REPUBLIC OF GHANA

MINISTRY OF AGRICULTURE IRRIGATION DEPARTMENT

WEIJA IRRIGATION PROJECT FEASIBILITY REPORT

VOLUME ONE — MAIN RERPOT

ARCHITECTURAL AND ENGINEERING SERVICES CORPORATION

in joint venture with

TAHAL CONSULTING ENGINEERS LIMITED

ACCRA
JUNE, 1977

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LIST OF ABBREVIATIONS

m	metre
mm	millimetre
cm	centimetre
km	kilometre
ft	foot, feet
ha	hectare
sq.km	square kilometre
cu.m	cubic metre
cu.m/hour	cubic metres per hour
cu.m/sec.	cubic metres per second
MCM	Million cubic metres
mg	Million gallons
mgd	million gallons per day
mmho	millimohs
v	volt
kv	kilovolt
KVA	kilovolt - ampere
kw	kilowatt
kwh	kilowatt hours
^{o}C	degrees centigrade
A.C.	asbestos-cement
C.I.F.	cost, insurance and freight
dia	diameter
ET	evapotranspiration
ETP	potential evapotranspiration
F.O.B.	free on board
M.S.L.	mean sea level
O & M	operation and maintenance
p.a.	per annum
P.S.	pumping station
TDH	total dynamic head
US $	U.S. dollar
ADB	Agricultural Development Bank
ECG	Electricity Corporation of Ghana
FDC	Food Distribution Corporation

LIST OF ABBREVIATIONS

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cu.m/sec.	cubic metres per second
MCM	Million cubic metres
mg	Million gallons
mgd	million gallons per day
mmho	millimoits
V	volt
kv	kilovolt
KVA	kilovolt x ampere
kw	kilowatt
kwh	kilowatt hours
°C	degrees centigrade
A.C.	asbestos-cement
C.I.F.	cost, insurance and freight
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CONVERSION TABLE

1 millimetre (mm)	= 0.03937 inch
1 centimetre (cm)	= 0.3937 inch
1 metre (m)	= 3.281 feet (ft)
1 kilometre (km)	= 0.6214 mile
1 hectare (ha)	= 2.471 acres
1 square kilometre (sq.km)	= 0.3861 square mile (sq. mile)
1 kilogramme (kg)	= 2.2046 pounds (lb)
1 metric ton (ton)	= 2.205 pounds (lb)
1 cubic metre per hour (cu.m/hr)	= 220 gallons per hour (gph)
1 cubic metre per second (cu.m/sec)	= 35.31 cubic feet per second (cfs)
1 million cubic metres (MCM)	= 220 million gallons (mg)
1 million cubic metres per day (MCM/day)	= 220 million gallons per day (mgd)
1 degree centrigrade (^{o}C)	= 5/9 (degree Fahrenheit (^{o}F) - 32)

CONVERSION TABLE

SUMMARY AND MAIN FINDINGS

1. Various preliminary investigations have recommended the utilization of the Weija New Dam, now under construction, as a water source for agricultural irrigation, in addition to its original function of supplying water to the City of Accra. The present study has a twofold objectives: (1) to formulate an economically sound irrigation development programme, enabling the authorities to undertake the design and implementation of the project; (2) to present a bankable document suitable for submission to international funding agencies such as the World Bank, should the Government of Ghana decide to apply for financial assistance.

2. The project is comprised of two areas, designated as Area No.1 and Area No.2, located 25 km (15.5 miles) and 13 km (8 miles) west of Accra, respectively. The soil survey covered some 3,100 ha in Area No.1 and about 400 ha in Area No.2. On the basis of soil classification for irrigation, a total gross area of 1,725 ha in Area No.1 and 250 ha in Area No.2 were found to be suitable for development. After the elimination of lands on account of topographic consideration and those earmarked for roads, canals, etc., the net cropping areas were demarcated: 1,320 ha (3,260 acres) in Area No.1 and 180 ha (445 acres) in Area No.2.

3. The selection of crops was guided by two main considerations: natural ecological conditions of the Project Area and economic considerations, such as crop profitability and marketing prospects. Based on these criteria, two representative farm types are proposed in the agricultural plan: a mixed farm type for all of Area No.1 and one-half of Area No.2, and a rice farm type, for the other half of Area No.2. With the introduction of irrigation both farm types will be able to raise two crops per year on the same area. The proposed mixed farm unit occupies an area of 2.5 ha (2.25 ha net) and its cropping plan includes field crops such as maize, groundnuts and tobacco, and vegetables such as tomatoes, pepper, okro and eggplants. Two versions of this cropping plan have been analysed in the study: with and without cassava. The rice farm unit has an area of 5 ha (4.5 ha net), growing two crops of rice per year, i.e. 9 ha net p.a.

4. The sprinkler method or irrigation has been recommended for most of the Project Area characterised by light soils with high infiltration rates, and only the 90 ha of rice farms will be surface irrigated. The total annual water requirements for irrigation have been estimated at about 15.5 MCM with the inclusion of cassava in the cropping plan and at 14.8 MCM without cassava.

