	618	555	555	833	1,000	777
Simsim (sesame)	1,265	1,296	1,234	1,209	1,337	1,437	1,500
Sunflower seed-white	972	1,019	763	763	600	625	700
Sunflower seed-grey, striped	888	888	625	625	550	600	625

We have raised the basic price by 5% for the following reasons. The stores of the Maize and Produce Board buy varying quantities at fixed prices. The Board has to store the quantities bought and to sell the products of the farmers. The social function performed by the Board is necessary to allow marketing of the products and is ultimately of benefit to both consumer and producer. The extra cost involved are paid for by the consumer. Marketing the produce from a scheme is less costly, but since large amounts have to be sold, fixed outlets must be looked for which, in turn, will lower the selling price.

After deduction of the transport cost (K.Sh. 55 for Masinga, K.Sh. 115 for Bura), the economic producer's prices result for the agricultural products that might be grown on the schemes (see Table I.12). To arrive at the financial producer's prices, K.Sh. 20 per ton have to be deducted to account for the county council cess.

If beans are to be cultivated on the schemes, the amounts produced will largely be consumed by the farmers. In determining the farmer's income, the amounts of beans consumed on the scheme have been valued at a financial consumer's price. This price represents the average price of the different types of beans; for Masinga it has been set at K.Sh. 970 per ton, for Bura at K.Sh. 1,000 per ton.

Table I.12 - Economic producer's prices at Bura and Masinga of agricultural products marketed by the Maize and Produce Board (in K.Sh./ton)

Product	Economic producer's price	
	Masinga	Bura
Mexican 142 beans	785	725
Canadian Wonder beans	660	600
Lima beans	995	935
Rosecco beans	715	655
Soy-beans	680	620
White haricots	640	580
Red haricots	535	475
Castor seed	680	620
Copra	1,290	1,230
Yellow grams	715	655
Groundnuts - Nyanza	1,350	1,290
Groundnuts - Uganda	995	935
Cow peas	520	460
Pigeon peas	650	590
Simsim (sesame)	1,320	1,260
Sunflower seed - white	680	620
Sunflower seed - grey, striped	605	545

6 SUGAR

6.1 Consumption

In recent studies on the trend of sugar consumption in Kenya up to 1980, different assumptions have been made which have caused the consumption estimates to vary widely (see Table I.13).

Table I.13 - Projections of sugar consumption in Kenya in the period 1970-1980 (in 1,000 tons)

	Projections Mumias Report (11)			Projections Ministry of Agriculture (12,13)	
	1	2	3	4	5
1970	152	150	157	151	-
	163	160	168	161	-
	174	169	174	172	188
	186	179	185	183	202
	199	189	198	195	217
1975	213	200	211	207	234
	227	212	224	221	251
	244	225	238	235	269
	261	238	254	250	290
	279	252	270	267	312
1980	299	267	287	284	335

During the years 1954 to 1969, the average compound rate of growth was 7.25 annually; since 1969, it has been over 8%. In 1970 and 1971, sugar consumption in Kenya was 162,000 and 183,000 tons respectively and exceeded the projections considerably. The projections of the Ministry of Agriculture in column 5 of Table I.13 show a growth rate of 7.50. Although it is a high rate, we feel such a growth rate is possible on the short term. In extrapolating this series, a growth of 7% a year has been assumed for the period 1980-1985 (see Table I.14, maximum estimate).

The following assumptions have served to arrive at a consumption pattern that we consider to be a minimum one:

- per caput consumption in 1972 : 16 kg
- population growth till 1980 : 3.1%
- population growth 1980-1985 : 3.0%
- income elasticity till 1980 : 1
- income elasticity till 1985 : 0.9
- growth of the per caput income : 2.5%

The pattern that we have used in our calculations as the best estimate has been based on the same values as those assumed for the minimum pattern, except for the growth of the per caput income which we have taken at 3.5%.

We have considered the projections made for the period 1970-1980 in a study of the Ministry of Agriculture (13) and extrapolated by us for 1980-1985 at a growth rate of 7% to be the maximum estimate.

In Table I.14 we have compared the expected trend of sugar consumption (in 1,000 tons) and the resulting per caput consumption in kg under these three estimates during the period 1972 to 1985.

Table I.14 - Expected trend of sugar consumption (in 1,000 tons) and per caput consumption (in kg) under three consumption patterns; period 1972-1985

Year	Sugar consumption			Per caput consumption		
	Minimum estimate	Best estimate	Maximum estimate	Minimum estimate	Best estimate	Maximum estimate
1972	187	187	188	abt 16	abt 16	abt 16
	198	201	202			
	210	214	217			
1975	222	228	234	17.2	17.7	18.1
	234	243	251			
	248	260	270			
	262	278	290			
	276	296	312			
1980	293	317	335	19.5	21.1	22.3
	308	338	359			
	324	358	384			
	341	380	411			
	360	404	440			
1985	379	428	470	21.8	24.6	27.0

6.2 Production

The production depends on climatic conditions which vary over the years, on pest and disease incidence and the supplies of sugar-cane by outgrowers. The current production amounts to 125,000 tons of sugar a year. As from 1973, this amount is expected to increase gradually due to more efficient use of the capacity and the start and extension of the production on the Mumias project.

Table I.15 compares the estimated production capacity stated in the reports of the Ministry of Agriculture under the minimum and the best estimate and shows the annual deficit in sugar under the two patterns.

Table I.15 - Expected annual sugar production and consumption and deficit in sugar in the period 1972 to 1985 (in 1,000 tons)

Year	Production estimates			Consumption pattern		Expected deficit in sugar under:	
	1	2	average 1 & 2	minimum estimate	best estimate	minimum estimate	best estimate
1972	110	143	127	187	187	- 60	- 60
	149	163	156	198	201	- 42	- 45
	178	195	187	210	214	- 23	- 27
1975	195	206	201	222	228	- 21	- 27
	200	211	206	234	243	- 28	- 37
	226	213	220	248	260	- 28	- 40
	228	214	221	262	278	- 41	- 57
	228	220	224	276	296	- 52	- 72
1980	228	226	227	293	317	- 66	- 90
	228	228	228	308	338	- 80	-110
	228	228	228	324	358	- 96	-130
	228	228	228	341	380	-113	-152
	228	228	228	360	404	-132	-176
1985	228	228	228	379	428	-151	-200

In a study of the Ministry of Agriculture (13) two alternatives for extension of the sugar production are mentioned. The first alternative concerns extension of the cane area by 8,400 ha, which will allow to adjust the supply of cane to the processing capacity of the existing sugar-mills. The second alternative provides for an extension of the cane area by 8,400 + 7,600 = 16,000 ha, whereby all the cane produced is also supplied to the existing sugar-mills.

Table I.16, next page, gives the total annual sugar production (in 1,000 tons) under the two alternatives in the period 1972 to 1985.

Table I.16 - Total annual sugar production (in 1,000 tons) under two alternatives; period 1972-1985

Year	Alternative 1 8,400 ha extension	Alternative 2 16,000 ha extension
1972	127	127
1973	156	156
1974	202	208
1975	226	248
1976	245	292
1977	259	285
1978	260	295
1979	263	298
1980	266	301
1981	267	302
1982	267	302
1983	267	302
1984	267	302
1985	267	302

In Table I.17 we have shown the sugar deficits or surpluses in 1,000 tons at the current production capacity and under alternatives 1 and 2 when assuming the minimum and the best estimates; column 7 shows the production surpluses if 6,500 ha of the Bura area are planted to sugar-cane.

Table I.17 - Sugar deficits or surpluses (in 1,000 tons) under the minimum and the best estimate at current and extended production in the period 1972 to 1985

Year	Deficit/surplus under minimum estimate at:			Deficit/surplus under best estimate at:			Bura production 6,500 ha
	current production	current production + 8,400 ha extension	current production + 16,000 ha extension	current production	current production + 8,400 ha extension	current production + 16,000 ha extension	
	1	2	3	4	5	6	7
1972	- 60	- 60	- 60	- 60	- 60	- 60	
	- 42	- 42	- 42	- 45	- 45	- 45	
	- 23	- 8	+ 2	- 27	- 12	- 6	
1975	- 21	+ 4	+ 26	- 27	- 2	+ 20	
	- 28	+ 11	+ 58	- 37	+ 2	+ 49	
	- 28	+ 11	+ 37	- 40	- 1	+ 25	
	- 41	- 2	+ 33	- 57	- 18	+ 17	7
	- 52	- 13	+ 22	- 72	- 33	+ 2	19
1980	- 66	- 27	+ 8	- 90	- 51	- 16	34
	- 80	- 41	- 6	- 110	- 71	- 36	52
	- 96	- 57	- 22	- 130	- 91	- 56	54
	- 113	- 74	- 39	- 152	- 113	- 78	54
	- 132	- 93	- 58	- 176	- 137	- 102	55
1985	- 151	- 112	- 77	- 200	- 161	- 126	56

6.3 Conclusions

The following conclusions have been based on the production figures related to the 'best-estimate' consumption pattern.

(1) If the current production area including that of the Mumias project is maintained, a considerable deficit in sugar is most likely to occur. Should the 6,500 ha of sugar-cane at Bura be gradually realized as from 1977, the amounts produced would reduce the deficits.

(2) If the current production area including that of the Mumias project is extended by 8.400 ha, sugar-cane growing in the 6,500-ha Bura area would still be feasible, the total sugar production being smaller than that projected under the 'best-estimate' consumption pattern.

(3) If the current production area including that of the Mumias project is extended by 16,000 ha for economic or social reasons, or both, sugar-cane growing at Bura would have to be postponed until 1979. Alternatively, the 8,400-ha extension could be realized plus sugar production at Bura starting in 1977; the remaining 7,600-ha extension could then serve to make up for any deficit as and when required.

When both the sugar production in the 6,500-ha Bura area plus the 16,000-ha extension are realized, a deficit is expected to manifest itself again at the beginning of the eighties.

When the production figures related to the minimum consumption pattern are considered, the following conclusions are arrived at.

(4) If only sugar-cane growing in the 6,500-ha Bura area is decided on, the risk of overproduction is negligible.

(5) If the 8,400-ha extension plus sugar-cane growing in the Bura area as from 1977 are decided on, a slight overproduction may occur during a few years.

(6) If the 16,000-ha extension is to be realized, the risk of overproduction would be greater and sugar-cane growing at Bura should not be started until 1980 or 1981.

