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tana river feasibility studies
the bura area

volume I main report

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To the Ministry of Agriculture
Attn. of the Permanent Secretary
Rhodes House
Kenyatta Avenue
P.O. Box 30028
NAIROBI
Kenya

y/ref.: o/ref.: arnhem, May 1973

subject: Tana River Feasibility Studies
The Bura Area

Dear Sir,

We have pleasure in submitting to you our Final Report on the Bura Area Feasibility Study.

The Report consists of two volumes:
- Volume I - Main report, summarizes the results of the study and our recommendations;
- Volume II - Technical Annexes, provides more detailed information about the various aspects studied.

Our main findings are set out below.

- Technically, it will be feasible to irrigate 4,000 ha in the Bura Area. We have recommended that cotton should be grown as the main crop.

- For a cotton project of 4,000 ha, we estimate the internal rate of return to be about 13½%. The total investments have been estimated at K.Sh. 56 million.

- Based on a farm size of 1.2 ha, the project can provide a reasonably good annual income ranging from K.£ 100 - K.£ 150 for some 3,330 farmers. Under these conditions we expect that the investments can be repaid and that the project can bear its own O & M costs.

- Under the above assumptions we expect that ultimately some 28,000 persons, including tenants' families, scheme staff, Government officials and private entrepreneurs, can be accommodated on the scheme.

To the Ministry of Agriculture
Attn. of the Permanent Secretary
NAIROBI
Kenya

- We have recommended that construction should start as early as possible. Including the preparatory activities we estimate that the works can start then early in 1975, and that the first tenants can be settled in 1977. The project can be in full operation in 1980.

- We envisage that the project can serve as a basis for the further development of large areas in the Lower Tana Region.

We wish to express our appreciation for the assistance we have received from the Kenyan Government Authorities which has been of great value to us in carrying out these studies.

We hope that the report will contribute to the development of irrigated agriculture in the Lower Tana Region.

Yours sincerely,

I L A C O B.V.,

H. Scheer,
Managing Director for Africa.

Republic of Kenya
Ministry of Agriculture
National Irrigation Board

Kingdom of the Netherlands
Ministry of Foreign Affairs
Department of International
Technical Assistance

TANA RIVER FEASIBILITY STUDIES

MASINGA AND BURA AREAS

THE BURA AREA

Volume I - Main Report

May 1973

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ILACO
INTERNATIONAL LAND DEVELOPMENT CONSULTANTS B.V.
Arnhem - the Netherlands

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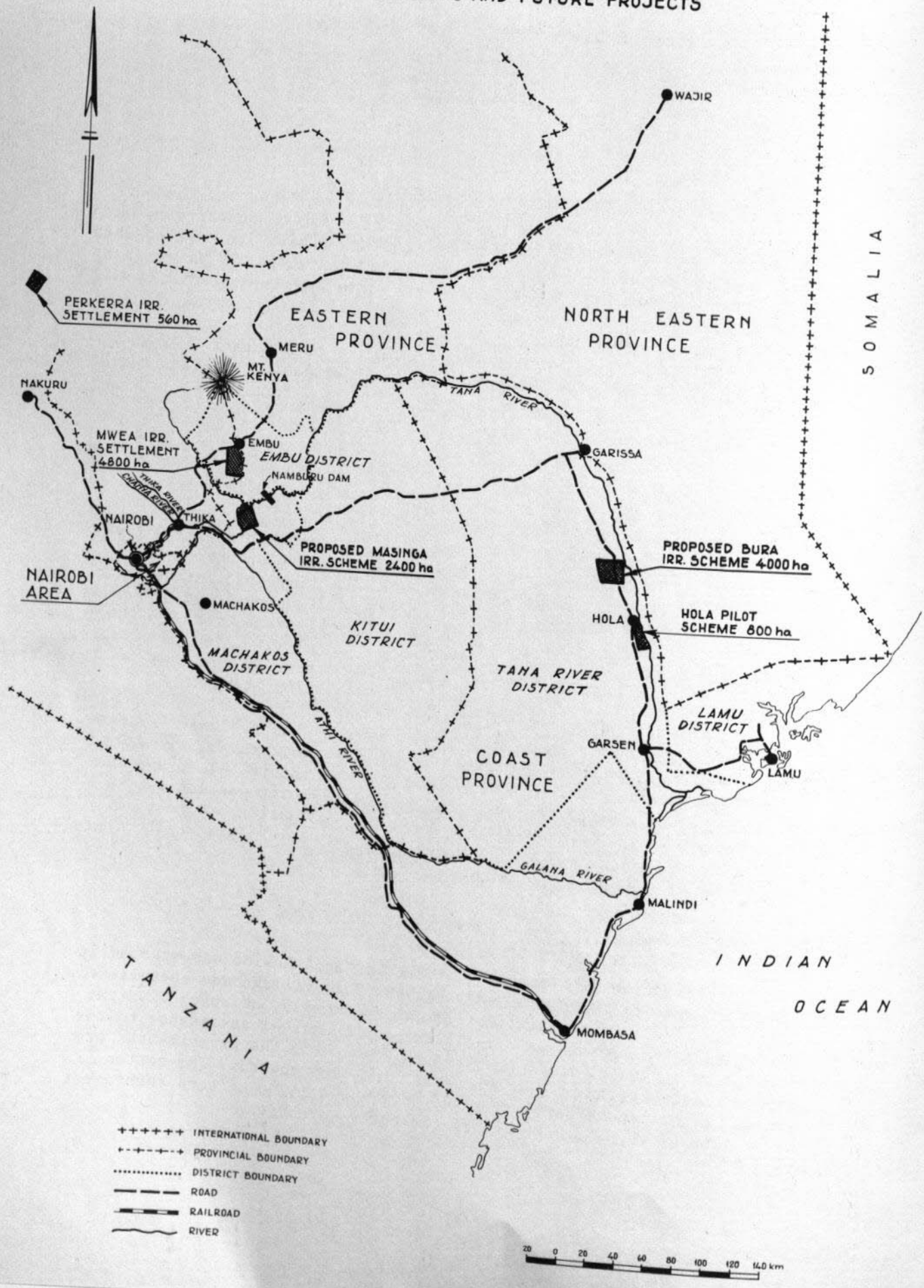
LOCATION OF EXISTING AND FUTURE PROJECTS



CHAPTER I

INTRODUCTION

1 GENERAL

In 1972, the Government of the Republic of Kenya and that of the Kingdom of the Netherlands agreed upon cooperation in carrying out feasibility studies in two areas along the Tana river, i.e. the Masinga area along the Upper Tana river and the Bura area along the Lower Tana river. The Department of International Technical Assistance of the Dutch Ministry of Foreign Affairs has entrusted ILACO (International Land Development Consultants B.V.) with the implementation of the study.

The fieldwork was carried out from July to November 1972 in close cooperation with the management of the National Irrigation Board and relevant departments of the Ministry of Agriculture.

2 BACKGROUND INFORMATION

2.1 General

The main objective of the current Development Plan (1970-1974) of the Government of Kenya is to accelerate the development of rural areas. The Government has recognized for a long time that intensification of the current agriculture and irrigation of undeveloped dry areas will help increase the carrying capacity of rural areas, rural productivity and rural incomes, and the quality of rural life. In its policies, the Government, therefore, considers irrigation development to be an important means to relieve unemployment and population pressure.

In view of the foregoing, the Government had two major surveys made on the irrigation potential of the Tana river, viz. the Survey of the Irrigation Potential of the Lower Tana River Basin, 1967, and the Upper Tana Catchment Survey in 1971. Subsequently, it was decided in 1971 to undertake a feasibility study on two irrigation projects situated in the Upper Tana Region (Masinga) and the Lower Tana Region (Bura) respectively.

2.2 Lower Tana - Bura Area

Irrigation development in the Lower Tana Region was started in the 1950s when the Galole Scheme near the Hola village was established. Until the middle of the sixties, it was no success, at which time the Netherlands Government was asked to render technical assistance to the scheme. As a result, ILACO has rendered advice on the experimental programme and operation of the scheme as from 1966 onwards. The cotton yields on the scheme have increased from about 1,200 kg seed cotton per ha in 1966/67 to over 3,000 kg in the early seventies.

In 1967, the UNDP/FAO Lower Rana River Basin Survey recommended that a 10,000-acre research and training centre should be established near Bura village. Following this recommendation and considering the promising results at Hola, the Kenya Government decided to have a study undertaken on the feasibility of irrigated agriculture in the Bura area. The results of the study have been presented in this report.

3 SCOPE OF THE WORK

The scope of the work has been defined by the Terms of Reference for the study as quoted below.

The aim of the feasibility study is to assess the technical and economic merits of the proposed projects in order to prepare bankable projects for financing. Details of the objectives are listed below.