5. The water source for the irrigation of both Areas will be the Weija Impounding Reservoir. Water to Area No.1 will be pumped by an intake pumping station to be erected near the village of Torkuse; water for Area No.2 will be released gravitationally from the reservoir through an outlet pipe installed in

SUMMARY AND MAIN FINDINGS

the spillway structure of the new dam. The planned conveyance system comprises 17.1 km (10.6 miles) main canals (12.5 km in Area 1 and 4.6 km in Area 2), along which 11 pumping stations will be installed to supply the head (40m) required for sprinkler irrigation. From the pumping station the water will be conveyed through main delivery pipes, telescoping to secondary pipelines running along the farm boundaries, to which the portable sprinkler lines will be connected Each farmer will have at least one portable line with sprinklers, with access to hydrants as necessary to cover his fields. For the rice farms in Area No.2 water will be supplied through gravitational outlets from the main canal.

6. About 11.5 km (7.1 miles) of high tension (11 KV) electricity lines running approximately parallel to the main conveyance canals, will supply power for the pumping stations of Area No.1. At each pumping station a transformer will be installed to step down the voltage for the pump motors. Two central transformers will be erected in Area No.2; from these transformers low tension lines (415 V) will supply power to the pump motors.

7. A network of drainage canals, consisting of interceptors, 24.3 km (15 miles) main drains, as well as secondary drains and boundary interceptors, will convey excess water to the main drainage collectors - the Okurudu river in Area No.1 and the Densu river in Area No.2. At a later stage, after about four years of project operation it may prove to be necessary to construct a subsurface drainage system covering about one-half of the Project Area.

8. Service roads, to provide access to the fields and for routine maintenance works, will be constructed along the main canals, forming part of the irrigation and drainage systems. The existing road network connecting the villages will be supplemented by a 3.6 km access road in Area No.1 and by the extension of an existing road in Area No.2.

9. It is suggested that the project be managed as an independent authority, functioning within the framework of the Ministry of Agriculture. A project Manager will be responsible for project operations including the regular updating of its programmes in the light of the experience gained. The Manager will be assisted by two senior officers: (1) an Agronomist who will supervise the agricultural aspects of the project, among them the extension service and other services such as the supply of inputs, marketing, farm machinery etc.; (2) an Engineer who will supervise the engineering aspects of the project such as the operation and maintenance of the water supply and irrigation systems. In addition the project authority will be in charge of project finances and will provide the necessary accounting and credit services for the participating farmers.

10. Physical development works are planned to be completed within a period of four years, however, full development, in terms of crop yields and generated income, is expected to be reached in the 9th year from the inception of implementation. With the introduction of irrigation and the adoption of improved production techniques crop yields will increase considerably and the total annual income generated at the full production stage is estimated at about ¢7.5 million with cassava and ¢7.2 million without cassava.

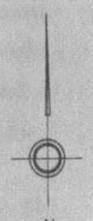
11. Total investments in the project will amount to about ¢17.3 million, or ¢11,500 per ha, including participation in the cost of the Welja Dam, irrigation and drainage systems on-farm development works and infrastructural facilities.

12. Economic evaluation of the project, under conservatively estimated prices and other parameters, gave an internal rate of return of 20.8%; at a 13 percent discount rate a benefit cost ratio of 1.67 and a net present worth of ¢11.6 million were obtained. These figures relate to the "with cassave" cropping plan; the value "without cassava" are slightly lower. Sensitivity tests, assessing the effects of increased investment costs or lower output prices, showed that fluctuations within a certain range would not materially affect project returns. It is, therefore, concluded that the project is economically feasible.

PART I - INTRODUCTION

PART 1 – INTRODUCTION

LOCATION MAP



SCALE:

1 0 1 2 3 4 5 km

0° 30' 0° 25' 0° 20' 0° 15' 0° 10' 0° 05' 0° 00'

5° 45' 5° 40' 5° 35' 5° 30' 5° 25' 5° 20'

From Accra to Nsawam

POKOASI

OYAMFA

MADINA

From Accra to Tema Motorway

MANHIA

DANCHIRA

AFUAMAN

ACHIMOTA

IMPOUNDING RESERVOIR

DAM AND WATER WORKS

DOMIABRA

ALAJO

KWASIMAN

GBAWE

AVENAW

AIRPORT

SAKUMO LAGOON

TEMA

MOKWE LAGOON

NUNGUA

KPESHI LAGOON

TESHI

WEIJA

AMANFRO

OBLOGO

CANTONMENTS

LABADI

CHRISTIANSBORG

TETEGBU

TOKUSE

AREA No. 2

SAKUMO LAGOON

MPUASE

"GBEGBE"