6.4 Summary

(a) Self-sufficiency in sugar could be attained by extending the current sugar-cane area by 8,400 ha as suggested in a study made by the Ministry of Agriculture and starting sugar-cane growing in a 6,500-ha area of the Bura scheme in 1978. A deficit in sugar is then likely to occur, but this could be prevented by taking the remaining 7,600 ha into production as and when required.

(b) Even if sugar-cane growing at Bura is left out of consideration, the phasing of the 16,000-ha extension as suggested by the Ministry of Agriculture would seem to be less advisable. It may result in a production surplus for a number of years, which could be prevented by adopting an as flexible phasing as possible.

(c) The foregoing conclusions have not been based on a comparative economic survey, because no economic data of the 8,400-ha and 7,600-ha extension areas are available. Neither could we make a comparison with a potential sugar production area elsewhere in Kenya for lack of data. This has been a serious limitation in our study.

6.5 Sugar price

In the past few years, the price level of sugar has shown a sharp rise; from 1966 to 1969 it was very low as a result of large surpluses on the world market which, in turn, have been caused by an extremely high production in each of the sugar-producing countries.

The world trade in sugar consists of a number of sub-markets, i.e. the USA-market, the Commonwealth Sugar Agreement, the agreement between Cuba and Russia and the free world trade. The free world trade covers not more than 6% of the total trade in sugar, but it shows extreme price fluctuations because it deals with sugar surpluses; from 1966 to 1969, even dump prices were quoted. This is why, in our opinion, we cannot use the free world trade as a basis in defining the economic price. Table I.18 gives a view of the sugar prices in the past ten years (import prices in K.Sh. per ton).

Table I.18 - Import prices of sugar, period 1963-1972

Year	United Kingdom raw, 96°, c.i.f. London	United Kingdom contract price to Commonwealth sugar producers	United States raw, 96°, spot price, c.i.f. New York
1963	1,407	907	1,192
	1,014	907	985
1965	421	828	964
	350	857	1,000
1967	378	843	1,050
	371	735	1,085
1969	571	735	1,121
	678	735	1,171
1971	782	843 (963)*	1,244
1972	1,210	843 (963)*	1,333

* The current basic contract price is K.Sh. 843 per ton. The United Kingdom pays an additional amount per ton, the level of which depends on the world market price, but it ranges from K.Sh. 120-K.Sh. 205 per ton (at present K.Sh. 120 per ton).

In estimating the long-term sugar price the following points have to be considered.

(1) The average prices per ton of sugar in the last ten years:

- United Kingdom, raw, 96^{o}, c.i.f. London K.Sh. 718
- United Kingdom, contract price to Commonwealth sugar producers K.Sh. 823
- United States, raw, 96^{o}, c.i.f. New York K.Sh. 1,115.

In defining the sugar price for Kenya based on world market prices, the distance to the exporting country and the transport of bags must be considered.

(2) In the Report of the Sugar Prices Committee of 16th February 1972, the Ministry of Agriculture of Kenya expects the world market price for sugar to range from K.Sh. 890 to K.Sh. 1,060 per ton in the next five years.

(3) In 1972, the c.& f. Mombasa price for imported sugar varied between K.Sh. 1,130 and K.Sh. 1,550 per ton.

(4) Internationally, the price level in the seventies is expected to be much higher than in the years 1960-1970.

(5) Various sugar-cane production and processing experts expect a long-term world market price of K.Sh. 850 to K.Sh. 950 per ton.

(6) In the future, world sugar consumption is likely to increase rapidly. The FAO, in its Agricultural Commodity Projections for 1970-1980, expect a rise of 32% in the seventies. The per-ton cost of the extra amount of sugar to be produced to meet the additional demand will be relatively high. At present, the factory costs per ton of sugar already range from K.Sh. 350 to K.Sh. 450.

(7) In defining the c.i.f. Mombasa price per ton of sugar, the foregoing points have been considered. It has proven impossible to derive the price from basic data. The long-term c.i.f. Mombasa price is expected to range from K.Sh. 650 to K.Sh. 1,550. Considering the current factory costs of K.Sh. 350 to K.Sh. 400, we feel that K.Sh. 650 c.i.f. Mombasa may represent a dump price. The upper limit of K.Sh. 1,550 has been based on the present level of the sugar price for Kenya. Such a high price may also prevail on the long term.

The c.i.f. Mombasa prices have been classified and by use of the probability theory the frequency of occurrence of the different price classes has been defined (see Table I.19).

Table I.19 - Estimated frequencies of occurrence c.i.f. Mombasa sugar prices

Price classes per ton of sugar (in K.Sh.)		Frequency of occurrence (in %)	
650- 750	x	5	= K.Sh. 35
750- 850	x	5	= " 40
850- 950	x	35	= " 315
950-1,050	x	30	= " 300
1,050-1,150	x	15	= " 165
1,150-1,350	x	5	= " 63
1,350-1,550	x	5	= " 72
			K.Sh. 990

The significance of these frequencies is that an average import price ranging from K.Sh. 650 to K.Sh. 750 per ton of sugar is expected to be realized one or two years within a period of 30 years. This holds also for the price classes K.Sh. 750-850; K.Sh. 1,150-1,350, and K.Sh. 1,350-1,550.

For the price classes K.Sh. 850-950, K.Sh. 950-1,050 and K.Sh. 1,050-1,150, this will be 10-11 years, 9 years and 5 years of the 30-year period respectively.

(8) In Table I.20 we have estimated the economic producer's prices as derived from the c.i.f. Mombasa price.

Table I.20 - Economic and financial producer's prices of sugar-cane

Y e a r	1977	1981	1986	1996	2006
C.i.f. Mombasa price per ton of sugar	990	990	990	990	990
Port charges	55	55	52	51	50
Administration and operation costs	10	10	8	8	8
Landed price (Mombasa)	1,055	1,055	1,050	1,049	1,048
Transport Bura-Mombasa	92	92	90	90	90
Processing cost	440	430	420	410	400
	523	533	540	549	558
Revenues Mombasa	7	7	10	10	10
	530	540	550	559	568
Cane to sugar ratio	(10)	(10)	(9.8)	(9.4)	(9)
Economic producer's price per ton of cane	53	54	56	59	63
Financial price, excluding cost of cane transport	52	54	56	59	63

7 RICE

7.1 Consumption

The marketing restrictions and the impact of maize deficits in the last few years have made it difficult for us to define the future domestic rice consumption.

The data of domestic consumption of rice in recent years vary widely as the following figures show:

1967-1969 : 12,000 to 14,000 ton
1970 : 16,000 to 18,000 tons
1971 : 28,000 ton.

The following reasons may underlie these varying data:

a) the rise in consumption from 18,000 ton in 1970 to 28,000 ton in 1971 was fully caused by maize deficits;

b) the rise in consumption was caused by maize deficits for 50%;

c) the rise in consumption is fully attributable to the (partial) removal of the marketing restrictions for this crop.

Based on these three possibilities, we have arrived at the following basic data:

a) total consumption in 1970 - 18,000 tons or 1.6 kg per caput;

b) total consumption in 1971 - 23,000 tons or 2.0 kg per caput;

c) total consumption in 1971 - 28,000 tons or 2.5 kg per caput.

In extrapolating these consumption figures to 1985, we have assumed a minimum and a maximum level, i.e.:

- minimum level: income elasticity 0.8
  growth of population till 1980 of 3.1% a year
  growth of population 1980 to 1985 of 3% a year
  growth of per caput income of 2.5% a year
  per caput income K.Sh. 1,000;
- maximum level: income elasticity 1.0
  growth of population as above
  growth of per caput income of 3.5% a year.

Taking the above data into account we have tried to define the trend of rice consumption in the period 1970 to 1985 (see Table I.21).

Considering the varying consumption figures in the past years we have taken the 1971 consumption of 23,000 tons as a starting point. To be able to define which alternative is most accurate, the figures for 1972 and subsequent years had to be compared with those valid under the different alternatives. In doing so, removal of marketing constraints such as insufficient supplies, supply in amounts and packing not meeting consumers' requirements, quality not meeting consumers' taste, has been taken into account. Once these constraints have been removed, we expect in 1972 a minimum rice consumption of 24,000 tons; at the 28,000-ton level, a consumption of 30,000 tons is considered to be the maximum estimate. In 1985, these figures would be 46,000 tons and 70,000 tons respectively.

7.2 Production

The existing NIB schemes produce some 20,000 tons a year at present. It has been assumed that the current amount of 2,500 tons produced in areas outside the NIB schemes will not rise considerably. Column 1 of Table I.22, next page, shows the amounts of rice to be produced on the existing NIB schemes in the years 1972 to 1980. The projections in column 2 include the rice yields to be produced in West Kano from 1974 and at Yala from 1979.

Table I.21 - Expected trend of rice consumption (in 1,000 tons); period 1970 to 1985

Year	Based on annual rice consumption of:					
	18,000 tons		23,000 tons		28,000 tons	
	minimum level	maximum level	minimum level	maximum level	minimum level	maximum level
1970	18	18				
1971	19	20	23	23	28	28
	20	21	24	24	30	30
1973	21	22	25	26	31	32
	23	24	27	28	33	34
1975	24	26	28	30	35	37
	25	27	29	32	36	39
1977	26	29	31	34	38	42
	27	31	33	36	40	45
1979	29	33	34	39	42	47
	30	35	36	41	45	51
1981	32	38	38	44	47	54
	34	40	40	47	49	58
1983	35	43	42	50	52	62
	37	46	44	53	54	66
1985	39	49	46	57	57	70
Per caput consumption in 1985	2.2 kg	2.8 kg	2.6 kg	3.3 kg	3.3 kg	4 kg

Table I.22 - Expected rice production on existing NIB schemes (in 1,000 tons)

Year	Production on existing schemes	Production including West Kano and Yala
1972	19.7	19.7
	20.2	20.2
1974	21.7	22.4
	23.6	24.9
1976	28.3	29.9
	28.3	29.9
1978	28.3	29.9
	28.3	30.8
1980	28.3	31.8

Table I.23 on the next page shows the rice deficits and surpluses in 1,000 tons to occur under the different alternatives and the amounts that will be available as from 1977 if it is decided to grow rice on the Bura scheme. The production planned in West Kano and at Yala has not been included since it will not bring about a material change in the figures presented.

If growing IRRI rice varieties starts at Bura in 1977, annual yields of 7,800 tons in 1980, 13,000 tons in 1990 and 15,000 tons in 2000 are expected to be attained. These amounts can be readily absorbed by the domestic market except under the first alternative. Rice consumption in the next few years, i.e. 1972, 1973 and 1974, will show which consumption pattern can best be applied. Tentatively, we have assumed that the yields produced can be sold on the domestic market. It may well be that even if rice production at Bura is decided on, a deficit will occur in the early eighties. But rice may also be produced in other areas. In the NIB estimates, West Kano and Yala with a total production of 3,500 tons in 1980 have been accounted for. The possibility of rice production at Bura should, therefore, be considered from a national point of view which could result in giving preference to other areas.