(a) To collect and evaluate the existing data on soils, land use, vegetation, and topography supported by aerial photographs, maps and all other available data and to supplement these data where necessary.

(b) To investigate and indicate the most feasible irrigation methods, including the establishment of crop water requirements and field and conveyance losses.

(c) To recommend suitable cropping patterns, cropping systems and size of holdings, with particular reference to cotton, groundnuts, soy-beans and sugar-cane.

(d) To give recommendations on the organization and management aspects of the projects with particular reference to N.I.B.

(e) To design the primary irrigation and drainage systems for the project areas, together with a general description of the requirements for pumping stations and intake structures.

(f) To give a general description of the projects including location, size, phasing and services to be supplied to the project from outside the area (e.g. communications, infrastructures, etc.).

(g) To give estimates of the investment costs of the projects, including:

1 - direct foreign currency costs for imported items, including services;
2 - secondary foreign currency costs for locally produced items, such as cement and fuel;
3 - local currency costs.

(h) To give estimates of construction and engineering costs, including additional surveys and investigations, final design and supervision of construction.

(i) To give estimates of the operating costs of the projects.

(j) To estimate increases in farm production and net farm incomes, in case of implementation of the projects.

(k) To give estimates of debt repayment possibilities and financial results to be expected from the projects.

(l) To give estimates of the internal rate of return on the investment in the projects.

(m) To estimate the benefits of the projects, both economical and social, including employment opportunities on the local and national levels.

(n) To estimate the economical and financial benefits of the projects in relation to the national income employment and foreign currency earning capability.

Next to the above-quoted Terms of Reference, we have duly considered the comments offered by the Ministry of Agriculture in its letter of 10th November 1972 on our Interim Report of October 1972.

The Bura area, located near Bura village and covering a gross area of some 7,000 ha, roughly comprises the area recommended in the UNDP/FAO Survey of the Irrigation Potential of the Lower Tana River Basin of 1967 for the establishment of a research and training centre of about 3,000 ha net, to which an area of 1,000 ha has been added to arrive at a net area of 4,000 ha.

4 THE REPORTS

The results of the Tana River Feasibility Studies have been presented in two separate reports, one dealing with the Masinga area, the other with the Bura area.

This report, dealing with the Bura Project, consists of two volumes:

Volume I comprises the Main Report in which the findings of the studies have been summarized and recommendations made.

Volume II contains the detailed results that have been compiled in 11 technical annexes.

5 ACKNOWLEDGEMENTS

Consultants have greatly appreciated the assistance that the Government of Kenya has rendered to the team through its various Ministries and Boards. They wish to make special mention of the cooperation of the National Irrigation Board (N.I.B.); the continuous interest shown by Dr. D. Ireri, Chairman of the Board, in the progress of the study has been most encouraging to the team.

Mr. P.S.T. Mirie, General Manager of the N.I.B., and his staff have very much contributed to making the fieldwork run smoothly by arranging for office accommodation, lodging facilities in the project area, transport, and other logistic requirements.

The frequent discussions with the General Manager and his staff have allowed the team to gain a better insight into the problems involved. The long experience that the N.I.B. has gained in all aspects of irrigated agriculture on their schemes has made it possible to deal with the study as efficiently as possible.

The team has had also many fruitful contacts with officials of the Ministry of Agriculture and of other Ministries, of various Boards, Research Institutes and others in Nairobi, in other towns and in the project areas. The valuable and kind cooperation experienced and the constructive discussions are gratefully acknowledged.

6 COMPOSITION OF THE TEAM

The team consisted of the following members:

G. Bos	M.A., B.Sc. sociology, organization and management; teamleader
A.D. Maier	M.Sc. civil engineering
J.C. van der Laan	M.Sc. irrigation and drainage
H. Bos	M.Sc. agronomy and agro-economy
H.E. Drijfhout	B.Sc. soils and land use
C.J. Schellekens	M.Sc. general economy.

All the team members are permanently employed by ILACO B.V., except for Mr. Maier, who is head of the Nairobi office of Bish & Partners, Consulting Engineers (subsidiary of N.V. Heidemaatschappij Beheer, ILACO's parent organization).

During their work in the field and at ILACO's head office in Arnhem, the team has been assisted by some other ILACO senior specialists in the fields of agronomy, soil science and land use, general economy, civil engineering and construction.

CHAPTER II

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

1 SUMMARY

On the basis of the Terms of Reference an area of 4,000 ha net of suitable soils have been selected in the Bura area for the establishment of an irrigation scheme. Irrigation water can be supplied to the scheme from the Tana river; sufficient water is always available for a 4,000-ha scheme.

The climate is suitable for a wide range of irrigated crops. A cropping pattern has been selected on the basis of social, financial and economic criteria. This cropping pattern consists of cotton in the main season and groundnuts as the main off-season crop. The cropping intensity for cotton and groundnuts will be 166% after about 15 years. In addition to these cash crops, a maximum of 14% of the scheme may be planted to subsistence crops.

Averaged over the three soil types, the level of the expected cotton yields at the start of the project will be about 1,900 kg/ha, increasing to about 2,850 kg/ha after 30 years. For groundnuts the projections are 900 kg/ha and 1,850 kg/ha respectively.

Bearing in mind that the farmer should earn a reasonable income, would have to hire only some labour during picking and a maximum number of people should be settled on the scheme, we have recommended a farm size of 1.2 ha.

For the supply of irrigation water a gravity intake and a main canal have been designed. A scheme has been designed including irrigation canals, drains, roads, a central compound and a number of farmers' villages. A total investment of about K.Sh. 56 million will be required to realize the complete works, including a cotton ginnery.

Provided that during the construction phase experienced staff will be available, we assume construction will take 4½ years. In that case the first crops can be harvested on part of the scheme two years after the start of the construction.

2 CONCLUSIONS

If a scheme as proposed above is implemented, its internal rate of return has been calculated to be about 13½%.

The financial return is directly related to the farmer's income, and, therefore, a policy matter which has to be decided on by the Government. Several alternative farmers' incomes have been calculated. One of these alternatives is a farmer's income of K.£ 60 in the initial years rising at 3% per annum to K.£ 150 in reference year 32. In this case all investments will be repaid and the financial return is 0%. If the farmer's income is not taken as a cost factor, the financial return of the scheme will be nearly 11%.

The foreign currency earning capacity resulting from the future cotton exports will be considerable.

If the scheme is implemented with the recommended farm size of 1.2 ha, 3,330 tenants can be settled on the 4,000-ha scheme. We expect that in total some 4,000 families, or about 28,000 people, will find a living on the scheme, including the scheme staff, labour, government personnel and private entrepreneurs.

Also considering that the Bura scheme may serve as a basis for further development in the Lower Tana Region, we conclude that the scheme as proposed in this study is feasible.

3 RECOMMENDATIONS

Based on the findings of our studies, we would make the following recommendations.

- If it is decided to establish a scheme in the Bura area as suggested in our report, the preparations for its implementation should be started as soon as possible.

- As, in our opinion, the Lower Tana Region offers good opportunities for sugar-cane growing, we would suggest that the research on sugar-cane at Hola should be intensified in line with the detailed research programme as laid down in ILACO's report on a visit to Hola submitted to the National Irrigation Board in April 1973.

- At a later stage, a comparative survey should be made on the extension of sugar-cane growing in Western Kenya versus the establishment of a sugar industry in the Lower Tana Region taking into account the further results of the intensified sugar-cane research at Hola. Depending on the findings of such a survey, a study could be made on the feasibility of establishing a sugar-cane project in the Lower Tana Region, north or south of the Bura cotton scheme.

- With a view to further development of the Lower Tana Region, an overall programme should be drafted indicating the planning of further projects. The programme should be based on the results of studies made in the region in the sixties and on those obtained at Hola; it should also consider the views and calculations presented in this report and the plans for development of the whole Tana River Basin to be drafted by the Tana River Development Authority.

CHAPTER III

THE PROJECT AREA

1 PHYSICAL ASPECTS

1.1 Location, topography and accessibility

The Bura project area is situated between 1°6' South and 1°12' South latitude and 39°51' East and 39°56' East longitude; it lies at an altitude ranging from 84 to 102 m above mean sea level. The area is bounded by the river flood plain in the East and the Garissa-Hola road in the West, and lies on both sides of the L. Hiraman.

The southern area comprises some 5,300 ha gross, of which 3,000 ha have been planned for irrigation; in the North, a net area of about 1,000 ha is suited to irrigated agriculture out of a gross area of 1,700 ha. The difference in net and gross area is not only constituted by part of the flood plain lands and the unsuitable soils, but also by the areas occupied by roads, canals, night storage reservoirs, drains, etc.