ACCRA

KAWLI LAGOON

From Accra to Winneba

ODUPONKPEHE

AREA No. 1

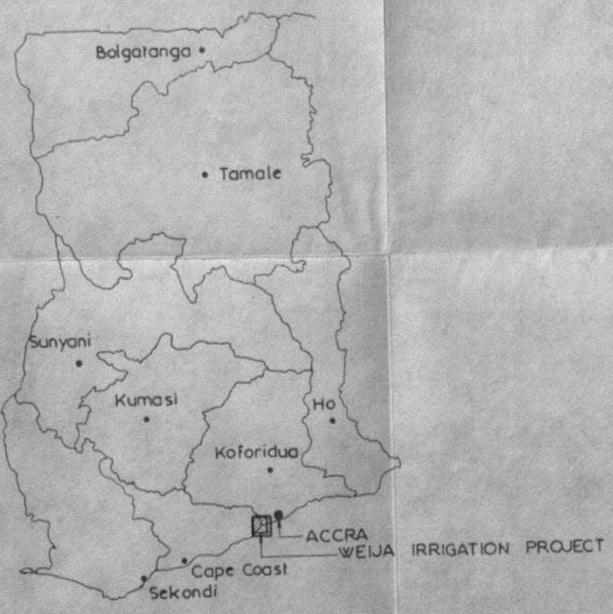
BOTIANAW

LANMA

NYANYANU

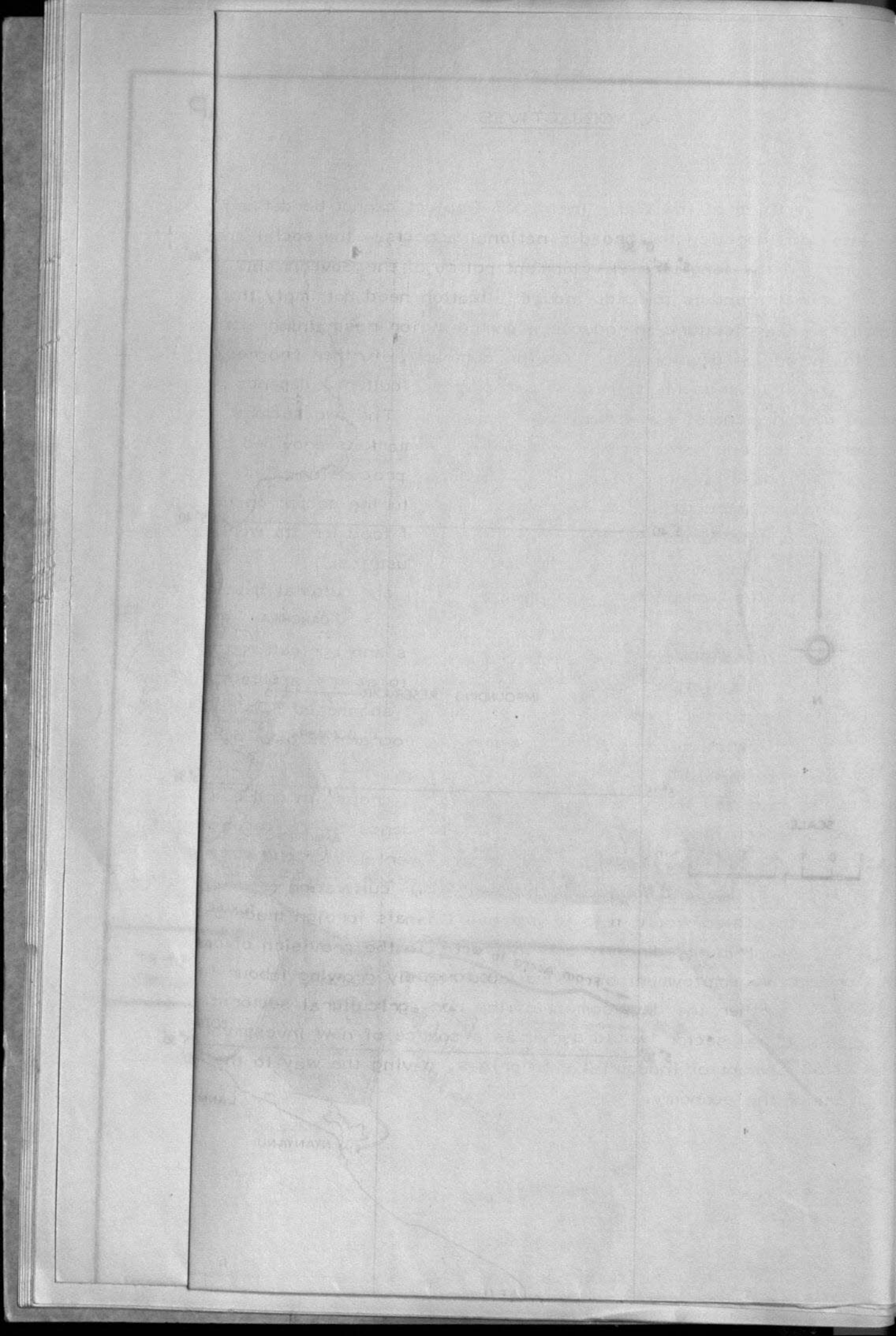
FETE

ENYA BERAKU



PROJECT AREA

WEIJA IRRIGATION PROJECT
A. E. S. C. — TAHAL



A. OBJECTIVES

1. General

The objectives of the Weija Irrigation Project cannot be defined without taking into consideration the broader national aspects - the social and economic background and the long-term development policy of the Government. The fact that the general trend is towards industrialization need not imply that the advancement of agriculture introduces a competing or restraining element, at odds with industrial development. On the contrary, further progress of Ghana's economy, which at present is largely based on agriculture, depends on the co-ordinated development of agriculture and industry. The two sectors are inter-dependent; on the one hand farmers need both the markets provided by a prosperous urban-industrial population, as well as the processing plants and the accompanying infrastructural facilities; the manufacturing sector on the other hand depends on the farms for a plentyful supply of food for its work-force and for providing the raw materials for agro-based industries.

Viewed in this perspective, the broad aims of agricultural development policy may be summarized as follows:

(i) To expand domestic supplies of foodstuffs and agricultural raw materials, in order to satisfy the growing demand and to assure a steady supply of arm products at moderate prices. The Government sponsored "Operation Feed Yourself" and "Operation Feed Your Industries" programmes have been launched with this purpose in mind.

(ii) To increase the production of exportable crops, in order to augment foreign exchange earnings and to lessen the dependence on the cocoa market.

(iii) To promote the domestic production of certain agricultural import substitutes, such as rice and tobacco, wherever their cultivation is economically feasible. Such a step would help to improve Ghana's foreign trade balance.

(iv) To contribute, directly and indirectly, to the provision of opportunities for the productive employment of the nation's rapidly growing labour force.

(v) To further the development of the non-agricultural sectors: a prosperous agricultural sector would serve as a source of new investment capital for the establishment of industrial enterprises, paving the way to the general development of the economy.

A. OBJECTIVES

General

2. Purpose of the Present Study

The irrigation development project described in this report is a family-farm programme designed to raise the present low income of the villagers in the Project Area through the intensification of agricultural production. Although the project constitutes a self-contained unit, occupying a relatively small area, it is intended to serve also as a model for other similar irrigation projects along the coastal belt west of Accra. These aims are in line with the general goals of national development policy of expanding farmland under irrigation and raising agricultural productivity through improved farming techniques.