A further study on the marketing opportunities of Basmati might reveal that this variety could be sold in the world market in the future. The ratio of the area under Basmati to that under IRRI might then be adjusted to the future marketing opportunities.

7.3 Rice price

The economic producer's price of rice has been based on import substitution. For Basmati, this price has also been determined on the basis of exports, but the marketing opportunities for this variety will have to be studied further.

The world market price of Thai rice, in US $ per ton, 5% brokens, f.o.b. Bangkok, was in the period 1955 to 1972:

1955 - 141	1961 - 137	1967 - 220
1956 - 138	1962 - 153	1968 - 203
1957 - 139	1963 - 144	1969 - 187
1958 - 148	1964 - 137	1970 - 143
1959 - 133	1965 - 137	1971 - 129
1960 - 125	1966 - 166	1972 - 142

The c.i.f. Mombasa price for rice has been based on:

- the average world market price, eliminating the three highest and three lowest values;
- the assumption that the Sindano variety equals Thai rice;
- an average grading factor of 1.35;
- ocean freight and insurance;
- actual prices of rice imports into Kenya;
- the assumption that the average Basmati-Thai price ratio on the world market is 1.40.

Table I-23: Rice deficits and surpluses to occur under 6 alternatives and expected rice yields at Bura (in '000 tons)

Year	Based on an annual rice consumption of:						Bura production			
	18,000 tons		23,000 tons		28,000 tons		Basmati main season	IRRI main season	IRRI off-season	IRRI main season + off-season
	minimum level	maximum level	minimum level	maximum level	minimum level	maximum level				
1972	0	- 1	- 4	- 4	-10	-10				
	- 1	- 2	- 5	- 6	-11	-12				
1974	- 1	- 2	- 5	- 6	-11	-12				
	0	- 2	- 4	- 6	-11	-13				
1976	+ 3	+ 1	- 1	- 4	- 8	-11				
	+ 2	- 1	- 3	- 6	-10	-14	0.5	0.8	0.3	1.1
1978	+ 1	- 3	- 5	- 8	-12	-17	1.5	2.1	0.8	2.9
	- 1	- 5	- 6	-11	-14	-19	2.5	3.6	1.6	5.2
1980	- 2	- 7	- 8	-13	-17	-23	3.7	5.3	2.5	7.8
	- 4	-10	-10	-16	-19	-26	3.9	5.5	2.8	8.3
1982	- 6	-12	-12	-19	-21	-30	4.1	5.8	3.2	9.0
	- 7	-15	-14	-22	-24	-34	4.3	6.1	3.5	9.6
1984	- 9	-18	-16	-25	-26	-38	4.5	6.4	3.8	10.2
1985	-11	-21	-18	-29	-29	-42	4.7	6.6	4.2	10.8

Economic producer's prices of rice in K.Sh. per ton have been determined based on import substitution (Table I.24) and on exports of Basmati (Table I.25).

Table I.24 - Economic producer's price of rice (in K.Sh./ton) based on import substitution

	1972 Sindano (IRRI)	Basmati
C.i.f. Mombasa	990	1,300
Port charges	55	55
Landed price	1,045	1,355
Transport to Bura	138	138
	907	1,217
Transport, milling, storage	190	190
	717	1,027
Paddy-rice conversion 65% of economic producer's price of 1 ton paddy	465	665

The financial producer's price, if derived from the world market price, is K.Sh. 415/ton for Sindano and K.Sh. 615/ton for Basmati; the difference of K.Sh. 50 with the economic price is caused by the county council cess and the contribution to the Stabilization Fund. At present, the financial prices are K.Sh. 485/ton and K.Sh. 760/ton respectively.

Table I.25 - Economic and financial producer's prices of Basmati based on exports (in K.Sh./ton)

F.o.b. Mombasa	1,150
Port charges	55
	1,095
Transport to Bura	138
	957
Transport, storage, milling	190
	767
Economic producer's price of 1 ton paddy	500
Financial producer's price	450

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CONTENTS

LIST OF TABLES

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1 GENERAL

This Annex deals with the following analyses of the Bura project.

- Economic evaluation based on prices of products and production factors representing the true value of such products and factors to the economy. Taxes and subsidies, being transfers within the economy and no social costs or benefits, have been excluded.
- Financial analysis based on the actual prices paid for products and production factors.
- Analysis of the farmer's income, in which different levels of the farmer's income have been considered.

2 METHODOLOGY

In the economic evaluation, annual costs and benefits have been quantified at discounted values. The internal rate of return is one of the criteria used in judging the results of the evaluation. This is the rate of interest at which the total discounted economic benefits equal the total discounted economic costs. The internal rate of return has been compared with the opportunity cost of capital, i.e. the rate of return that can be attained if the capital to be invested were used for other, economically marginal, projects. A generally accepted estimate of the opportunity cost of capital for Kenya is 10%.

In the financial analysis two procedures have been followed. First we have calculated the rate of return using market prices for inputs and outputs, but not counting farmer's income as a cost. The return thus arrived at is a return to capital suppliers and farmers combined.

Next, we have assumed varying repayment conditions for financing the project combined with alternative minimum levels of farmer's income and have calculated the resulting rate of return (or the interest rate the project can bear).

The analysis includes also the foreign currency implications of the project.

There are many unpredictable factors influencing the basic parameters in a feasibility study. We have considered to use the risk analysis method but it proved almost impossible to make realistic estimates of the influence of the risk factors on the basic parameters. The results of applying this method would not justify the high costs involved. Therefore, we have preferred to use the sensitivity analysis.

It may well be that other experts will not share our views as regards the assumptions and projections made. In our study we have accounted for this by presenting alternative solutions showing the effect of different assumptions and projections on the ultimate results. It will be noted that the figures presented have not been rounded off; this may suggest a certain degree of accuracy that we have not applied. We have not done so since the series of figures are interdependent and rounding off might have caused them to become inconsistent.

3 OUTCOME OF THE ANALYSES

Our studies have revealed that based on technical, economic and sociological considerations, the best solution would be to establish a 4,000-ha project in the Bura Area where cotton would be grown as the main crop and groundnuts as the major off-season crop. Once the area under groundnuts in the off-season would cover two-thirds of the total cropped area, the introduction of a third crop could be considered, for which we have suggested the subsistence crops maize and beans.

A gravity intake has been recommended for the supply of irrigation water to the scheme.

The main findings of the analyses which will be elaborated in the following pages are:

- the internal rate of return of the project is 13½%;
- the financial return, if the farmer's income is not taken as a cost factor, is 10¾%;
- of the five alternative farmer's income patterns considered, the following two have been found to be most realistic:

. 1977 - K.Sh. 1,200 per year	. 1977 - K.Sh. 1,200 per year
. 1986 - " 1,566 " "	. 1986 - " 2,050 " "
. 1996 - " 2,104 " "	. 1996 - " 2,050 " "
. 2008 - " 3,000 " "	. 2008 - " 2,050 " "
financial return, taking the farmer's income as a cost factor: 0%	financial return, taking the farmer's income as a cost factor: 0%

- the investment cost in the period 1974 to 1980 will be K.Sh. 56 million;
- the local and foreign currency components of the investment costs will be K.Sh. 31 million (56%) and K.Sh. 25 million (44%) respectively;
- 37% of the operation costs will require foreign currency as from 1980;
- the foreign currency earning capacity (in 1,000 K.Sh.) in the period 1977 to 1986 will be:

. cotton revenues in foreign currency		100,527
. foreign currency component operation costs	35,398	
. foreign currency component investment costs	24,877	
		60,275
		40,252

3.1 Internal rate of return

The data as shown in Table J.1 have served to calculate the discounted values at different rates of interest presented in Table J.2.

Table J.1 - Estimated project revenues and costs (in K.Sh. 1,000) - gravity intake alternative

Year	Gross revenues *	Hired labour **	Investment costs ***	Cost of management, maintenance and operation
1974			1,500	181
1975			6,629	818
1976			15,489	1,599
1977	903		6,746	2,270
1978	3,258	10	5,624	2,739
1979	6,413	31	5,167	3,051
1980	8,485	64	168	3,061
1981	9,319	85		
1987	11,000	173		3,061
1997	12,896	267		3,061
2007	14,887	360		3,061

* Gross revenues: area x yields x producer's price minus direct, variable costs minus investment in agricultural machinery

** Hired labour : labour to be hired during cotton picking at a farm size of 1.2 ha

*** Investment in intake, main canal and inspection roads, secondary and tertiary irrigation system, staff houses, workshop, etc.

Table J.2 - Aggregated discounted values (in K.Sh. 1,000) at different rates of interest

Rate of interest	Discounted				
	Revenues	Hired labour	Investments	Operation costs	Balance
0	355,743	6,500	41,825	93,000	+ 213,418
10	85,581	1,225	39,376	27,803	+ 17,177
12	69,573	950	39,088	23,600	+ 5,935
13	63,230	830	38,955	21,896	+ 1,549
				IRR: 13½%	
14	57,722	751	38,829	20,400	- 2,258
15	52,926	671	38,710	19,079	- 5,534

Notes: - All values are social values.
- The net revenues in the "without-the-project" case are negligible, causing the revenues in the "with" case to represent the benefits.
- The opportunity costs of the unskilled labour (settlers) have been taken at zero.
- The internal rate of return is over 13½%.

3.2 Financial return

It is emphasized that in this calculation the labour cost of the tenants has not been included as a cost factor. We have decided to do so because we wanted to define the effect of alternative repayment conditions and alternative patterns of growth in farmer's income on the financial rate of return. In other words, the calculations in this section show the returns to the financing agencies and the settlers combined before "profit-sharing".

In Table J.3 we have presented the data required to calculate the discounted values and financial return at different rates of interest, while Table J.4 shows the results of the calculations.