The topography of the Bura area is fairly regular; the area slopes gently southward and eastward, and relatively limited land grading will be required.

The project area is accessible by unmetalled roads from Garissa (100 km) and via Garsen from Malindi (240 km). These roads are liable to flooding in the wet season, and difficult to pass by motor cars after rainfall. The nearest railway head is Mombasa, 350 km from the area. The village of Bura is situated just across the Tana river, and can be reached on foot.

The nearest administrative centre is Hola, 45 km south, which also has an airstrip.

1.2 Climate

Like the whole of East Africa, Bura has two rainy seasons, viz. November/December and March/April. In between these seasons the climate is very dry, with a very hot period in January and February, and a relatively cool period from June till October.

Rainfall data proved available only from a station near Bura just across the river, with records covering 1920 to 1930 and 1967 to 1971. More complete meteorological records from 1963 onwards have been kept at Hola. As the data are not very reliable, we had to use them with caution. The rainfall in the area is very erratic and may vary between 200 and 1,000 mm per annum; the average annual rainfall at Bura is 415 mm (14 years), at Hola 470 mm (11 years). The average temperatures are high, from over 29° C in February and March to 26° C in July and August; the

mean maximum temperature is over 35° C and the mean minimum temperature below 20° C in February and August respectively. Solar radiation shows the same pattern: high values in March (almost 600 cal/cm^2/day) and low ones in July (450 cal/cm^2/day).

Wind speeds are high, on average from 80 mpd in December to 140 mpd in August; the prevailing wind direction is South during most of the year.

Due to the low rainfall no agricultural crops can be grown without irrigation; with irrigation, the climate is excellently suitable for agriculture.

1.3 Hydrology

1.3.1 General river characteristics

The Tana river is the source of irrigation water for the Bura scheme. The discharge of this river is in excess of the water requirements of the scheme throughout the year.

Its flow depends both on direct runoff and on groundwater seepage. Sudden peak flows from runoff are followed by long flow recessions when the flow mainly depends on groundwater sources.

Between Garissa and Bura, the Lower Tana river meanders through a flood plain at a fairly gentle gradient of about 0.46 pro mille. The flood plain is on average about 3 km wide.

1.3.2 Water discharges and water levels

The probability of occurrence of minimum and maximum annual flows has been calculated, based on daily records of gauging station 4G1 at Garissa. The data from station 4G4 at Lahza indicate that the same flows may be expected at the proposed sites of the intake for the scheme. The annual maximum flows to be expected are:

$Q \geq 2{,}600$ m^3/sec (return period 50 years)
$Q \geq 2{,}900$ " (" " 100 ").

The annual minimum flows to be expected:

$Q \leq 31$ m^3/sec (return period 5 years)
$Q \leq 27$ " (" " 10 ").

Flows exceeding 1,000 m^3/sec are likely to occur in the periods April-June and October-December. Flows less than 50 m^3/sec can be expected in the period January-April and from August to November.

The water levels to be expected at the intake sites have been estimated, based on the scarce data. At Q = 27 m^3/sec, the level at the proposed gravity intake is 108.90 m; at Q = 2,900 m^3/sec, 115.45 m. At the pumping intake these levels are 96.93 m and 102.72 m respectively. These data are not considered to be accurate enough. Additional daily measurements of the river stages at the proposed intake sites are necessary and should be started as soon as possible. Current metering is advisable.

1.3.3 Quality of the river water

The sediment load of the water of the Lower Tana river is mainly silt, the content of which builds up with increasing river discharges; a silt/fine sand content between 700 and 3,000 p.p.m. at a discharge of about 1,000 m^3/sec has been measured.

The water has been classified as low salinity low sodium water, with an average electrical conductivity (EC) of 215 micro mhos/cm and an average sodium absorption ratio (SAR) of 0.6. This is excellent water, Class C_1S_1 of the U.S. Salinity Laboratory, and water of this quality is not expected to give rise to salinity problems.

1.4 Soils

As many soils data have been presented for the Bura area in the Lower Tana Basin Study, the soil survey has been concentrated on the problem soils, i.e. the fairly and marginally suitable soil units. These soils have been sampled to determine their chemical and physical properties. In addition, some sampling was done at Hola to assess the changes that will occur in these soils under irrigation. The problem soils have swelling and shrinking properties to varying extents. Their chemical data compare well with those of the Lower Tana Survey. For similar soils at Hola, where the original sampling data and those after years of irrigation have been considered, it has been found that salts have been leached from the topsoils but that the saline-alkali subsoils have generally increased in alkalinity.

Crop yields in Bura on the highly suitable, well suitable and suitable soils are expected to equal those obtained at Hola. The marginally suitable soils are expected to yield less, also because of their shallower topsoils.

2 SOCIAL ASPECTS OF THE PROJECT AREA

The project area is very sparcely populated and only used for grazing by Orma pastoralists. The population density is estimated at about 1 person per sq. km on the average.

Outside the project area along the Tana river, Pokomo cultivators grow food crops, mainly for their subsistence.

Demographic data of the area are very scarce, especially those about the Orma. The urbanization rate and migration trend of the Orma are very low, of the Pokomo they are substantially higher.

The state of services and activities in the project area is either extremely low or non-existent.

3 PRESENT STATE OF AGRICULTURE

No crops are grown in the area. During and shortly after the rainy period herdsmen roam through the area with their cattle, moving closer to the Tana river in dry periods of the year.

The project is located on Trust Land of the Tana River County Council.

The Orma have no traditional rights on parts of the land as is usual among transhumant pastoralists. Grazing rights are usually vested in the lineage or in the tribe, but they have not been clearly demarcated. Permanent huts are not found in the area; the Orma build temporary huts when their herds are grazing the area.

4 DEVELOPMENT WITHOUT IRRIGATION

Under the semi-arid conditions as prevalent in the area, crop production without irrigation is impossible. Without water supply, the area will be used only for grazing during the wetter periods of the year. The total net production value of cattle raising is estimated at K.Sh. 8,400 a year, which works out at an average family income of K.Sh. 600 a year for the total project area.

By improving breeds and providing more waterholes and dipping installations, the net production value is expected to increase about 10% over a project period of 31 years.

As no substantial economic development can be envisaged without water, financial evaluations of future development without irrigation would make no sense in view of the extremely low net production value of the cattle. This implies that without water, only some very minor improvements in the social situation will be possible.

CHAPTER IV

THE PROJECT

1 BRIEF DESCRIPTION

Based on available maps, field surveys and soil investigations we have calculated that out of some 7,000 ha gross, 4,000 ha net are suitable for irrigated agriculture.

The irrigation water is to be supplied from the Tana river by gravity through a canal of about 48 km. We have also studied the possibility of pumping water from the Tana river, but our calculations have revealed that this is a somewhat less attractive solution because of the higher recurrent costs in this case.

The water will be conveyed via branch canals, block feeders and unit feeders to the fields. A drainage system has also been designed.

Our agronomic and agro-economic calculations have shown that growing cotton as the main crop will give the best results. As secondary crops we have recommended groundnuts and maize. In view of the remoteness of the area we have proposed that maize should be included in the off-season cropping, since this will allow the farmers to meet part of their own food requirements. Moreover, we expect that the farmer's income from maize will not differ much from that to be derived from groundnut growing.

We have calculated that when the above crops are grown on a 1.2-ha farm, the farmers will be able to attain reasonably good incomes.

It might be considered to establish a fairly large ginnery at Bura, which could also handle the cotton from Hola.

The villages for the tenants will be somewhat larger than is usual on other N.I.B. projects; we expect that this will make them more viable units, where various facilities can be provided at less cost per inhabitant.

The central compound as envisaged will include enough space for residential areas, a technical and an administrative centre, a processing unit, playing grounds, sports' fields, schools, a hospital, stores, shops, a cinema, etc., which will provide the inhabitants with the means to create a good quality of rural life.

2 AGRICULTURAL DEVELOPMENT AND PRODUCTION

2.1 Cropping patterns and projected yields

The Hola Pilot Scheme has proven that irrigation makes high-level crop production possible in the Lower Tana Region. For reasons of economy, marketing and processing, however, only a limited number of crops can be grown successfully in the region. Another constraint on crop growing are the alkali subsoils of the marginally suitable soils which restrict the types of crops to be grown and their yield potentials.

In the economic evaluation cotton, groundnuts, rice, maize and beans have been considered, representing highly profitable cash crops and traditional food crops respectively. As rice is difficult to rotate with other crops, it has been evaluated separately.

Yields are expected to increase rapidly on soils of classes 1 and 2; on class-3 soils, the rise in yields will be somewhat slower due to the alkalinity of the subsoil (see Table IV.1).