More specifically, the objectives of this study may be defined as follows:

- To review critically previous plans, surveys and information pertaining to the Project Area.
- To evaluate existing topographical and soil surveys and to supplement the available data by field and laboratory tests and by the drawing up of soil classification maps.
- To study existing land utilization in the Project Area and to assess the physical and economic feasibility of introducing irrigation.
- To evaluate the suitability of existing and new crops, from the ecological and marketing aspects.
- To draw up production budgets on the basis of water requirements, input costs and output prices.
- To draw up an overall agricultural plan.
- To determine the comsuptive use of water of the proposed crops.
- To evaluate alternative irrigation methods and to prepare preliminary designs for irrigation and drainage systems.
- To draw up cost estimates of the entire system of water supply, conveyance, distribution and on-farm irrigation and drainage networks.
- To prepare plans for infrastructural facilities, particularly roads and electricity supply.
- To plan the organizational structure of the project, inclusive of extension and other supporting services, operation and maintenance of the irrigation and drainage systems, manpower requirements and cost estimate of all organizational items.
- To analyse the economic feasibility of the project and to evaluate the financial prospects of the proposed farm types.

In the following chapters of this report the Consultants have attempted to fulfil these objectives, paying particular attention to the formulation of a realistic and optimal development programme.

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B. BACKGROUND

1. The Role of Agriculture in Ghana

Ghana occupies an area of about 240,000 sq. km (92,000 sq. miles) and its population was estimated to be somewhat less than 10 million in 1975[1] and growing at the rate of 2.7 percent p.a.

Ghana's economy is heavily dependent on agricultural production: the agricultural sector - including cocoa, livestock, fisheries and forestry - contributes some 42 percent of the Gross Domestic Product (GDP). Defined in a norrower sense, agricultural crops (excluding cocoa and forestry) account for about 14 percent of the GDP. The dominant role of agriculture is even more pronounced in Ghana's export trade - agricultural products account for about 70 percent of the country's foreign exchange earnings, albeit most of it is derived from cocoa exports. That Ghana is primarily an agricultural country is reflected also in the employment component: about 2 million people, or 55 to 60 percent of the working population are employed in agriculture, including some half million engaged in cocoa production.

The total cultivated area under the main crops is estimated at 3.2 million hectares, almost half of which is occupied by cocoa plantations. Of the remainder, some 800,000 ha are under cereals (maize, millet, sorghum, rice) and about 600,000 ha are planted to roots and tubers (cassava, yams).