Table J.3 - Estimated project revenues and costs (in K.Sh. 1,000) - gravity intake alternative - market prices

Year	Gross revenues	Hired labour	Investment costs	Costs of management, maintenance and operation
1974			1,500	
1975			7,549	181
1976			18,205	888
1977	927		8,573	1,762
1978	3,323	10	7,157	2,546
1979	5,884	31	6,572	3,147
1980	8,534	64	263	3,573
1981	9,314	85		3,599
1987	10,921	173		3,637
1997	13,069	267		3,685
2007	15,065	360		3,701

Table J.4 - Discounted values (in K.Sh. 1,000) at different rates of interest - market prices

Rate of interest	Discounted				
	Revenues	Hired labour	Investments	Operation costs	Balance
0	357,355	6,500	49,819	110,995	+ 190,041
9	95,402	1,403	47,365	35,683	+ 10,952
10	85,352	1,225	47,151	32,570	+ 4,406
				F.R.: 10¾%	
11	76,675	1,073	46,942	29,889	- 1,229
12	69,298	950	46,748	27,563	- 5,963
13	62,943	830	46,558	25,542	- 9,987

The financial return, if farmers' incomes are not considered to be a cost factor, is over 10¾%.

3.3 Financial return at alternative patterns of farmer's income

The annual financial result is constituted by the annual project revenues minus operation costs minus small investments which are to recur several times during the project period (re-investments). The result may show either a surplus or a deficit.

If the financial result is positive, the surplus can serve to:

- provide the farmers with an income;
- repay loans;
- pay the interest on the loans.

Table J.5 shows the annual financial surpluses/deficits expected to occur during the project period (1975-2007).

Table J.5 - Annual financial results; period 1975-2007 (in K.Sh.1,000)

Year	Gross revenues	Cost of hired labour	Operation costs	Financial surplus/deficit
1975			- 181	- 181
1976			- 888	- 888
1977	927		- 1,762	- 835
1978	3,323	- 10	- 2,546	+ 767
1979	5,884	- 31	- 3,147	+ 2,706
1980	8,534	- 63	- 3,573	+ 4,897
1981	9,314	- 85	- 3,599	+ 5,629
1986	11,025	- 160	- 3,631	+ 7,234
1996	13,639	- 257	- 3,680	+ 9,702
2006	15,105	- 351	- 3,699	+ 11,055

In the following pages we will calculate a number of financial returns using different assumptions with regard to the minimum level of the farmer's income and the loan conditions for financing the project.

3.3.1 Income pattern I, assuming that:

- the loans for financing the primary investments and the initial working capital will not be repaid;
- no interest will be paid;
- the initial annual financial deficits will be borne by an outside agency;
- no minimum is set for the farmer's income;
- the annual financial surpluses, if available, will be fully used to provide the farmers with an income.

Hence, the annual farmer's income will be:

$$\frac{\text{annual financial surplus, if available}}{\text{number of farmers}}$$

Table J.6 - Annual farmer's income - pattern I

Year	Annual farmer's income (K.Sh.)	Annual farmer's income (K.£)
1977	0	
1978	+ 511	
1979	+ 1,120	
1980	+ 1,469	60
1981	+ 1,689	
1986	+ 2,170	100
1993		
1996	+ 2,911	150
2006	+ 3,317	165

3.3.2 Income pattern II, assuming that:

- the loans for financing the primary investments and the initial working capital will not be repaid;
- the minimum annual farmer's income will be K.£ 60;
- the total annual farmers' incomes during the project period will equal the total annual financial surpluses less deficits, or total farmers' incomes =

$$\sum_{t=1974}^{2007} \text{revenues}_t - \sum_{t=1974}^{2007} \text{hired labour costs} \quad \sum_{t=1974}^{2007} \text{operation costs}$$

Table J.7 - Annual farmer's income - pattern II

Year	Annual farmer's income (K.Sh.)	Annual farmer's income (K.£)
1977	1,200	60
1978	1,200	
1979	1,200	
1980	1,354	
1981	1,574	
1986	2,054	100
1996	2,911	150
2006	3,317	165

At this pattern, the financial return will be negative.

3.3.3 Income pattern III, assuming that:

- the loans for financing the primary investments and the initial working capital will be fully repaid;
- no interest will be paid;
- the minimum annual farmer's income will be K.£ 60;
- in any year the farmer's income will not exceed the financial surplus, unless the minimum income is not attained;
- the total annual farmers' incomes during the project period will equal the total annual financial surpluses less deficits minus the total primary investment and initial working capital.

Table J.8 - Annual farmer's income - pattern III

Year	Annual farmer's income (K.Sh.)	Annual farmer's income (K.£)
1977	1,200	60
1978	1,200	
1979	1,200	
1980	1,250	
1981	1,304	
1986	1,574	75
1994	2,006	100
1996	2,114	
2004	2,546	125
2006	2,654	130

In defining this income pattern the financial return has been taken to be zero (the farmer's income has been considered to be a cost factor).

3.3.4 Income pattern IV, assuming that:

- the loans for financing the primary investments and the initial working capital will be fully repaid;
- the minimum annual farmer's income will be K.£ 60;
- in any year the farmer's income will not exceed the financial surplus. unless the minimum income is not attained;
- there will be a financial deficit in the first production year, i.e.
- 1977, at which time the farmer's income will also be K.£ 60. As from 1977, the farmer's income is assumed to grow by 3% annually, so that it will be K.£ 150 in reference year 32;
- any financial surplus left will be used to pay interest on the loans.

Table J.9 - Annual farmer's income - pattern IV

Year	Annual farmer's income (K.Sh.)	Annual farmer's income (K.£)
1977	1,200	60
1978	1,236	
1979	1,273	
1980	1,311	
1981	1,351	
1986	1,566	
1995		100
1996	2,104	
2002		125
2006	2,828	
2008	3,000	150

In this case, the financial return will be about 0%.

3.3.5 Income pattern V, assuming that:

- the loans for financing the primary investment and the initial working capital will be fully repaid;
- the minimum annual farmer's income will be K.£ 60;
- in any year the farmer's income will not exceed the financial surplus, unless the minimum income is not attained;
- taking the foregoing conditions into account, the annual farmer's income will be brought at a level of K.£ 100 as soon as possible;
- as from the year in which a farmer's income of K.£ 100 a year has been realized, it will be kept at this level so that the remaning financial surplus can be used to repay loans and, if possible, to pay interest.

Table J.10 - Annual farmer's income - pattern V

Year	Annual farmer's income (K.Sh.)	Annual farmer's income (K.£)
1977	1,200	60
1978	1,200	
1979	1,200	
1980	1,460	
1981	1,680	
1986	2,050	100
↓	↓	↓
2007	2,050	100

Income pattern V results in a financial return of 0%.

The introduction of maize and beans as subsistence crops will have little effect on the results of the above analysis since it will not happen until reference year 15. The maximum area under maize and beans, i.e. 14% of the cropped area in the off-season, will be attained in reference year 21. This means that in reference year 20, maize and beans production will contribute K.Sh. 221 to the annual farmer's income of K.Sh. 2,911; in reference year 31 this will be K.Sh. 241 to an income of K.Sh. 3,317 (see income pattern I, sub-section 3.3.1).

3.4 Primary investments up to 1980

The primary investments up to 1980, and the local and foreign currency components of the investment costs have been shown in Table J.11.

Table J.11 - Primary investments, local and foreign currency components (in K.Sh.)

Year	Investments, including cotton ginnery	Local currency component	Foreign currency component
1974	1,500,000	750,000	750,000
1975	7,549,000	4,249,000	3,300,000
1976	22,205,000	11,881,000	10,324,000
1977	9,999,000	5,844,000	4,155,000
1978	7,492,000	4,384,000	3,108,000
1979	6,878,000	3,981,000	2,897,000
1980	680,000	337,000	343,000
Total	56,303,000	31,426,000	24,877,000

The investment of K.Sh. 1,500,000 in 1974 represents the estimated cost of the design of the project.

In the other calculations, the costs of the cotton ginnery have not been considered in the investments, but accounted for indirectly in the cottonseed price; in this case we have included the cost of the ginnery in the investments, viz. K.Sh. 4,000,000 in 1976 and K.Sh. 1,000,000 in 1977.

The investments in agricultural machinery which are usually included as a cost element in the revenues, have been taken into account in this table to present the total investments to be made.

3.5 Operation costs and foreign currency earning capacity

The costs of operation during the project period and the relevant foreign currency components in K.Sh. and per cent have been presented in Table J.12.

Table J.12 - Costs of operation and foreign currency components (K.Sh.)

Year	Costs of operation	Foreign currency	Component in %
1977	3,319,233	1,054,395	32
1978	5,896,004	1,966,507	33
1979	8,471,278	2,763,565	35
1980	11,135,720	4,106,174	37
1981	11,320,731	4,170,757	37
1987	12,427,700	4,571,281	37
1997	13,486,060	5,023,097	37
2007	13,027,782	5,245,703	37

The table shows that as from 1980 foreign currency will be needed to cover 37% of the operation costs which include the costs of the ginnery, of transport and of investment in agricultural machinery. The farmer's income has not been taken as a cost factor.

In the following table we have presented the foreign currency earning capacity up to 1986 and 2007 respectively

Table J.13 - Foreign currency earning capacity (in K.Sh. 1,000)

	1977 - 1986		1977 - 2007	
Revenues from cotton in foreign currency		100,527		415,828
Foreign currency component:				
- operation costs	35,398		139,623	
- investment costs	24,877		24,877	
		60,275		164,500
Earning capacity		40,252		251,328

3.6 Basic data

In this sub-section we have summarized the basic data used in the analyses.

Table J.14 - Cropped areas in hectares

Year	Area available for cropping	Main season	Off-season		
		Area under cotton	Area under		
			ground-nuts	maize	beans
1977	700	665	280	-	-
1978	1,800	1,710	756	-	-
1979	2,900	2,755	1,276	-	-
1980	4,000	3,800	1,840	-	-
1987			2,400	0	0
1997			2,640	320	240
2007	4,000	3,800	2,640	320	240

Table J.15 - Crop yields in kg/ha

Year	Cotton	Groundnuts	Maize	Beans
1977	1,900	900	1,550	700
1978	1,970	950	1,700	740
1979	2,040	1,000	1,850	780
1980	2,110	1,050	2,000	820
1987	2,450	1,350	2,650	1,050
1997	2,650	1,700	3,300	1,250
2007	2,850	1,850	3,750	1,350

Table J.16 - Economic producer's prices per crop (in K.Sh./ton)

Year	Cotton	Groundnuts	Maize	Beans
1977	1,310	1,103	270	725
1978	1,315	1,099	256	
1979	1,320	1,096	242	
1980	1,325	1,092	228	
1987	1,343	1,085	209	
1997	1,355	1,085	226	
2007	1,360	1,085	235	725

Table J.17 - Financial producer's prices per crop (in K.Sh./ton)

Year	Cotton	Groundnuts	Maize	Beans
1977	1,343	1,083	525	1,000
1978	1,341	1,079	511	
1979	1,340	1,076	497	
1980	1,338	1,072	483	
1987	1,343	1,065	441	
1997	1,355	1,065	414	
2007	1,360	1,065	400	1,000

In the above table, we have assumed that the maize and beans produced will serve to meet part of the food requirements of the farmer's family, so that the farmer will have to buy limited quantities of these products. In the financial analysis, maize and beans have, therefore, been valued at consumer's purchase prices.