Table IV.1 - Yields in kg/ha and NPV's in kg/ha in reference year 31

Crops	Yields in kg/ha			Weighed average	Average NPV K.Sh./ha
	soil class 1	soil class 2	soil class 3		
Cotton	3,400	3,000	2,400	2,850	2,750
Maize	4,500	4,000	3,000	3,750	100
Beans	1,600	1,400	1,100	1,350	550
Groundnuts (shelled)	2,400	2,000	1,400	1,850	1,040
Rice					
Basmati-MS*	4,500	4,500	-	4,500	2,140
IRRI-varieties MS*	6,000	6,000	-	6,000	1,940
IRRI-varieties OS*	5,000	5,000	-	5,000	1,480

* MS = main season
OS = off season

As proven at Hola, cotton, the most profitable crop, is to be grown from February to August. During the short off-season from September to January, groundnuts would be most profitable. But if a farmer grows only cotton and groundnuts, he has to buy his food at a high price.

In view of the foregoing, we have calculated the farmer's income under three alternative cropping patterns. Under each of these alternatives, cotton is to be grown during the main season. In the off-season, either (1) groundnuts or (2) food crops to meet 50% of the farmer's food requirements supplemented with groundnuts, or (3) food crops to meet 100% of the farmer's food requirements when possible supplemented with groundnuts, have been projected.

Economically, a combination of cotton and groundnuts has proved most profitable, but financially the farmer will hardly gain, if he replaces food crops grown for his own consumption by groundnuts.

The annual farmer's income, calculated at financial prices and including costs of casual labour but excluding charges for management and water, will increase for an 0.8-ha farm from K.Sh. 1,300 to K.Sh. 2,600 a year over the 30-year evaluation period, 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. It should be realized that these incomes are averages over the whole scheme, and that the farmer's income is likely to vary on the different soil types.

The labour requirements have been calculated, assuming a family size of seven persons, three of whom will be potential workers. Normally, each of them is expected to work twenty days a month; in peak periods, e.g. during harvesting, 26 days. The farmer's family labour suffices to run an 0.8-ha farm. At a 1.2-ha farm size, some labourers will have to be hired during cotton picking. With farms of 1.6 ha, it is doubted whether enough labourers would be available in the region to cope with the cotton harvest.

When comparing the farmer's income and the labour requirements under the above three farm sizes, an average farm size of 1.2 ha is recommended.

2.2 Rice cultivation

In view of its sensitivity to alkalinity, rice should be grown on soils of classes 1 and 2 only. Experience elsewhere in Kenya has shown that two rice crops can be grown in one year. Ultimate yields and NPV's per ha have been presented in Table IV.1,page 12. Basmati, a high-priced long-grain variety, is the most profitable crop during the October-March season, while IRRI-varieties should be grown during the off-season from March to August, when the yields of Basmati are expected to be very low.

The annual farmer's income on a 1.2-ha farm would increase from about K.Sh. 860 in year 1 to K.Sh. 3,370 in year 31, which is less than the income to be derived from growing cotton and secondary crops.

No casual labour needs to be hired from outside the scheme for the proposed 1.2-ha rice farm.

In addition to the rice grown on soils of classes 1 and 2, cotton, groundnuts and maize will be grown on soils of class 3, which cover about 36% of the project area. Yields will be lower than on the soils of classes 1 and 2, especially in the first five years.

2.3 Research

To achieve the projected high yields, an adequate research organization should be available to the scheme. The research work should be concentrated on the type of crops and the varieties to be grown, on planting periods, on fertilizing, on disease and pest control, and on improved farming techniques. Initially, the research could be conducted at Hola.

3 WATER REQUIREMENTS AND WATER AVAILABILITY

The water requirements at the intake of the main supply canal have been calculated. They have been based on open water evaporation to which certain crop coefficients have been applied which, in turn, have been adjusted for cropping calendars and cropping intensities. Four different cropping patterns have been used. In addition, adjustments have been made for effective rainfall, pre-irrigation and losses.

The evaporation has been calculated, using the McCullogh tables for the computation of the Penman estimate of open water evaporation. The monthly values of the crop coefficients have been estimated on the basis of research work elsewhere in Kenya. As a crop cannot be planted over a whole scheme in one day, adjustments had to be made for staggered growing periods and also for intensities. The effective rainfall has been calculated from the one-in-five-year dry monthly rainfall, using the meteorological data available for the Bura area. The results had to be adjusted for pre-irrigation, for the first irrigation, and for the soil moisture depletion in the last month. Certain percentages have been assumed for conveyance and field losses, resulting in an overall efficiency of 65%.

The water requirements on the 4,000-ha scheme will vary between 1.15 and 4.11 m^3/sec for cotton, and between 0.42 and 4.33 m^3/sec for a combination of cotton and rice.

The minimum flow of the Tana river at the site of the proposed intake is always in excess of the water requirements of the 4,000-ha scheme.

4 INTAKE AND MAIN SUPPLY CANAL

Two possibilities for the supply of irrigation water from the Tana river have been considered, a gravity intake and a pumping station. The costs of investment, and of operation and maintenance under the two alternatives have been compared. A gravity intake has been found to be slightly more advantageous than a pumping station, because of the higher recurrent costs of the latter.

An intake structure is to be built outside the main riverbed with an entrance canal of about 100 m to the river. The structure will consist of two Armco nestable pipes, Ø 4.5 feet (1.37 m) each with movable gates to regulate the flow.

At the beginning of the entrance canal, a sloping sill has been planned to prevent sand from entering the canal as much as possible. Furthermore, the first part of the main supply canal will be excavated in excess for temporary sand storage.

The main supply canal will be 48 km long. The first 11 km will have to be excavated rather deeply, subsequently the canal will more or less follow the contours. Four out of five seasonal watercourses

(laghas) will be crossed by the main canal by means of inverted siphons, at one of which a flush sluice cum spillway has been planned. For the crossing with the lagha Tula, a culvert will be constructed.

For the maximum water intake of 4.11 m^3/sec, the canal will have to be about 1.80 m deep with a bottom width of 2.70 m. Seepage losses have been taken at 10%.

5 LAND DEVELOPMENT

5.1 General layout of the scheme

A preliminary layout of the scheme has been made, as presented in Map no 3. For the net area of 3,000 ha south of the L. Hiraman, the Lower Tana report design could be used; a new design had to be made for about 1,000 ha north of the stream. The 1 : 20,000 scale map showing the design has been derived from a 1 : 10,000 scale map and a 1 : 50,000 scale map, which, unfortunately, did not agree with each other very well. We, therefore, strongly recommend that a detailed topographical survey should be made for the definitive design.

Certain soil groups classified as unsuitable (see Map no 2) have been left out of the design; on these soils the villages and central compound have been planned.

The length of the furrows has been taken at 300 m, which has proved satisfactory at Hola. Some grading will be needed.

5.2 Irrigation

The furrows will be laid out under a grade of 0.1 to 0.4%. A grade of 0.2% is recommended, but the natural grade should be followed as much as possible. Every field will have its own inlet from a unit feeder and the tenants will irrigate 90 mm net from a head ditch, every two weeks in periods of maximum demand. Unit feeders will receive water from block feeders, which, in turn, will be fed from night storage reservoirs. These reservoirs have been planned, because day-time irrigation is considered to be much more efficient than continuous irrigation. The block and unit feeders will, therefore, have double capacity. Three branch canals have been projected, each of them built on a slight ridge in the terrain, which will feed the night storage reservoirs continuously at a duty of 1 litre/sec/ha.

Drop structures will be needed in the branch canals; they have been projected just before the off-take to the reservoirs. Even though the maximum velocity is kept below 50 cm/sec because of erosion dangers in canal banks (Hola experience), no drop structures will be necessary in block and unit feeders.

Water measurements will be taken at the off-takes to the branch canals.

5.3 Drainage

Apart from a limited flow through cracks in the soils when dried out, all drainage will be surface drainage. The grading requirement for irrigation will also serve for drainage.

In view of the arid climate in the Bura area, the drainage coefficient for the scheme has been estimated at 2 litres/sec/ha; completely filled, the drains can cope with double this capacity, but for short periods only. The maximum velocity in the drains has been taken at 80 cm/sec. No area reduction factor has been taken into account because the areas using one and the same main drain are too small.

Unit drains will carry the water to block drains, which discharge into the main drains. The main drains will flow into the Tana river via the flood plain lands, where the drainage water can be used by the farmers to irrigate small shamba's.

Drop structures will be required only in the main drain, especially in the area where the land slopes into the flood plain lands. One of the drop structures is to be built into a weir on every main drain for water measurements.

6 BUILDINGS AND INFRASTRUCTURE

6.1 Layout

A central compound and nine villages have been planned on the scheme. The villages will be spread in such a way that the distances from homes to the fields are minimized as much as possible. The central compound and the villages are proposed to be situated on soils unsuitable for cropping.