In spite of the leading role of agriculture in the Ghanaian economy, agricultural production has not kept pace with the rising demand of the growing population. Neither land nor labour is a limiting factor to increased crop production and it appears that the solution must be sought in making more efficient use of the available resources.

Thus, the main objectives of national agricultural policy, as outlined by the Government are:

- production of sufficient food to feed the population;
- production of enough raw materials for existing and envisaged agro-based industries;
- diversification and increase in the sources of earnings.

Among the means for attaining these objectives are the current Governmental programmes "Operation Feed Yourself" and "Operation Feed Your Industries", which have already met with considerable success in bringing more land under cultivation and raising the generally low crop yields.

1/ Based on the 1970 Census of 8.56 million.

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One of the constraints to agricultural development appears to be the shortage of capital and credit facilities. There are other limiting factors, such as lack of year-round water supply in drought affected regions; organizational and institutional shortcomings as reflected in the deficient supply of agricultural inputs and inadequate extension service.

Being limited in size and scope, the Weija Irrigation Project is not expected to make an immediate impact on Ghana's economy. But if it succeeds, with the help of Government support and in collaboration with public organizations, to overcome the constraining obstacles, it may serve as a prototype with far-reaching long-term effects on the country's agricultural development.

The formulation of national agricultural policy and its execution rests with the Ministry of Agriculture. Of the six major departments of the Ministry, three are concerned with the Weija Irrigation Project and will be directly involved in its implementation: the Irrigation Department, the Agriculture Department and the Agricultural Mechanization and Transport Department. Another institution expected to play an important part in the promotion of the project through the provision of credit facilities is the Agricultural Development Bank (ADB). The ADB grants short-term loans to individuals and groups of farmers to meet production and marketing costs.

2. History of the Project

Plans for utilizing some of the water impounded in the Weija Reservoir for crop irrigation were first put forward by Nippon Coei Co. Ltd. in their "Preliminary Report on Comprehensive Development of Water Resources in Southwestern Ghana", published in January, 1967.

This tentative proposal was followed up later in the same year by Mr. K.M. Shah of the Irrigation, Reclamation and Drainage Division of the Ministry of Agriculture. In his "Report on Irrigation Feasibility in the Densu Basin from the Proposed Reservoir at Weija", Mr. Shah recommends the extension of the irrigated area from about 1,400 ha (3,500 acres) proposed by Nippon Coei to some 1,700 ha (4,200 acres) and supports his recommendations by a preliminary economic appraisal and cost estimates, which point to the economic feasibility of such a project.

Tahal Consulting Engineers Ltd. in association with Engineering Science Inc. - engaged in the design of the water supply scheme for the Accra-Tema Area - took the water requirements of this project into consideration in the report: "Design Phase of the Water Supply and Sewerage Works for the Accra-Tema Metropolitan Area, Ghana - Weija New Dam for Municipal Water and Irrigation", published in 1968. The design submitted in this report makes provisions for additional water by raising the height of the dam and increasing thereby the capacity of the reservoir.

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Several subsequent studies, dealing with various aspects of agricultural and economic development in Ghana, refer to the Weija Irrigation Project.

- "Ghana Sector Studies: The Role of Irrigation in Agricultural Development" prepared for the Ministry of Finance and Economic Planning by the Nathan Consotium for Sector Studies, 1970;
- "The Current Economic Position and Prospects of Ghana, Vol.V (Agriculture)" prepared by the International Bank for Reconstruction and Development/International Development Association, October, 1970.
- "Appraisal of the Accra-Tema Water Supply Project Second Stage" prepared by the International Development Association, March, 1974.

All the above studies regard the conditions in the Area as being favourable for the development of irrigated agriculture and call for a fullscale feasibility study of the project.

On the strength of these appraisal the Ministry of Agriculture engaged the services of Architectural and Engineering Services Corporation and Tahal Consulting Engineers Limited, and a contract was signed on 1st May, 1975 for preparing the Feasibility Study presented in this report.

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C. THE PROJECT AREA

1. Introduction

The Project Area analysed in this report extends over 1,700 ha (4,200 acres) gross in two distinct land areas separated by a distance of about 7.5 km (4.7 miles). (See location map, following page). The larger one, designated Area No.1, comprises 1,500 ha (3,500 acres), and Area No.2 - 200 ha (700 acres). Although the two areas will have separate water supply systems, their incorporation into a single development scheme is justified by their common water source - the Weija Impounding Reservoir.

Both areas are located west of Accra, along the main Accra-Winneba highway: Area No.1, about 25 km from Accra, between latitudes $5^{o}29'$ and $5^{o}32'$ N and longitudes $0^{o}23'$ and $0^{o}26'$ W; Area No.2 lies about 13 km from Accra, between latitudes $5^{o}33'$ and $5^{o}34'$ N and longitudes $0^{o}19'$ and $0^{o}21'$ W.