Table J.18 - Direct variable farm costs per cropped ha (in K.Sh.)

Year	Cotton	Groundnuts	Maize	Beans
1977	735	286	205	445
1978	750	307	206	453
1979	766	328	208	461
1980	781	348	209	469
1987	857	460	220	520
1997	900	545	235	585
2007	935	595	250	620

The direct variable farm costs used in the financial as well as the economic analyses include less items than those presented in Annex D: "Agronomy and Agro-economy". The main cost items are fertilizers and fuel.

The indirect and fixed farm costs with the exception of the investments in agricultural machinery, have been included in the other maintenance and operation costs of the project (see also footnote 1 of Table J.1 in Sub-section 3.1).

As the present subsidy on fertilizers equals the taxation on gasoil, the same amount for farm costs has been used in the economic and the financial analysis. Of course, we do not know whether these two items will continue to be equal in the future.

Investment in agricultural machinery

The annual investments during the project period vary widely. As from 1977, the annual investment in agricultural machinery will be K.Sh. 350,000 on the average, while in the first four project years they have been estimated at:

K.Sh. 425,000 in 1977
" 335,000 " 1978
" 310,000 " 1979
" 420,000 " 1980.

Costs of hired labour

The following costs of hired labour have been used in the calculations:

Year	K.Sh.
1977	-
1978	10,000
1979	30,000
1980	65,000
1987	175,000
1997	265,000
2007	360,000

As the project is situated in a rather remote area, we expect it to be difficult to hire labour on a temporary basis; this is why we have assumed the social costs of hired labour to be equal to the actual hired labour costs.

Net revenues in the 'without-the-project' case

This item has been considered in the economic analysis because the irrigation scheme, if implemented, will replace the current agricultural activities in the area. The amount involved is negligible; it has been assumed to be K.Sh. 8,600 in 1972 and to grow by 10% during the project period.

Opportunity cost of unskilled labour

This cost item has been included in the economic analysis because the irrigation scheme, if implemented, would replace the current agricultural activities of the settlers in the areas from which they originate. Given the high rate of unemployment, the rapid population growth and the difficulties met in creating new employment opportunities, we do not expect the production in the areas from which the settlers originate to be affected by the implementation of the scheme; therefore, we have taken the opportunity cost of unskilled labour at zero.

Design costs

These costs have been estimated at K.Sh. 1.5 million (see Sub-section 3.4, Table J.11).

The cost elements fuel (insofar as it has not been included in the direct variable costs) and unskilled labour have been valued differently in the economic and financial analyses. The fuel price includes 35% taxes which have not been taken as a cost factor in the economic evaluation; in this evaluation unskilled labour has been valued at zero for the same reason as outlined under the heading "Opportunity cost of unskilled labour" above. Consequently, we had to use different price series for investments, operation, maintenance and management in the economic and financial analyses (see Tables J.19 to J.26).

Table J.19 - Investments (in K.Sh.) in the water supply system up to main canal under the gravity and pumping intake alternatives respectively

Year	Gravity intake		Pumping intake	
	economic evaluation	financial analysis	economic evaluation	financial analysis
1975	4,698,000	5,174,000	3,189,000	3,512,000
1976	9,396,000	10,347,000	6,379,000	7,025,000
1987			1,925,000	1,925,000
1997			1,925,000	1,925,000

Table J.20 - Investments in main, secondary and tertiary irrigation systems under both gravity and pumping intake alternatives (in K.Sh.)

Year	Economic evaluation	Financial analysis
1976	2,660,000	3,270,000
1977	4,181,000	5,138,000
1978	4,181,000	5,138,000
2979	4,181,000	5,138,000

Table J.21 - Annual operation and maintenance costs of supply canal, intake, roads and irrigation system - gravity intake alternative (in K.Sh.)

Year	Economic evaluation	Financial analysis
1976	65,000	69,000
1977	295,000	318,000
1978	455,000	489,000
1979	615,000	660,000
1980	775,000	833,000
2007	775,000	833,000

Table J.22 - Annual operation and maintenance costs of pumping station, pumps, supply canal, roads and irrigation system - pumping intake alternative (in K.Sh.)

Year	Economic evaluation	Financial analysis
1976	65,000	69,000
1977	427,000	512,000
1978	815,000	1,007,000
1979	1,200,000	1,500,000
1980	1,412,000	1,758,000
2007	1,412,000	1,758,000

Table J.23 - Investments in staff houses and villages* (in K.Sh.)

Year	Staff houses		Villages	
	economic evaluation	financial analysis	economic evaluation	financial analysis
1976	373,000	468,000	342,000	487,000
1977	822,000	1,239,000	1,026,000	1,462,000
1978	673,000	1,023,000	684,000	975,000
1979	488,000	750,000	684,000	975,000
1980	519,000	801,000	342,000	487,000
1981	147,000	236,000	-	-

* excluding tenants' houses.

Table J.24 - Other investments (in K.Sh.)*

Year	Economic evaluation	Financial analysis
1976	1,216,000	1,420,000
1977	1,585,000	1,887,000
1978	1,209,000	1,437,000
1979	272,000	294,000
1980	126,000	146,000
1981	21,000	27,000

* including working capital up to K.Sh. 1,334,000.

Table J.25 - Annual operation and maintenance costs houses, villages, etc. (in K.Sh.)

Year	Economic evaluation	Financial analysis*
1976	51,000	51,000
1977	202,000	286,000
1978	314,000	453,000
1979	399,000	598,000
1980	443,000	706,000
1981	476,000	746,000
1982	482,000	759,000
2007	482,000	853,000

* The financial cost includes the interest payable on short-term seasonal loans.

Table J.26 - Annual management costs (in K.Sh.)*

Year	Economic evaluation	Financial analysis
1976	130,000	130,000
1977	552,000	567,000
1978	990,000	1,046,000
1979	1,416,000	1,518,000
1980	1,681,000	1,843,000
1981	1,800,000	2,000,000
1982	1,805,000	2,015,000
2007	1,805,000	2,015,000

* The management costs have been based on salaries and emoluments as valid in 1972/73.

Note on Table J.26:

It has been difficult to define whether, and if so, to which extent the management costs should be assumed to rise. The labour productivity in the management and operation sector is expected to increase over the years. Part of the increased productivity will be reflected in higher yields, and partly it will be shown by the lower per-ton cost of the products. In view of the foregoing it would seem to be justified to expect the management cost per worker to increase. A rise in labour productivity could, however, imply that the number of employees in this sector would decrease over the years; if so, the increase in management cost per worker will not or only partly be reflected in the total salary costs in this sector.

On the other hand, due to the shortage of qualified staff at present, the salary cost per employee in this sector is high. But in view of the current education and training programme in Kenya, this shortage is likely to lessen and a slight increase in salary cost per man will then show. This is why we have assumed the salaries to increase by 2% a year as from 1972/73 in our sensitivity analysis.

3.7 Sensitivity analysis and critical assumptions

The following assumptions have been made in our sensitivity analysis.

3.7.1 Overestimation of cotton prices or yields

At 10% the internal rate of return drops from 13½% to 11½% and the financial return from 10¾% to 9%.

At 20% the internal rate of return drops from 13½% to 9½% and the financial return from 10¾% to 7%.

3.7.2 Underestimation of direct, variable farm costs

At 10% the internal rate of return drops from 13½% to 12¾% and the financial return from 10¾% to 10%.

At 20% the internal rate of return drops from 13½% to 12% and the financial return from 10¾% to 9½%.

3.7.3 Underestimation of investment in agricultural machinery

The effect of underestimating the investment in agricultural machinery by either 10% or 20% is negligible.

3.7.4 Underestimation of all other investments

At 10% the internal rate of return drops from 13½% to 12½% and the financial return from 10¾% to 10%.

At 20% the internal rate of return drops from 13½% to 11½% and the financial return from 10¾% to 9¼%.

3.7.5 Underestimation of the management, operation and maintenance costs

At 10% the internal rate of return drops from 13½% to 12¾% and the financial return from 10¾% to 10¼%.

At 20% the internal rate of return drops from 13½% to 12¼% and the financial return from 10¾% to 9½%.

3.8 Critical assumptions

- In the economic analysis, the opportunity cost of unskilled labour to be employed for construction work have been taken to be zero. Because of the high rate of unemployment, the rapid population growth and the difficulties met in creating new employment opportunities, we feel that transfer of this labour will not affect, either positively or negatively, the economic growth in the region from which these people originate.

Some experts may differ of opinion with us. If the opportunity cost of unskilled labour for the construction activities is taken at K.Sh. 500 or K.Sh. 240 a year (see Annex H: Tana Catchment Survey), the internal rate of return is 12½% or 13% respectively.

- Subsequently, we have also taken the opportunity cost of the unskilled labour in construction and of the future tenants at K.Sh. 500 and K.Sh. 240 respectively; the respective internal rates of return proved to be 10¼% and 11¾%.

- In our calculations the annual management costs have been taken to be constant throughout the project period. The reasons for our doing so have been discussed in the note on Table J.26, page 235, but they do not justify the assumption that management cost will remain constant. We are unable to predict how the management costs will develop, both financially and when valued at shadow prices. To define the sensitivity of the project to changes in these costs, we have calculated the internal rate of return and the financial return under the assumption that the costs of management will grow annually by 2% as from 1972/73. It has been found that the internal rate of return will then drop from 13½% to 12½% and the financial return from 10¾% to 9¾%.

- Construction costs in Kenya have rapidly increased in the last few years. Should the costs in the construction sector rise more rapidly than the producer's prices of agricultural products in the coming years, this may have a bearing on the profitability of the project. How wide the difference in increase will become, is difficult to predict. In the sensitivity analysis we have assumed the difference in increase at 2% annually as from 1972/73 to 1980; the resulting internal rate of return appeared to be 12½% and the financial return 10% instead of the original percentages of 13½% and 10¾% respectively.

- Should both the management costs and the investment costs go up by 2% annually, the internal rate of return and the financial return would be 11½% and 9% respectively.

- The life of the project has been taken at 31 years. This means that 1977, the first production year, will be reference year 1. In view of the relatively high internal rate of return, extending the project life will have little or no effect on the calculations. This does not hold true for the financial return, when the farmer's income is considered to be a cost factor.