The central compound has been projected close to the centre of the scheme, near the Hola-Garissa road. It contains locations for a technical and an administrative centre, housing areas for staff and labour, schools, sports' grounds, a civil and a shopping centre, and a hospital.

6.2 Technical and administrative centres

The technical centre will consist of a workshop for repairs and maintenance of a tractor fleet of 40 tractors and some other machinery. Separate space has been planned for carpenting, welding, a fuel station, etc. In the technical centre, a generator has been proposed to provide electricity to the workshops and to the staff houses.

The administrative centre will mainly include office space; a special room has been planned for a research laboratory.

The technical and the administrative centres will be of primary importance to the proper functioning of the scheme.

6.3 Housing

Staff housing includes a guest house, a general manager's house, senior and junior staff houses. The larger houses can be built by contractor, the other ones under the project's own management.

As farmers usually pay for their own housing on N.I.B. schemes, we have followed this practice also for the Bura project.

We would recommend that the type of house to be built for the tenants should be subject of study and discussion among the management, the future settlers, Housing Research Institutes, and Government officials. This would allow to design a type of house adjusted to the specific family structures of the future settlers. We presume that such houses will be more expensive than those on other irrigation schemes, and have, therefore, recommended that the period for repayment of housing loans should be longer than arranged for at present, with possibly a grace period of some years, or a low amortization rate in the first years.

In view of the foregoing, we have drafted only a sketch for a tenant's house of simple construction, having a floor space of 30 m^2. In view of the heavy soils with their swelling and shrinking properties, special attention must be given to the foundation of these low-cost houses; like for all the other houses and buildings, a reinforced concrete strip has been suggested. The outer walls could be made of 10-cm thick cement-sand blocks.

6.4 Social services

In this Sub-section some social services are briefly discussed, which are considered essential for a successful scheme.

A social hall should be built in each village which may serve many purposes such as meetings, training courses, adult education classes, etc., and it could also house a dispensary. The cost of construction of these social halls has been included in the project cost.

Not included but nevertheless essential are several other facilities such as a nursery and primary schools in each village; a secondary school and a village polytechnic at the central ocompound; dispensaries in each village and a hospital at the central compound; sports' grounds and recreational facilities.

6.5 Main roads

The existing Hola-Garissa road has been deflected around the scheme. Rather high costs are involved in constructing this road, because two seasonal streams have to be bridged. Two north-south and three east-west running roads will form the main direct routes on the scheme. These roads are opening up the scheme by three connections with the deflected road to Garissa.

All primary roads will be of the all-weather type. For surfacing, a 10-cm layer of coral limestone will be used, because the material is available in the vicinity. The width of the main roads will be 9 and 6 m, the surfacing 6 and 4 m respectively. All roads must be cambered and bordered by drains.

6.6 Supply of drinking water

Water from the Tana river is the only source for drinking water. Combined sand filters and chlorification units must be installed for purification of the water.

The central compound and each village will have their own water tower. In the villages, communal water points will be installed at the beginning of the branch roads; the staff houses in the central compound will have their own water points.

7 PROCESSING

The cotton production in the project area is expected to grow rapidly, in about 10 years to about 10,000 tons of seed cotton. In the next 20 years, the production will gradually increase to 11,000 tons a year. Additionally, some 2,500 tons of seed cotton per year are produced in the Hola area, about 45 km from the Bura project. At present, seed cotton from Hola is ginned at Lamu, about 260 km away from the area.

Hence, a ginnery handling some 12,500 to 13,500 tons of seed cotton a year could become a feasible proposition in a relatively short period of time. A fairly big ginnery with a production capacity of 30-35 bales of lint cotton per hour would be needed. The capital investment in such a ginnery has been estimated at about K.£ 250,000 in current prices. During the ginning season, a labour force of 50-75 people, of whom 10-15 must be skilled, will be needed.

Other solutions that may be considered are:

- phased installation of two smaller-sized ginneries, in line with the increase in production;
- installation of one or two ginneries, the size of which is to be related to the ginning season, i.e.:
  - in case of a short season, a high-capacity ginnery;
  - in case of a longer ginning season, a ginnery with a smaller capacity and facilities to store the seed cotton.

Considering that various alternatives are possible, we would recommend that a feasibility study should be made some 2½ years before the first cotton crop will be harvested.

It is estimated that the delivery time of a ginnery will be about half a year and its erection in the area will take about one year, including a running up period.

The ginnery will need about 40 kWh per bale installed capacity, or a total installed capacity of 2,000 h.p.

8 ORGANIZATION AND MANAGEMENT

An organization system has been recommended with particular reference to the N.I.B.; it is, therefore, related to the Trust Land (Irrigation Areas) Rules, 1963, which are in force on all the irrigation projects of the N.I.B. Under these rules the farmers are licensees for their holdings; the license is valid for one year, but is automatically extended when the licensee does not fail to comply with the rules. This system works satisfactorily on the N.I.B. schemes.

The management of the project is to provide the farmers with many services and inputs, such as water, seeds, insecticides, fertilizers, guidance in marketing of their produce, land preparation, etc. The farmers will have to pay for these inputs and services.

The management of the scheme as suggested is somewhat more intensive than that for a rice scheme of the same size, because cotton poses more difficulties as regards irrigation, weeding, control of pests, etc. than rice.

The personnel requirements for all levels of staff have been presented in Annex G; we have also made recommendations on training for different levels of staff.

9 SOCIAL ASPECTS

The scheme is expected to meet the objectives of the rural development plans of the Kenya Government, i.e. to increase rural production and productivity, rural employment, and rural incomes, and to improve the quality of rural life.

Crop production in the Bura area has been discussed in Section 2 of this chapter. The scheme will offer employment for at least some 4,000 people, i.e.:

3,330 farmers
410 project staff, including casual labour
200 school teachers
50 shopkeepers
40 people in agricultural processing
30 government employees (postal services, police, local government, medical and health services, etc.).

Assuming that each family will consist of 7 persons on the average, about 28,000 people will then be able to live on the scheme.

For all alternatives that we have considered, the annual farmer's income will be over K.£ 100 in the early eighties.

In addition, we expect that the scheme will provide the Orma and Pokomo living outside the Bura project area with some employment opportunities during peak periods, with better marketing opportunities for their produce and thus improve their present level of income.

Furthermore, they will benefit from the educational and health facilities on the scheme.

10 DESIGN AND IMPLEMENTATION

Pilot projects

We have assumed that the Government will decide on the implementation of the project before October 1973, and that the ministries concerned will meanwhile take steps to initiate the design phase, such as reserving funds, recruiting personnel and making logistic arrangements. If so, the design work can start late in 1973 or early in 1974; it is expected to take about 9 months. We expect that negotiations with financing institutions including appraisal of the project, will take place simultaneously. Subsequently, invitations to tender can be arranged in October 1974.

Depending on the Government's policy and decisions, an organization must be established which is to supervise the construction of the minor works to be undertaken by the N.I.B. proper or by any other Government agency.

If no serious delays occur, we estimate construction can start early in 1975. Figure IV.1 roughly indicates the proposed design and implementation schedule. A more detailed work plan for construction of the main supply canal and the land development on the scheme has been presented in Annex E.

Detailed critical path analyses and planning networks will have to be worked out during the design period, both for the whole project and for the major parts of the works. In this report we will only discuss a few items of special interest.

- We have recommended that the housing of the tenants should be subject of study and discussion among the parties concerned. Such a study should start in 1974, in order that the first villages could be built before construction of the scheme starts to provide housing for labourers to be employed.
  Construction of the villages will last until the end of 1979 when all the tenants will have to be settled.

- Construction of the central compound and of the staff houses should start early in 1976.

- Construction of the water supply system cannot start until the main canal will have been completed by the end of 1976. Consequently, other provisions will have to be made for the supply of water to both the people and the works. It could be pumped temporarily from the Tana river or hauled by trucks.

- We recommend that a clinic should be built as soon as construction starts. In 1978, when about 1,500 tenants are expected to have settled, and the total population of the scheme may be about 9,000-12,000 people, the constructoion of a hospital should start.