There are several villages within and adjoining Area No.1 and none in Area No.2. The village of Oduponkpehe (also known by the name Kasewa Gariba), with a population of about 1,000 is conveniently located at a junction of the main highway and serves as a local market centre, with markets held twice a week. There are two other villages along the Accra-Winneba highway: Torkuse (population 700) at the eastern approach to Area No.1, and Galilea (population 100) about midway between Torkuse and Oduponkpehe. To the south of Galilea village, across the main road, is a State Farm.

The village of Tubakrom (population 350) is located on the paved road (locally known as Mile 13) connecting the main highway with the seashore. Another village along the same road but lying outside the project boundary is Kokrobite (population 1,000). Bantana (population 150) lies on the road running south from Oduponkpehe close to the western boundary of Area No.1, and farther on this road, outside the Project Area, is the village of Nyanyanu (population 4,000). The two villages, Kokrobite and Nyanyanu, situated outside but close to the Project Area, have been mentioned here because their populations will likely be affected by project development.

Two or three private family farms are the only habitation in Area No.2.

2. Climate

The climatic characteristics of the Project Area are briefly described in the following; more detailed information is presented in Appendix C-1.

C. THE PROJECT AREA

1. Introduction

The Project Area analyzed in this report extends over 1,700 ha (4,200 acres) gross in two distinct land areas separated by a distance of about 7.5 km (4.7 miles). (See location map, following page).

The larger one, designated Area No.1, comprises 1,500 ha (3,500 acres), and Area No.2 - 200 ha (700 acres). Although the two areas will have separate water supply systems, their incorporation into a single development scheme is justified by their common water source - the Weija Impounding Reservoir.

Both areas are located west of Accra, along the main Accra-Winneba highway: Area No.1, about 25 km from Accra, between latitudes 5°32' and 5°33' N and longitudes 0°23' and 0°25' W; Area No.2 lies about 13 km from Accra, between latitudes 5°33' and 5°34' N and longitudes 0°19' and 0°21' W.

There are several villages within and adjoining Area No.1 and more in Area No.2. The village of Oduponkpehe (also known by the name Kasoa Garliba), with a population of about 1,000 is conveniently located at a junction of the main highway and serves as a local market centre, with markets held twice a week. There are two other villages along the Accra-Winneba highway: Torkuse (population 700) at the eastern approach to Area No.1, and Gallea (population 100) about midway between Torkuse and Oduponkpehe. To the south of Gallea village, across the main road, is a State Farm.

The village of Tubakrom (population 350) is located on the paved road (locally known as Mile 13) connecting the main highway with the seashore. Another village along the same road but lying outside the project boundary is Kokrobite (population 1,000). Bantama (population 150) lies on the road running south from Oduponkpehe close to the western boundary of Area No.1, and farther on this road, outside the Project Area, is the village of Nyanyanu (population 4,000). The two villages, Kokrobite and Nyanyanu, situated outside but close to the Project Area, have been mentioned here because their populations will likely be affected by project development.

Two or three private family farms are the only habitation in Area No.2.

2. Climate

The climatic characteristics of the Project Area are briefly described in the following; more detailed information is presented in Appendix C-1.

a. Rainfall

The Project Area is located in the driest part of the coastal belt, with a mean annual rainfall of 846 mm (33.3 inches). The rainy season lasts from March through July; about 70 percent of the annual rainfall occurs during this period and about 54 percent during the three rainiest months - April, May, and June. The annual dependable rainfall - an empirical parameter for estimating the mean minimum rainfall - is about 635 mm (25 inches). The mean number of rainy days in the wet season is about 50 and in the dry season 20.

The mean date of the beginning of the rainy season in the Project Area is 6-7 March. The variability of the rainfall, in terms of the ratio of the standard deviation to the mean was estimated at about 0.3 and 0.35 for the wet and dry seasons, respectively. 1/

For maximum rainfall intensities see Appendix Table C-1/2.

b. Length of Day, Temperatures, Solar Radiation

The Project Area lies at the latitude of about $5^{o}30'$ N, thus daylight hours are practically uniform during the year, with a minimum of 11.8 hours in December and a maximum of 12.4 hours in June. The mean total hours of bright sunshine during the six-month periods May-October and November-April are 1,000 and 1,384 hours, respectively. The average annual percentage of sunshine in Accra is 54.8%; monthly averages are given in Appendix C-1.

There is very little variation in temperatures throughout the year. Records kept at the Weija Waterworks over a 21-year period show that average monthly temperatures range from 24.1 ^{o}C in August to 27.7 ^{o}C in March, with an annual average of 26.2 ^{o}C. See Appendix Table C-1/3 for monthly average, minimum and maximum temperatures.

The mean daily solar radiation in Accra is 425 cal/sq. cm. Daily solar radiation values per month are given in Appendix F-1.

c. Humidity and Evaporation

Relative humidity and evaporation in the Project Area are discussed in Part II of this report with relation to crop water requirements and the data are presented in Chapter F (Section 1) and in Appendix F-1.