Considering the type of investments to be made, their residual value cannot be set at zero, but should be based on their income-generating potential in reference year 31. To this end, we have calculated the financial return assuming that the annual farmer's income of K.Sh. 60 in reference year 1 and of K.Sh. 2,050 as from reference year 10 (income pattern V) will be a cost factor; based on this assumption the financial return proved to be 0% at a project life of 31 years.

When extending the project life in our calculations from 31 to 40 and 50 years respectively, we have assumed the gross revenues, hired labour costs and operation costs in the reference years 31 to 50 to be equal to the respective values in year 31.

The following table shows that extending the project life to 50 years will cause the internal rate of return to rise from zero to nearly three per cent.

Table J.27 - Discounted values and financial returns at different project periods, income pattern V and farmer's income taken as cost factor

Project period (years)	Discounted values, at three per cent (K.Sh.1,000)	Financial return (%)
31	- 25,618	0
40	- 12,627	abt 2
50	- 1,719	" 3

- In our calculations we have assumed that maize and beans will be cultivated as subsistence crops as from reference year 15; ultimately, these crops are expected to cover 14% of the area under off-season crops at a maximum.

We are of the opinion that cash crop (i.e. groundnuts) cultivation in the off-season should be limited to 66% of the total area available for cropping. For, this will allow crop rotation and the growing of a third crop. Ideally, the remaining cropping area should be made available to the farmers for growing one or more food crops to meet their own food requirements insofar as this will not jeopardize the cultivation of the cash crops cotton and groundnuts. Although we have considered maize and beans in our calculations, we feel that it is for the farmers to decide which food crops they want to grow.

- When the first results of our studies became available, we were faced with the following question: would extension of the originally planned project area to 8,000 ha in the future offer opportunities and have consequences which should be taken into account in the decision-making at the time when the original project would be started? Our views in this respect are as follows.

For the 4,000-ha scheme, intake by gravity has been recommended. If an integrated plan for development of an 8,000-ha scheme is decided upon, three alternative ways of water supply will be possible, i.e.:

1 - intake by gravity for the 4,000-ha area and an independent supply system for the additional 4,000 ha (or larger area);

2 - intake by gravity for the total ultimate area of 8,000 ha;

3 - intake by pumping for the original 4,000-ha area, to be replaced by a gravity-intake system for the ultimate 8,000 ha in the second phase of the project.

Clearly, we are unable to examine these alternatives within the terms of reference of our present assignment. To arrive at a sound judgement we would have to study each of the three alternatives in more detail. Although we have recommended intake by gravity for the 4,000-ha scheme, such detailed studies could reveal that intake by pumping would be the optimum solution, if extension of the 4,000-ha area to 8,000 ha is envisaged (alternative 3).

In conclusion, we would suggest that either implementation of the 4,000-ha scheme should be started irrespective of possible further development of the Bura area, or alternatives 2 and 3 should be further investigated first.

3.9 Intake by pumping versus intake by gravity

In comparing the above two alternative ways of water supply we have used the same criteria. The main results of our analyses based on the 'intake-by-pumping' alternative will be summarized in the following pages.

3.9.1 Internal rate of return - pumping alternative

Table J.28, next page, shows the estimated project benefits and costs under the pumping alternative.

Our calculations have shown that under the intake-by-pumping alternative the internal rate of return is also 13½%.

Compared to the latter alternative, investment costs are lower but operation costs higher. An important part of the operation costs are constituted by the cost of fuel, which item is subject to a taxation of 35%; as mentioned earlier, this taxation has not been considered as a cost factor in the economic evaluation. In view of the prevailing international conditions as regards fuel supply, we expect this cost element to rise fairly rapidly in the future, and to affect the prices of a large number of products. Clearly, the effect will be more pronounced when a production technique is applied calling for the use of high amounts of fuel than when a technique is resorted to, implying a relatively lower cost component for fuel. We have not been able to account for this cost increase in our analysis, but we expect it to have a greater impact on the internal rate of return under the intake-by-pumping solution than when the intake-by-gravity alternative would be decided upon.

Table J.28 - Estimated project revenues and costs in K.Sh. 1,000 - intake-by-pumping alternative (Cf. Table J.1)

Year	Gross revenues	Hired labour	Investment costs	Costs of management, maintenance and operation
1974			1,500	
1975			5,121	181
1976			12,473	818
1977	903		6,747	1,731
1978	3,258	10	5,624	2,630
1979	6,413	31	5,167	3,325
1980	8,485	64	168	3,688
1981	9,319	85		3,699
1987	11,000	173	1,925	3,699
1997	12,896	267	1,925	3,699
2007	14,887	360		3,699

3.9.2 <u>Financial return - pumping alternative</u>

Table J.29 - Estimated project revenues and costs in K.Sh. 1,000 - intake-by-pumping alternative (Cf. Table J.3)

Year	Gross revenues	Hired labour	Investment costs	Costs of management, maintenance and operation
1974			1,500	
1975			5,887	181
1976			14,882	888
1977	927		8,573	1,955
1978	3,323	10	7,157	3,064
1979	5,884	31	6,572	3,988
1980	8,534	64	263	4,495
1981	9,314	85		4,522
1987	10,921	173	1,925	4,559
1997	13,069	267	1,925	4,607
2007	15,065	360		4,623

According to our calculations, the financial return under the pumping alternative is somewhat lower than when intake by gravity will be choosen.

3.9.3 Alternative patterns of farmer's income

In Table J.30 we have presented the annual financial surpluses/deficits expected to occur during the project period (1976-2007) under the pumping alternative.

Table J.30 - Annual financial results; period 1976-2007 (in K.Sh.1,000); (Cf. Table J.5)

Year	Gross revenues	Cost of hired labour	Operation costs	Financial surplus/deficit
1975			- 181	- 181
1976			- 888	- 888
1977	927		- 1,955	- 1,028
1978	3,323	- 10	- 3,064	+ 249
1979	5,884	- 31	- 3,988	+ 1,865
1980	8,534	- 64	- 4,495	+ 3,975
1981	9,314	- 85	- 4,522	+ 4,707
1986	11,025	- 160	- 4,553	+ 6,312
1996	13,639	- 257	- 4,602	+ 8,780
2006	15,105	- 351	- 4,619	+ 10,135

Based on the figures shown in the above table we have repeated the farmer's income exercises of Sub-sections 3.3.1 to 3.3.5, using income patterns I and V only. The results of this exercise and the comparison with those established for the intake-by-gravity alternative have been presented in Table J.31, next page.

The financial return under the gravity alternative, assuming income pattern V, has been found to be 0%. Under the pumping alternative, the financial return based on income pattern V proved to be negative. Hence, when using the pumping alternative, the assumptions on which income pattern V has been based, cannot be met (see Sub-section 3.3.5); for, up to 1990 the annual farmer's income would be higher than the annual financial surplus.

Table J.31 - Comparison of annual farmer's income (in K.Sh.) - income pattern I - gravity intake versus pumping intake alternative

Year	Annual farmer's income	
	gravity alternative	pumping alternative
1977	0	0
1978	+ 511	+ 166
1979	+ 1,120	+ 772
1980	+ 1,469	+ 1,193
1981	+ 1,689	+ 1,412
1986	+ 2,170	+ 1,894
1996	+ 2,911	+ 2,634
2007	+ 3,317	+ 3,041

3.9.4 Investments

The investment costs under the two alternatives up to 1980 have been compared in Table J.32.

Table J.32 - Investments up to 1980 (in K.Sh. 1,000) - Cf. Table J.11

Year	Investments up to 1980	
	gravity alternative	pumping alternative
1974	1,500	1,500
1975	7,549	5,887
1976	22,205	18,882
1977	9,999	9,999
1978	7,492	7,492
1979	6,878	6,878
1980	680	680
Total	56,303	51,318

Based on the findings of our analyses and the above difference in investments up to 1980, we have decided to recommend the intake-by-gravity alternative.

3.10 Other alternatives

After some preliminary investigations we have formulated a number of alternatives which we considered to be feasible from agronomic, economic, social and technical points of view.

In Sub-sections 3.1-3.8 of this Annex we have elaborated the alternative which we feel to be the most profitable one; Sub-section 3.9 deals with the intake-by-gravity alternative which, based on the criteria used, proved to work out at a slightly less favourable result. In this sub-section we will discuss some other alternatives that we have considered.

3.10.1 Establishment of a 4,000-ha net sugar-cane scheme

We have outlined our views on this alternative in our Interim Report on the feasibility of sugar-cane growing in the Bura area, January 1973. The 4,000-ha net project area includes 2,550 ha that are suitable for the cultivation of sugar-cane. This area is too small to warrant the establishment of a sugar industry in the Bura area. A reconnaissance survey has been made to find out whether soils suited to sugar-cane growing are available in the vicinity of the planned scheme. A total area of 6,500 ha net could be selected, but this area could not be served by the main canal and intake that have been projected for the 4,000-ha area.

From an agricultural point of view, the 6,500-ha area is expected to produce high yields; in a basic analysis, the internal rate of return has been calculated to be 12% and we expect that if the area were used for sugar-cane growing, the farmers would be able to attain reasonable, annual incomes. For further details, we refer to the above-mentioned Interim Report.

3.10.2 Establishment of a 4,000-ha net scheme with cotton in the main season and subsistence crops in the off-season

We assume that maize and beans constitute the major food of the future farmers on the scheme and that they will attach great value to growing these crops on their own land. We have, therefore, formulated two alternatives to examine the consequences of including subsistence crops in the cropping pattern.

In the economic evaluation we have used the economic producer's price which in 1977 we have based largely on exports and in 1982 exclusively on exports.

In the financial analysis we have started from the assumption that the farmer needs maize and beans to meet his food requirements and that he will have to buy these products if he cannot grow them on his own land. Hence, we have used a consumer's price in this analysis.

In alternative 1 we have assumed that cotton will be the main crop in the 4,000-ha net area and that in the off-season maize and beans will be grown to meet 100% of the food requirements of the farmer's family. As the cropping intensity will rise from 40% in reference year 1 to 80% in reference year 21, it will be impossible to produce sufficient subsistence crops in the first few years; in reference year 12, the farmers will be able to grow such quantities of maize and beans that they need no longer buy these products. The remaining area can then be used to grow groundnuts.

Under this alternative, the internal rate of return is 11¾% and the financial return 10½%.

Alternative 2 starts from the assumption that ultimately the farmer will be able to meet 50% of the food requirements of himself and his family. In that event the internal rate of return is 12¼% and the financial return 10¾%.