DESIGN AND IMPLEMENTATION SCHEDULE

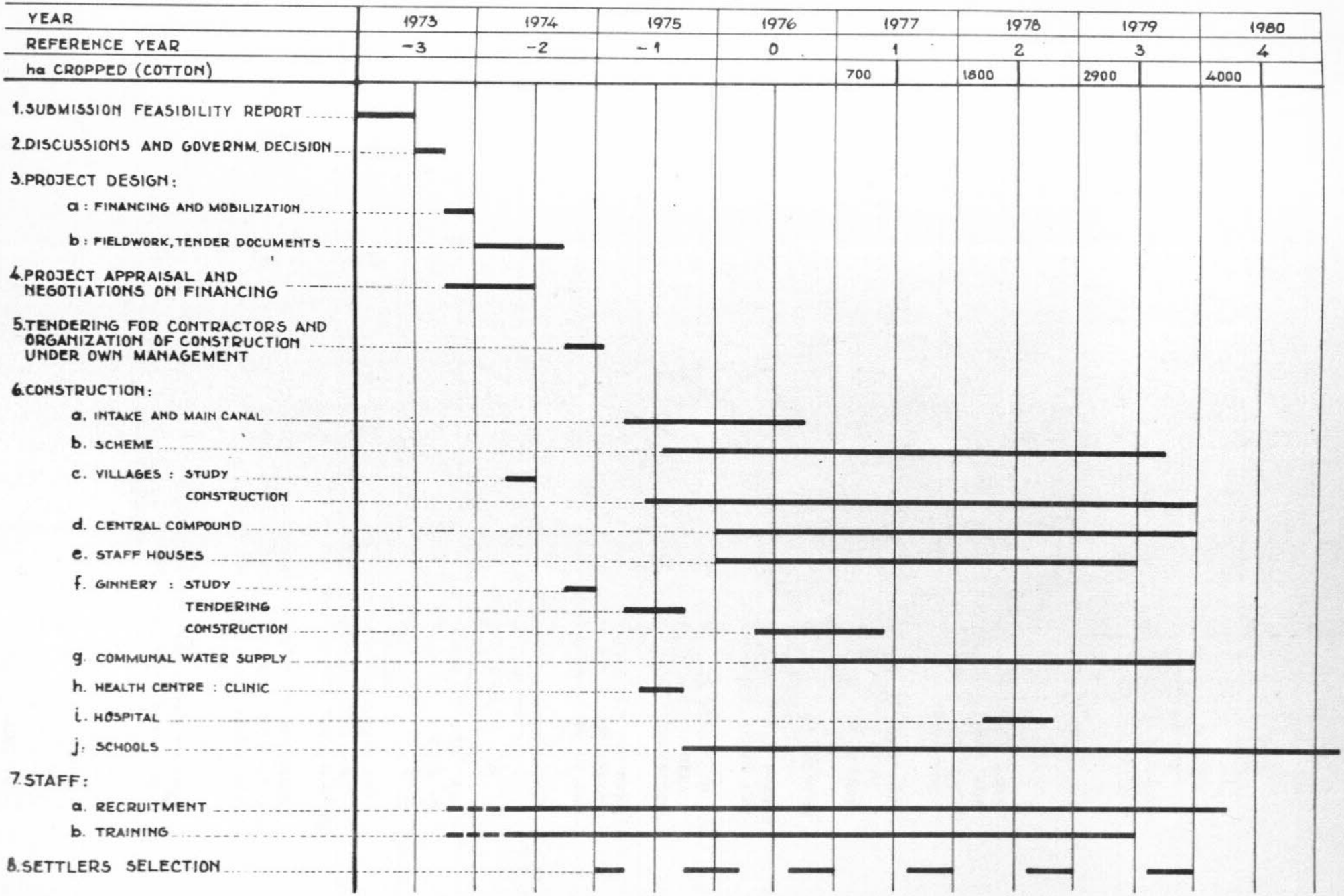


FIG. IV.1

BURA

- The building of schools should be set going as early as 1975. This may encourage families with children to settle on the scheme, which may help create a balanced community as early as possible. The building of schools will continue in the early years of the project depending on the number of pupils present on the scheme.

11 CONSTRUCTION METHODS

Construction has been planned to take 4½ years. First the construction of the main canal will be started, and half a year later the development of the scheme is to commence. After 1½ years the main canal will be completed and the first 700 ha will be ready for cultivation; each subsequent year another 1,100 ha will be completed.

In view of the large amount of earth to be moved, the main canal will be excavated mechanically, with the aid of large excavators and bulldozers. Similarly on the scheme those works calling for moving of large quantities of earth, such as excavation of the main drains, construction of roads, the fill for branch canals, and the land grading are to be carried out by machines. We estimate that during the first year somt thirty items of heavy equipment will be required, which number will be reduced to about half as soon as the work on the main canal has been completed.

Excavation of the irrigation canals and most of the drains on the scheme will be carried out in hand labour. The construction works will offer employment to about 1,000 men at a maximum during the second year of construction, and to about 650 men later on.

Construction of the intake and all major structures on the main canal will take place in the first 1½ years. Construction of the minor structures will be carried out in line with the other activities in the areas to be developed.

During the fieldwork in Kenya we have discussed the advantages and disadvantages of having the project constructed by contractors or under the supervision of a Government agency. If the construction of the Bura scheme were carried out by a specialized Government agency, high investments would be required in equipment and personnel. This is not justified for a 4,000-ha scheme, if continuity of the activities of this agency cannot be guaranteed. Therefore, we recommend that for the Bura scheme the following course of action should be adopted.

The major construction works requiring expensive machinery and highly specialized experience could best be done by contractors, i.e. construction of main canal, large structures and intake, and the building of workshop, offices and staff housing.

The minor works on the scheme such as land grading, minor structures, construction of the irrigation canals and drains, and the building of subordinate staff and tenants' housing can be carried out under the project's own management.

The cost estimates for the construction have been based on the foregoing assumptions, i.e. major works to be done by contractors and minor works under the project's own management.

12 INVESTMENTS AND RECURRENT COSTS

The construction cost estimates presented in this section have been based on bills of quantities derived from the preliminary designs and unit rates. A contractor's fee has been included in those items of the construction which in our opinion should be carried out by a contractor.

The investments have been phased over the years in accordance with the construction programme as discussed above.

Table IV.2 - Estimated investments including cotton ginnery up to 1980 (in K.Sh. 1,000)

	1974	1975	1976	1977	1978	1979	1980	Total
Design	1,500							1,500
Construction intake, main canal, inspection roads		5,174	10,347					15,521
Construction irrigation works			3,270	5,138	5,138	5,138		18,684
Cotton ginnery			4,000	1,000				5,000
Farm mechanization				425	335	310	420	1,490
Other investments*		2,370	4,588	3,436	2,019	1,430	260	14,108
Total	1,500	7,549	22,205	9,999	7,492	6,787	680	56,303

* The other investments (in K.Sh. 1,000) include:

- housing	K.Sh.	4,753
- administrative centre	"	359
- workshop		1,017
- central compound	"	1,544
- villages (excluding tenants' housing)	"	4,273
- enclosures	"	323
- investments in means of transport	"	500
- working capital	"	1,344
		14 m

Our estimates of the operation costs are given in Table IV.3, next page.

Table IV.3 - Estimated operation costs (in K.Sh. 1,000)

	1975	1976	1977	1978	1979	1980
M. & O. roads, irrigation and drainage systems		69	318	489	661	833
Management	130	567	1,046	1,518	1,843	2,001
Direct variable farm costs			613	1,626	2,698	3,832
M. & O. buildings, houses, workshops, etc.	97	340	513	662	713	753
Total	227	976	2,490	4,295	5,915	7,419

13 MARKETS AND PRICES

The market structure in Kenya is governed by a system of Marketing Boards, which are authorized to handle the buying and selling of the agricultural products grown in the country. The boards that will be of major importance to the scheme in this regard are the Maize and Produce Marketing Board and the Cotton Lint and Seed Marketing Board. The scheme will have to cooperate closely with these two boards as regards marketing of the crops concerned.

In the economic evaluation prices have been used, which represent the true value of the commodity to the economy; in the financial evaluation market prices have been used. Present and future prices have been based on relevant data supplied to us by the Marketing Boards and on world market prices of these products.

Table IV.4 shows the economic and financial producer's prices arrived at in our analyses.

Table IV.4 - Economic and financial producer's prices of crops to be grown at Bura

	Economic producer's prices (in K.Sh./ton) (economic evaluation)			Financial producer's prices (in K.Sh./ton) (financial evaluarion)		
Years	1977	1987	2007	1977	1987	2007
Crops						
cotton	1,310	1,340	1,360	1,340	1,340	1,360
groundnuts	1,100	1,085	1,085	1,080	1,065	1,065
maize	270	210	235	525	440	400
beans	725	725	725	1,000	1,000	1,000
Basmati rice	665	665	665	760	760	760
IRRI rice	465	465	465	485	485	485
sugar-cane	53	56	63	52	56	63

CHAPTER V

ECONOMIC JUSTIFICATION AND PROJECT BENEFITS

In the economic and financial analyses, various alternatives have been reviewed. The results of our calculations have shown that a 4,000-ha scheme where cotton is grown in the main season and groundnuts in the off-season would be most justified economically, based on the following considerations.