Monthly vapour pressures recorded in Accra are given in Appendix Table C-1/5.

1/ Ussher, A.K.L.: Climatic maps of Ghana for agriculture, Ghana Meteorological Services Department, Legon, 1969. For the period 1936-1965.

a. Rainfall

The Project Area is located in the driest part of the coastal belt, with mean annual rainfall of 848 mm (33.3 inches). The rainy season lasts from March through July, about 70 percent of the annual rainfall occurs during this period and about 54 percent during the three rainiest months - April, May, and June. The annual dependable rainfall - an empirical parameter for estimating the minimum rainfall - is about 635 mm (25 inches). The mean number of rainy days in the wet season is about 50 and in the dry season 20.

The mean date of the beginning of the rainy season in the Project Area is March. The variability of the rainfall, in terms of the ratio of the standard deviation to the mean was estimated at about 0.3 and 0.35 for the wet and dry seasons, respectively. 1/

For maximum rainfall intensities see Appendix Table C-1/2.

b. Length of Day, Temperatures, Solar Radiation

The Project Area lies at the latitude of about 5°30' N, thus daylight hours are practically uniform during the year, with a minimum of 11.8 hours in December and a maximum of 12.6 hours in June. The mean total hours of bright sunshine during the six-month periods May-October and November-April were 1,000 and 1,334 hours, respectively. The average annual percentage of sunshine in Accra is 54.8 %, monthly averages are given in Appendix C-1.

There is very little variation in temperatures throughout the year. Records kept at the Weija Waterworks over a 21-year period show that average monthly temperatures range from 24.1 °C in August to 27.7 °C in March, with annual average of 26.2 °C. See Appendix Table C-1/3 for monthly averages, maximum and maximum temperatures.

The mean daily solar radiation in Accra is 428 cal/ sq. cm. Daily solar radiation values per month are given in Appendix F-1.

c. Humidity and Evaporation

Relative humidity and evaporation in the Project Area are discussed in Part II of this report with relation to crop water requirements and the data presented in Chapter F (Section 1.) and in Appendix F-1.

Monthly vapour pressures recorded in Accra are given in Appendix Table C-1/5.

1/ Ussher, A.K.L.: Climatic maps of Ghana for agriculture, Ghana Meteorological Services Department, Legon, 1959. For the period 1930-1955.

d. Winds

There are no records of wind velocities in the Project Area itself, but they are considered to approximate the values measured at the Accra Meteorological Station. As shown in Appendix Table C-1/16, the annual variation in wind velocities is quite small. The annual average is 5.6 m/sec, with a mean monthly minimum of 4.1 m/sec and a maximum of 7.5 m/sec.

3. Soils and Topography

In all, the surveyed area covered a total of about 3,350 ha: 2,913 ha in Area No.1 and 437 ha in Area No.2. This spread of the survey was carried out so as to be able to demarcate the most suitable tracts for development.

Full description of the surveyed soils is given in Appendix C-2; in the following is a concised outlay of the project area lands.

a. Geomorphology, Topography and Drainage Aspects

From the geomorphological point of view, area No.1 has a gently rolling to gently undulating complex landscape. The north-eastern and the western parts are represented by a complex of low hills with dominant slopes of 2 to 5 percent. The eroded material washed down from the hilly area is mainly sandy, sometimes with a bed of gravels and is deposited in the valleys over a clay stratum.

The central and southern parts of the Area form the low plain of the Okukrudu stream and its tributaries. They are generally level with slopes of less than 1 percent. The sandy material eroded from the hilly area is deposited over a gleyed and sodic clay material of lagoon origin. Along the Okukrudu stream the soils are heavier, medium or fine textured.

Area No.2 is generally very gently undulating. Except for the area of the central hill, not surveyed, the area is more-or-less flat with slopes of less than 2 percent. Along the Densu river there are oxbows, some 2-3 metres lower than the surrounding area. Other low lying areas are represented by microvalleys and ponds.

The distribution of areas by slopes in both Areas shows that gently and moderately sloping lands with 2-8 percent slopes occur on 1,006 ha or 30.0% of the total area; gently sloping areas with 2-5 percent slope on 703 ha or 20.9% of the total area; nearly level lands with 1-2 percent slopes on 335 ha, or 9.9% of the total area, and level lands with less than 1 percent slopes on 1,306 ha or 39.1% of the total area.

From the drainage aspect, the area is divided as follows: 1,612 ha or 48.1% of the total area with somewhat excessive and excessive drainage; 48 ha or 1.4% of the total area with good drainage; 65 ha or 1.9% of the total area with imperfect drainage and 1,625 ha or 48.6% of the total area show poor and very poor natural drainage.

b. Soil Units

Fifteen soil units were mapped; seven in Area No.1 and eight in Area No.2. The main characteristics and recommendations for use of the fifteen soil units are summarized in Table C/1. The complete analysis of the physical, chemical and land use characteristics of the general soils are given in Appendix C-2.