We have considered the above alternatives not only with a view to the selection of the ultimate project; our calculations have also served to give an insight into the implications if in the interest of the future farmers it were decided to start with subsistence crops in the off-season and to switch over to cash crops as soon as this is considered to be justified from a social point of view.

3.10.3 <u>Establishment of a 2,550-ha net scheme with cotton in the main season and groundnuts as the main off-season crop</u>

The Bura area is covered by three different soil classes (classification Lower Tana Study). As the Class-3 soils give relatively low yields per ha, we have assumed under this alternative that only a net area of 2,550 ha, comprising 750 ha Class-1 soils and 1,800 ha Class-2 soils, will be used for crop growing, i.e. cotton in the main season and groundnuts as the main crop in the off-season.

If intake by gravity were applied, the internal rate of return would be 13¾% and the financial return 11½% under this alternative.

Although for the 2,550-ha scheme the internal rate of return and financial return are slightly higher than for the 4,000-ha scheme, we have recommended to implement the 4,000-ha scheme. We have done so first in view of the higher settlement capacity of such a scheme, secondly because the differences in outcome are likely to be negligable, due to the uncertainties in the basic factors used in the calculations. Especially the yields on the soils of class 3 are difficult to predict and they have been kept on the conservative side.

3.10.4 <u>Establishment of a 2,550-ha net rice scheme with Basmati in the main season and IRRI in the off-season</u>

Under the intake-by-gravity alternative, the internal rate of return will be 9% and the financial return 8¼%; the pumping alternative results in an internal rate of return of 8½% and a financial return of 7½%.

3.10.5 <u>Establishment of a 2,550-ha net rice scheme with IRRI in both the main season and the off-season</u>

With intake by gravity the internal rate of return proved to be $8\frac{3}{4}$% and the financial return $7\frac{1}{2}$%.

Annex J

CONTENTS

1 GENERAL

The Kenya Government has made rural development its basic strategy in the second Five-Year Plan. The following quotation from the Plan clearly illustrates this: "For it is our aim that the fruits of development will be shared amongst the mass of the people as a whole, not just amongst a favoured few." Furthermore, the plan states: "...... the Government has undertaken both to ensure that the benefits of economic growth will be distributed as widely as possible ......".

Generally speaking, irrigation schemes can be considered to promote rural development objectives, such as:

- to increase rural production and productivity;
- to increase rural employment opportunities;
- to improve the quality of rural life;
- to increase rural incomes.

The methods to increase the rural production and productivity and the projected results have been discussed extensively in Annex D: Agronomy and Agro-economy. This Annex will deal with the social aspects of the Bura irrigation scheme, including rural employment opportunities, the quality of rural life and rural incomes.

Considering the above quotations, we will also make recommendations on facilities which will be of benefit to population groups living around the scheme, especially the Orma and the Pokomo.

2 RURAL EMPLOYMENT OPPORTUNITIES

2.1 Selection of future settlers

2.1.1 Construction period

If the Government decides to implement the scheme, we expect construction to start in 1975 (ref. year - 1), see Annex E. We have estimated in the same Annex that a labour force of about 900-1,000 men will be required in 1975 and part of 1976; afterwards the labour force will gradually decrease.

In our planning we have assumed that some 700 ha can be planted by the first tenants early in 1977. This would mean that, based on a farm size of 1.2 ha, some 580 tenants will have to be settled by the end of 1976.

We recommend that the future settlers on the scheme should be offered the opportunity to work as labourers in the construction period of both the main canal and the other works. This might enhance their motivation and involvement in the scheme and would also help to avoid that a large labour force will be without employment when construction has been completed. This also applies to the technical and administrative personnel to be employed during construction; whenever possible, they should be attracted for staff positions on the scheme.

We, therefore, recommend that the Government Committees entrusted with the selection of future tenants should start their work for the Bura scheme in the second part of 1974.

2.1.2 Settling period

The Government Committees selecting future settlers for irrigation schemes have gained several years of experience in both the Tana River District (Hola) and other districts of Kenya where irrigation schemes are located.

As the waiting list of applicants for a farm at the Hola project already numbers some 4,000 men, we trust there will be enough applicants for the Bura scheme. The selection criteria include: landless, jobless, poor, preferably with agricultural background and experience, able-bodied, not too young and not too old, married, some children. The experience on other schemes has shown that unmarried tenants tend to be less stable; moreover, they cannot provide enough family labour to handle their farms. Too old applicants show a lower adaptability to modernization and acculturation, and cannot handle their farms up to standard. We see no reason to recommend a change in the present selection criteria.

The waiting list for Hola also includes some applicants from Nairobi and the coastal areas. If it is decided to implement the Bura scheme, more people from remote areas are expected to apply for a farm.

2.2 Total employment opportunities

2.2.1 On the scheme

Generally, intensification of agriculture by irrigation and other inputs highly increases the employment opportunities.

Our calculations, presented in previous Annexes show that with a farm size of 1.2 ha some 3,330 farmers can be settled in a net area of 4,000 ha. Next to these tenants, we have planned a staff, including casual and contractual labour, of slightly over 400 people. With such a population we estimate that some 200 school teachers will be needed, some 50 or more shopkeepers, some 40 workers for the processing department, some 30 government officials (post office, police, local government officials, personnel for a hospital, etc.). This will bring the total employment capacity of the scheme at about 4,000 at least.

Based on an estimated family size of 7, the total population on the scheme would be some 27,000-29,000 people in a gross area of some 7,000 ha (see Annex C), i.e. 400 persons per sq. km in an area where we estimate the present population density to be 1 person per sq.km.

We have proposed a farm size of 1.2 ha. More employment could be generated on the scheme with a smaller farm size, but then we expect the rural income of K.£ 100 - K.£ 150 including subsistence crops to be grown on the scheme, as stated by the Ministry of Agriculture in its letter TANA/1 of 10th November 1972, cannot be arrived at in the first two decades of operation. We feel the 1.2-ha farm to represent a farm size providing a balance between settlement capacity and rural income. The subject of rural income will be further elaborated in Section 4 of this Annex.

2.2.2 Outside the scheme

If the scheme proves successful, we expect that employment opportunities will be also created for the population outside the scheme. The Orma pastoralists may find some opportunities for odd services to the scheme. The scheme will offer a marketing opportunity for their cattle and related products.

Many Pokomo are expected to apply for a plot and depending on the decision of the Selection Committee, several of them will leave their lands alongside the river. The Pokomo remaining alongside the river will find more opportunities for employment on the scheme, such as jobs as hired labour during peak periods and services for the management and staff. They will also be able to market the crops that they grow alongside the river on the scheme.

Finally, we expect that tradesmen in different articles will benefit from the new market, constituted by a population of about 30,000 people.

3 QUALITY OF RURAL LIFE

3.1 On the scheme

The success of an irrigation scheme and that of its farmers does not only depend on physical features, such as higher harvests and increased incomes. Very important factors are non-physical aspects such as the farmers' motivation, their degree of participation, the feeling of well-being in family and other social structures, the access to different services, in short, the quality of rural life.

Planners cannot create satisfaction, motivation, participation, and a high quality of rural life. They can only try to provide people with the means that can serve to achieve a high quality of rural life, and they cannot do so without the participation of those who are involved in the planning process. This is why we have recommended at several stages actively to engage the men and women who have to make the scheme, i.e. the future settlers, their families, the staff, local and central government officials and any others.

In the following sub-section we will deal briefly with the different aspects of the quality of rural life, and will make recommendations on some items of this complex feature.

3.1.1 Housing

Most important items in the farmer's life are his house, his village, and daily life with his family and neighbours, in his house, in his village, on his farm.

Traditionally, the Pokomo, the Kamba and the Kikuyu practise polygyny. We cannot foresee from which tribes the settlers on the scheme will originate, but several of them are expected to continue to practise polygyny like on other schemes. Their traditional houses were adapted to these specific composite family structures, e.g. separate houses for wives, etc. It is unlikely that these traditional homesteads can be reproduced on the scheme, because this will make modern services like water supply and other facilities too expensive.

In Figure H.1 of Annex H we have provided a sketch of a tenant's house. It should be considered to be tentative only. We recommend that future settlers, the Government Ministries, and the Housing Research and Development Unit of the University of Nairobi should take part in developing a house meeting the following requirements:

1. low cost, ranging from K.£ 200 - K.£ 300, repayable by the farmers in a period of some 7-10 years;
2. providing accommodation for polygynous families in which traditionally the wives and children are housed separately;
3. providing opportunities for grown-up boys to sleep separated from their parents, as is customary amongst the Pokomo and other tribes.

We cannot foresee at the moment how such a house should be constructed. Furthermore, we assume that some adaptation of family and wider social structures and traditional customs will take place among the settlers' families. As Dr. Muga has stated: "Social change is inevitable and even desirable, but this will come about gradually as new developments are introduced. Force which uses radical methods to bring about change will fail to create the desired results of raising the standard of living of the population and at the same time it will destroy their customs and social organization at the outlet".

Studies made by Dr. Muga and the staff of the Ahero Irrigation Research Station at the Ahero Pilot Scheme have shown that adequate housing is one of the most important items which can help remove the constraints on the success of the scheme and on the well-being of the tenants.

3.1.2 Villages

The proposed location of the villages as shown in Map 3, Annex E, has been based on the following considerations.

1. The walking distance from house to field should not exceed about 3 km.

2. Whenever possible, the villages should house farmers who have their fields in the same irrigation unit in a certain radius around the village, so that they will have a common interest in the water of the same canal.
3. The villages should be not too small; larger villages would make some services (communal water) less expensive, and they would be more viable units, where facilities like schools, a social hall, a small market, etc. could be established with more chance of success. On the other hand, the villages should be not too large, because then mutual contacts among the villagers would decrease or cease to exist.
4. The villages should be located only on lands which are unsuitable for cropping.

On the basis of these criteria we have proposed villages which are substantially larger than those on other schemes like Mwea, Hola and Ahero where, in general, a village does not accommodate more than some 100 tenants. The proposed villages for Bura vary in size from 280-300 to 440-450 tenants.

3.1.2.1 Layout

We have sketched a layout for a village in Figure H.1 of Annex H. We would recommend, however, that during the design period future inhabitants, officials from the local and central government, and institutions like the Housing Research and Development Unit of the University of Nairobi should be sounded to arrive at a layout which is adapted as much as possible to the ideas of the future inhabitants, without increasing the cost of construction.