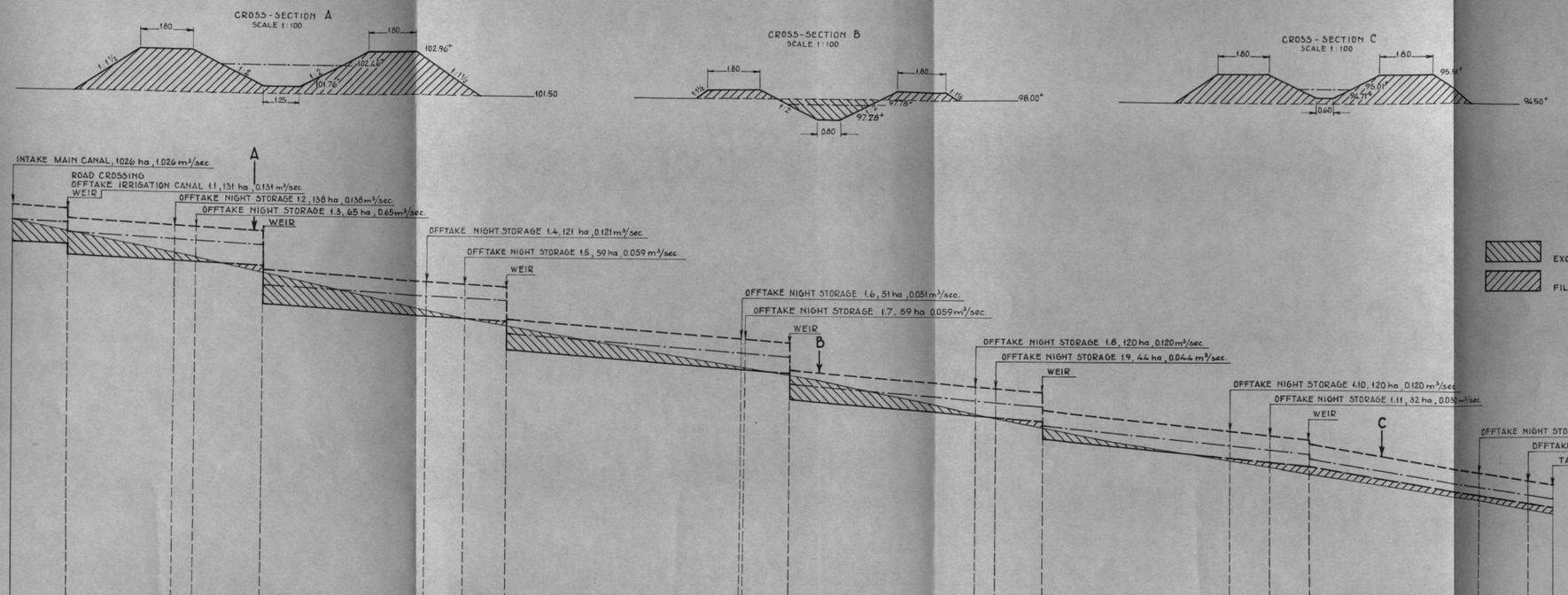
- The internal rate of return will be 13½% which is most satisfactory.
- It will be possible to attain a farmer's income of K.£ 100 a year within a reasonably short period of time; at this income the financial return will be 0%.
- The scheme will offer employment opportunities for 3,330 farmers and about 450 people in the M. & O. and processing sectors.

Under this alternative, the project results are equal to or more favourable than under the other ones considered.

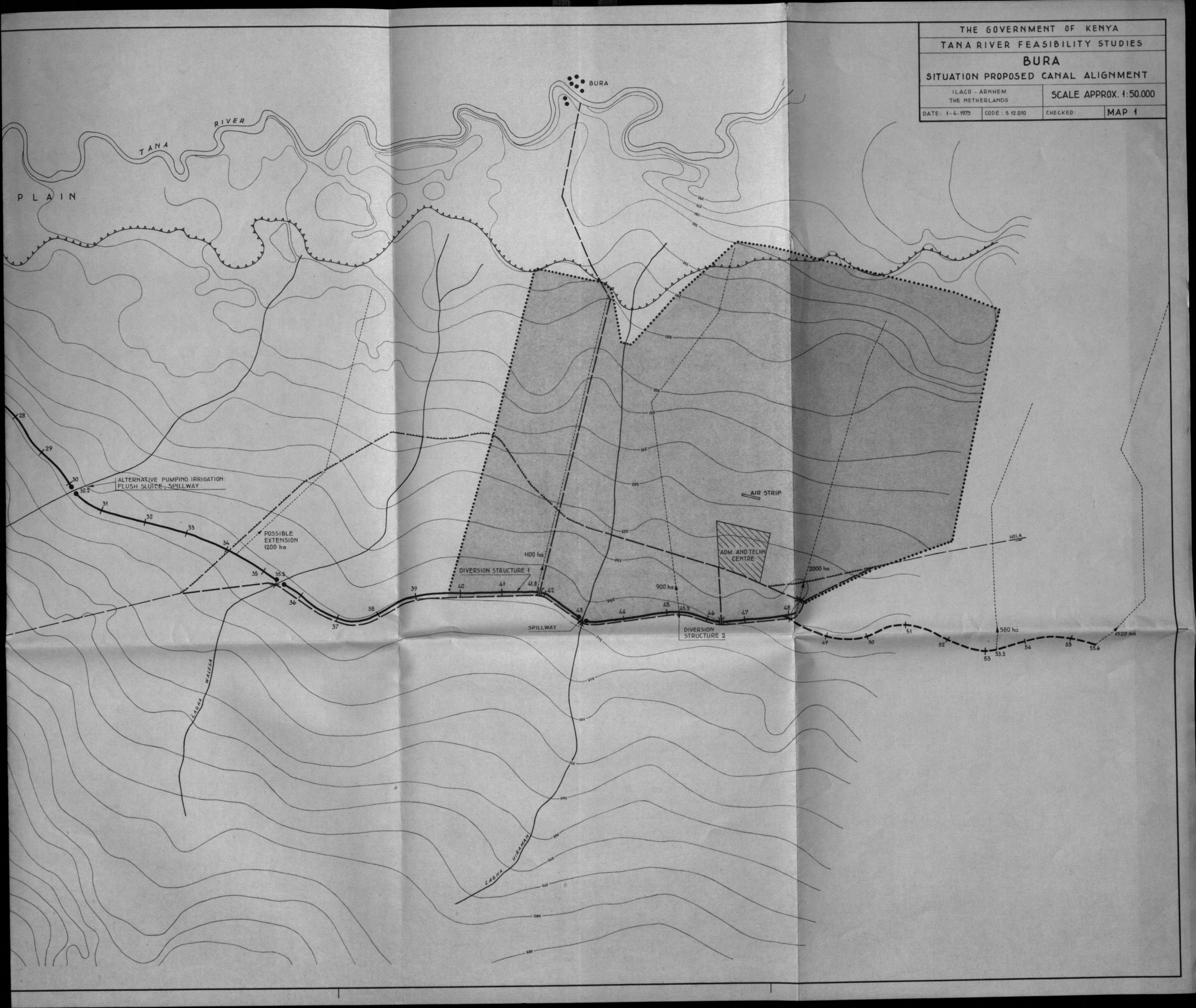
The gross revenues of the project - minus the cost of hired seasonal labour and before deduction of the costs of management, maintenance and operation - will be K.Sh. 8.5 million in 1980 and K.Sh. 14.5 million in 2007. The net revenues - after deduction of the cost of management, maintenance and operation - have been estimated at K.Sh. 5.5 million in 1980 and K.Sh. 11.5 million in 2007.

Up to 1980, when construction of the scheme will be completed, the total investment will amount to K.Sh. 56 million, the foreign currency component of which has been estimated to be K.Sh. 25 million. The highest annual investment, viz. K.Sh. 22.2 million, will be needed during the construction phase in 1976.

THE GOVERNMENT OF KENYA			
TANA RIVER FEASIBILITY STUDIES			
BURA, BRANCH CANAL 1			
LONGITUDINAL PROFILE AND CROSS-SECTIONS			
ILACO - ARNHEM THE NETHERLANDS		SCALE 1:10.000/1:100	
DATE : 1/4/73	CODE : 5.12.010	CHECKED:	DRW. 1



DISTANCE (m)	0	190	560	620	840	1440	1920	1720	2340	2350	2710	3370	3640	3600	4260	4600	4540	5140	5320	5410
GROUND LEVEL (m)	103.00		102.00		101.00		100.00		99.00		98.00		97.00		96.00		95.00		94.00	93.45
NET AREA (ha)	1086	955			752				572			462				298			146	
WATER DUTY (l/sec/ha)	1.0	1.0			1.0				1.0			1.0				1.0			1.0	
DISCHARGE (m³/sec)	1.086	0.955			0.752				0.572			0.462				0.298			0.146	
SLOPE IN WATER LINE (‰)	0.45	0.50			0.57				0.70			0.80				1.0			1.60	
SIDE SLOPE	1:2	1:2			1:2				1:2			1:2				1:2			1:2	
MANNING'S KM	40	40			40				40			40				40			40	
WATER DEPTH (m)	0.75	0.70			0.65				0.55			0.50				0.45			0.30	
BED WIDTH (m)	1.40	1.25			1.00				0.90			0.80				0.60			0.60	
MEAN VELOCITY (m/sec)	0.50	0.50			0.50				0.50			0.50				0.50			0.50	
WATER LEVEL (m)	103.22	103.15	102.80		102.45	101.09		100.60	99.49		98.80	97.86		97.15	96.49		95.55	95.39		94.00
BED LEVEL (m)	102.47	102.40	102.05		101.75	100.44		99.95	98.94		98.25	97.36		96.65	96.04		95.10	95.09		93.70
FREE BOARD (m)	0.50	0.50			0.50				0.50			0.50				0.50			0.50	
EMBANKMENT WIDTH (m)	1.80	1.80			1.80				1.80			1.80				1.80			1.80	
SIDE SLOPE EMBANKMENT (OUTSIDE)	1:1½	1:1½			1:1½				1:1½			1:1½				1:1½			1:1½	
CREST LEVEL EMBANKMENT (m)	103.72	103.65	103.30		102.95	101.59		101.10	99.99		99.30	98.36		97.65	96.99		96.05	95.89		94.50


THE GOVERNMENT OF KENYA
TANA RIVER FEASIBILITY STUDIES
BURA
SITUATION PROPOSED CANAL ALIGNMENT
ILACO - ARNHEM
THE NETHERLANDS
SCALE APPROX. 1:50.000
DATE: 1-4-1979
CODE: 5.12.010
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MAP 1
BURA
TANA RIVER
PLAIN
ALTERNATIVE PUMPING IRRIGATION:
FLUSH SLUICE, SPILLWAY
POSSIBLE EXTENSION 1200 ha
1100 ha
DIVERSION STRUCTURE 1
900 ha
SPILLWAY
DIVERSION STRUCTURE 2
ADM. AND TECHN. CENTRE
AIR STRIP
2000 ha
580 ha
1520 ha
HOLA
LAGHA WAESA
LAGHA HIRAMAN
28
29
30
30.2
31
32
33
34
35
35.5
36
37
38
39
40
41
41.8
42
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52
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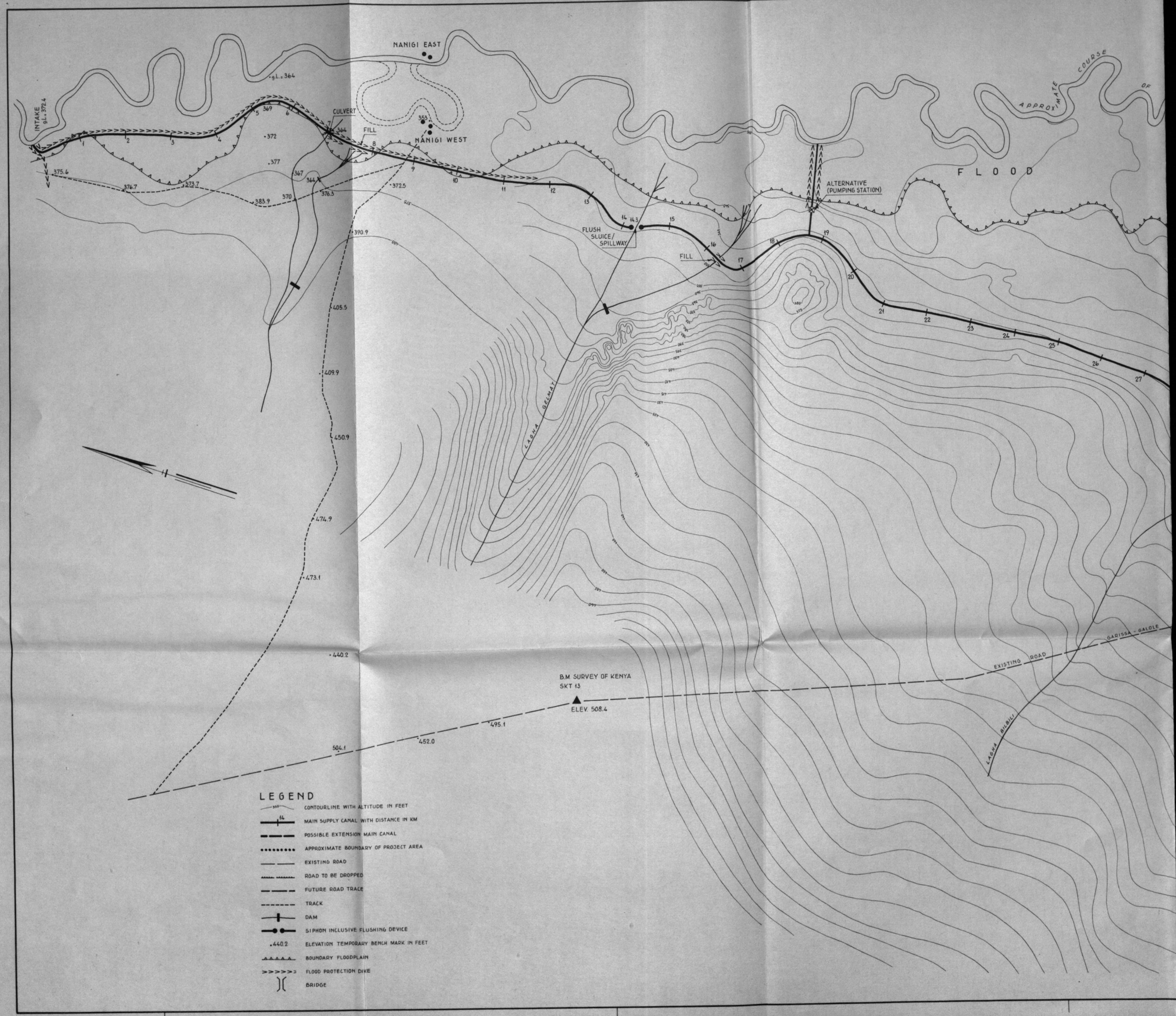
53.3
54
55
55.6


NANIGI EAST
NANIGI WEST
INTAKE
g.l. = 372.4
CULVERT
FILL
FLUSH SLUICE/ SPILLWAY
ALTERNATIVE (PUMPING STATION)
FLOOD
APPROXIMATE COURSE OF
LAGHA GELMAT
LAGHA BILBILI
EXISTING ROAD
GARISSA - GALOLE
B.M. SURVEY OF KENYA
SKT 13
ELEV. 508.4
LEGEND
CONTOURLINE WITH ALTITUDE IN FEET
MAIN SUPPLY CANAL WITH DISTANCE IN KM
POSSIBLE EXTENSION MAIN CANAL
APPROXIMATE BOUNDARY OF PROJECT AREA
EXISTING ROAD
ROAD TO BE DROPPED
FUTURE ROAD TRACE
TRACK
DAM
SIPHON INCLUSIVE FLUSHING DEVICE
ELEVATION TEMPORARY BENCH MARK IN FEET
BOUNDARY FLOODPLAIN
FLOOD PROTECTION DIKE
BRIDGE

THE GOVERNMENT OF KENYA

TANA RIVER FEASIBILITY STUDIES

BURA - SUITABILITY MAP

ILACO - ARNHEM
THE NETHERLANDS

SCALE APPROX. 1: 20,000

DATE: 1-4-1973 | CODE: 5.12.010 | CHECKED: | MAP 2

LEGEND

CONTOUR LINE ELEVATION (IN METERS)

TANA RIVER BASIN BOUNDARY

LOCATION AND NUMBER OF SOIL PIT

SUITABILITY CLASSES

1	HIGHLY SUITABLE
2	SUITABLE *
3	FAIRLY SUITABLE
4	MARGINALLY SUITABLE TO UNSUITABLE *
5	NON-IRRIGABLE BECAUSE OF LOCATION AND TOPOGRAPHY

* WHERE THE DISTINCTION IS MADE BETWEEN A AND B, A MEANS A HIGHER SUITABILITY THAN B

THE GOVERNMENT OF KENYA

TANA RIVER FEASIBILITY STUDIES

BURA
SCHEMATIC IRRIGATION LAYOUT

ILACO - ARNHEM
THE NETHERLANDS

SCALE APPROX. 1 : 20,000

DATE: 1-4-1973 | CODE: 5.12.010 | CHECKED: WOL | MAP 3