Furthermore, we suggest that future tenants to be housed in a village should be selected well in advance of construction of the village. This will allow to adapt the layout of the village to traditional customs and structures, e.g. in relation to settlers of the same tribes, or clans, sub-clans, lineages, etc., if necessary.

3.1.2.2 Demography

Like at Mwea, Hola and Ahero, we expect a household to consist of about 7 persons; such a household may be a polygynous composite family with some relatives. We do not expect this household size to be the average in the first few years. Much will depend on the success of the farmers in these years and on the status of the future settlers. When they still have land or a house in their area of origin (as it has been rumoured to be the case on other schemes occasionally), part of the family may stay behind to safeguard old interests and to have a foothold in the paternal area. When future settlers have no security in their paternal homeland such as land, houses, or more well-to do relatives, larger families are expected to settle down.

Rapid success and good incomes will result in large families in a relatively short time, as it has been experienced on other schemes in Kenya. This will be caused by different facts such as:

- no children will be left behind with relatives;
- poor relatives will be attracted;
- the number of wives will increase; such an increase in wives per husband can easily amount to 0.2 to 0.4 woman and can reach an average of 1.6 to 1.7 wives per husband, with extremes of three or more.

The Family Planning Education Programme launched by the Ministry of Health can also be expected to influence the family sizes.

With all these factors in mind it is difficult to present demographic prognoses and to estimate when the household size of 7 persons will be reached. It is even more difficult to forecast if the household sizes will on average considerably exceed the number of 7 persons when incomes will continue to increase on the long run.

We have decided to base our estimates on 7 persons, and have used this figure in calculating the requirements for different facilities like water supply, health facilities, educational facilities, etc.

3.1.2.3 Social infrastructure in the villages

With villages of a larger size than is now usual on the other schemes, more viable units may be created where a social infrastructure can be established at less cost per inhabitant.

a. <u>Educational facilities</u>

<u>Primary schools</u>

With a village size ranging from some 280-300 to 440-450 tenants, the population will vary between some 1,900-2,100 and 2,900-3,100 inhabitants, based on an average household size of 7 persons.

Given a normal age structure, the eligible primary school population (6-12 years or 7-13 years) will vary between 19 and 21% of the population, or on average 20%. With an enrolment percentage of about 80, the primary school population in the villages will range from 300 to 500 pupils, depending on the village size. We do not expect that this enrolment percentage will be reached in the first few years; it will then largely depend on the household size and on the capacity of the farmers to pay for the school fees. Building of schools can then be extended gradually.

But we would recommend that enough space for schools should be reserved in the villages to accommodate pupils at an enrolment percentage of 80. The class rooms should be based on a class size of 30-40 pupils. In addition, spacious playing ground has to be reserved for the pupils.

As establishing primary schools is not considered to be a task of the scheme, we have not included the relevant cost in our estimate. We assume that the Government will take care of providing schools in cooperation with the villagers. But the project management and the NIB should stimulate and promote the establishment of schools from the onset of the scheme.

We recommend that the curriculum of the primary school should be adapted as much as possible to the conditions as prevalent on the scheme. Especially agricultural aspects should receive due attention; school gardens are recommended.

Nursery schools

The establishment of a nursery school in the village is recommended, since there is a fast growing interest for this type of school in the country.

Adult literacy groups - adult training

We do not expect that special infrastructure provisions will be needed for these educational and training aspects. Such education and training can be provided in the primary school buildings and/or in the social hall. Maendeleo women's groups, Youth Clubs and 4-K Clubs can also use these facilities.

b. Health facilities

We propose that a dispensary should be located in the social hall.

A nutrition survey at the Mwea Irrigation Scheme has disclosed that the diet of the tenants was less balanced than that of farmers living outside the project. There may be a tendency to spend more money on luxury goods like radios and bikes than on food rich in protein and vitamin. Usually the caloric requirements are met with adequately, but the intake of protein and vitamins is often lower than required for a good health condition. Good information on this subject to all inhabitants is a must. It can be provided to the farmers' wives in special meetings in the social hall, and also at the schools, at adult training courses and the like.

Furthermore, we propose that all villages should be provided with an area where each tenant can have a small plot to grow vegetables, bananas, chillies and other garden crops.

Regular information should also be supplied to the settlers about the hazards of malaria and bilharzia. Spraying of insecticides and moluscides against insects and snails is recommended to be done by the Disease and Pest Control Division (see Annex G: Organization, Management, Personnel).

Information and services as regards family planning by officials of the Ministry of Health should also be part of the Health Services.

c. Social hall

We propose to build a spacious social hall of a simple construction open at its sides in each village with a large open space nearby. This hall could serve many purposes such as:

- a meeting place for the villagers, for baraza's, etc.;
- to give adult training courses, a centre for special clubs, information courses, etc.;
- to accommodate a dispensary;

- a place for cotton grading in case of rain;
- a small market centre for the village.

If all inhabitants take part actively, the social hall could become a real community centre. We have entered the costs of the social halls in the villages as project costs.

d. Shops

Space should be reserved, preferably near the open place of the social hall, where private entrepreneurs can establish some shops, stores, etc.

e. Communal water supply

This physical infrastructure has been described in Annex E. The costs involved have been entered as project costs. Good potable water will greatly help to ensure a good state of health of the villagers.

f. Sports' and recreational facilities

In the proposed layout of a village we have sketched a spacious area where the villagers can practise different sports. Indoor sports and recreation could be arranged for in the social hall.

3.1.2.4 Social structures in the villages

It is difficult to predict to which extent acculturation will affect family structures and the wider social structures in a village and working relationships among the farmers. This will largely depend on the traditional structures as prevalent in the areas from where the new settlers have come, on their attitude towards change and how they themselves will develop new structures, both at village level and lower levels, to meet the requirements of their new circumstances.

The management of the project and the Government can only provide some social infrastructure like houses, schools and meeting places which are considered to be necessary for the functioning of the social structures. But should new social structures develop which would require new infrastructure, it is recommended that the tenants should be helped to realize the facilities needed.

It should be the task of the village councils to encourage the development and functioning of social structures in the villages.

3.1.3 Central compound

We have sketched a layout for this centre of the scheme, where we propose to reserve space for:

- an administrative centre;
- a processing centre;
- residential areas

- educational facilities;
- a market area and shopping centre;
- playing grounds, sports' fields, etc.;
- hospital;
- social halls.

A definitive design of the compound should be made during the design period.

For further reference, see Annex H: Buildings and Infrastructure.

3.1.3.1 Housing

a) Houses for staff

A definitive layout of the housing for the various categories of staff has to be made during the design period. At that time it could also be considered if it is advisable to relocate the villages C and E, which we have now proposed some kilometres north-east and east of the central compound.

b) Houses for labourers

At Masinga, we expect that the required casual labour and manpower for contracts can be attracted partly from the scheme and partly from the population living in the surroundings, so that no housing for casual and contractual labourers will be needed.

At Bura, the required manpower can also be partly attracted from the scheme population. But since the surrounding area is only very sparsely populated, we have assumed that two-thirds of the total labour force (150 manyears) will have to be attracted from elsewhere and to be housed on the scheme. We have, therefore, included 100 labour houses in our cost estimate (see Annex H, Table H.1, page 185).

3.1.3.2 Educational facilities

Primary school

A primary school has been envisaged to serve all the children of the central compound, i.e. the children of the staff members, the labourers, the personnel of the Processing Department and of the Health Department, Government officials, shopkeepers, etc.

Secondary school

We propose to establish a secondary school near the central compound which could serve students from the whole irrigation scheme, as well as from surrounding areas.

Village polytechnic

We recommend that a village polytechnic should be established near the central compound. The curriculum should be adapted to the special skills required on the scheme.

Nursery school

We have also planned a nursery school.

The costs of educational facilities have not been entered as project costs. We assume that these costs will be met from Government budgets, possibly partly financed by self-help schemes.

3.1.3.3 Market area and shopping centre, cinema

Enough space should be reserved for these facilities. Shopping premises and a cinema should be left to private enterprise. Banking facilities could also be established here.

3.1.3.4 Playing grounds, sports' fields

Enough space should be reserved for these facilities when designing the definitive layout.

3.1.3.5 Social hall

A social hall is recommended like for the villages. It can be expected that the staff will establish a club.

3.1.3.6 Health facilities

In Sub-section 3.1 of this Annex we have estimated an ultimate total project population of some 28,000-29,000 people. This large number of people will call for an adequate hospital, which should serve also people living around the project area, like the Orma and Pokomo. The costs of a hospital have not been included in our estimates. We assume that these will be met from Government funds.

3.1.3.7 Other Government services

Enough space should be reserved for other facilities like local Government administration, a police post, post and telephone offices, fire protection post, etc.

3.2 Outside the scheme

As stated before, the scheme could be instrumental in promoting rural development in a much wider region than its own area. The scheme will provide educational and health facilities to people living in the surroundings like the Orma and Pokomo. It will also allow them to market their produce such as cattle, milk, butter, crops grown along the river, fish from the Tana river, handicraft articles, etc.

We also propose that in designing the main canals enough provisions should be made for drinking places for the cattle of the pastoralists; this should be done such that supply of water to the scheme would not be jeopardized. Such facilities might prevent the Orma from watering their cattle in uncontrolled places, which could damage canals or dikes.

The scheme could assist the Pokomo cultivators in using tailwater which is to be spilled into the flood plains east of the project, which are at present totally uncultivated. Presumably, several hectares in the flood plains could then serve to grow food crops and some fodder crops for the Orma cattle.

Both during construction and operation of the scheme more opportunities may come forward in which the scheme and the Government can help the population in the surroundings to benefit from the scheme and to improve the quality of their rural life.

The Orma will also benefit from the good water that will become available in the villages on the outskirts of the scheme. We have, therefore, based our estimates of communal water supply on a project population of 27,000-29,000 people and about 2,000 outsiders, in total some 30,000 people ultimately.

4 RURAL INCOMES

4.1 On the scheme

The farmer's income has been discussed extensively in Annex J, Sub-sections 3.3.1 to 3.3.5. Several alternative patterns of farmer's income have been calculated under different assumptions as regards distribution of the financial surplus of the scheme.

The results have shown that the scheme can provide the farmer with a reasonably good income and that in general an income of over K.£ 100 per annum can be attained in the early eighties.

4.2 Outside the scheme

As discussed in Sub-section 2.2.2 of this Annex, the scheme will provide both the Orma and the Pokomo with some opportunities for employment during peak periods, and for odd services.

It is difficult to quantify the effect of such temporary employment opportunities on the incomes of the Pokomo and the Orma, but we expect that the scheme will bring about an improvement in their present levels of income.

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