The fifteen soil mapping units have been classified in four land classes for irrigation: two classes of arable land (USBR Classes 2 & 3); one of arable with limitations (USBR Class 4) and one-arable (USBR Class 6).

Arable land are defined as those which, after the necessary improvement will have, when irrigated, a sufficient productive capacity to cover development and production costs, and will also leave a reasonable profit, so that the farmer may enjoy a satisfactory standard of living.

Non-arable lands are defined as lands which do not comply with minimum conditions of productivity or adaptability for irrigation.

The criteria of land classification for irrigation are presented in Table C/2.

The soils in the study area fall within definition of the four irrigation classes, as follows:

(1) Class 2 - Arable Land covers 34.0 ha or 1% of the total area. It includes lands of moderate suitability for irrigation farming. The soils of this class have slight soil, topography and drainage problems. The soil problem is due to limitations resulting from the moderate soil depth, low content of nutrients; the topography problem is due to a slope of 2-3 percent and the drainage problem arises from an imperfect natural drainage.

Only one subclass, 2 std. was mapped.

From the drainage aspect, the area is divided as follows: 1,012 ha or 68.1% of the total area with somewhat excessive and excessive drainage; 48 ha or 1.4% of the total area with good drainage; 85 ha or 1.9% of the total area with imperfect drainage and 1,823 ha or 98.6% of the total area show poor and very poor natural drainage.

b. Soil Units

Fifteen soil units were mapped; seven in Area No.1 and eight in Area No.2. The main characteristics and recommendations for use of the fifteen soil units are summarized in Table C\1. The complete analysis of the physical, chemical and land use characteristics of the general soils are given in Appendix C-2.

The fifteen soil mapping units have been classified in four land classes for irrigation: two classes of arable land (USBR Classes 2 & 3) one of arable with limitations (USBR Class 4) and one-arable (USBR Class 6).

Arable land are defined as those which, after the necessary improvement will have, when irrigated, a sufficient productive capacity to cover development and production costs, and will also leave a reasonable profit, so that the farmer may enjoy a satisfactory standard of living.

Non-arable lands are defined as lands which do not comply with minimum conditions of productivity or adaptability for irrigation.

The criteria of land classification for irrigation are presented in Table C\2.

The soils in the study area fall within definition of the four irrigation classes, as follows:

(1) Class 2 - Arable Land covers 14.0 ha or 1% of the total area. It includes lands of moderate suitability for irrigation farming. The soils of this class have slight soil, topography and drainage problems. The soil problem is due to limitations resulting from the moderate soil depth, low content of nutrients; the topography problem is due to a slope of 2-3 percent and the drainage problem arises from an imperfect natural drainage.

Only one subclass, 2 std, was mapped.

TABLE C/1: SUMMARY OF SOIL SURVEY CHARACTERISTICS

Soil Unit No.	Description of Soil Unit	Present Land use	Recommended land use	Land Classification for Irrigation	Area	
					ha	%
1	Alluvial-colluvial soils, coarse textured on surface over heavy texture in depth, brownish grey and yellowish brownish grey, deep, gently sloping on local alluvial-colluvial materials; excessively drained.	Savanah with several cultivated areas.	Arable, Sprinkler or drip irrigation for vegetables, groundnuts, maize cassava.	4 Sst	244.4	7.3
2	Alluvial-colluvial soils, coarse and moderately coarse textured on surface over heavy texture in depth, yellowish brownish grey, moderately deep limited by heavy textured sodic layer; level, on large low plains, on local alluvial colluvial materials; poorly drained.	As above	As above	4 Ssd	1,163.1	34.8
3	Alluvial-colluvial soils, coarse textured on surface, on middle gravelly layer, over heavy textured slightly saline and strongly sodic layer, yellow brownish grey, very shallow, limited by gravelly layer on heavy layer; nearly level on foot slopes, on alluvial-colluvial materials; poorly drained.	As above	As above	4 Ssd	37.9	1.1
4	Alluvial soils, very strongly gleyed, medium to heavy textured on surface over heavy texture, black brown, very shallow, limited by heavy textured and sodic layer; level on valley bottoms, on alluvial materials; very poorly drained.	Savanah	Arable, Rice	4 Rsd	135.3	4.0
5	Residual soils, coarse textured on surface over heavy texture (sometimes with middle gravel layer), brownish grey to reddish brown, shallow and moderately deep, limited by heavy layer; gently and moderately sloping on hillock slopes, on gravels; somewhat excessively drained.	Savanah with several cultivated areas.	Arable, Sprinkler or drip irrigation. Cultivation of vegetables, maize, groundnuts, cassava.	4 Sst	983.1	29.4

TABLE C/1: SUMMARY OF SOIL SURVEY CHARACTERISTICS

Soil Unit No.	Description of Soil Unit	Present Land use	Recommended Land use	Land Classification for irrigation	Area ha	Area %
1	Alluvial-colluvial soils, coarse textured on surface over heavy texture in depth, brownish grey and yellowish brown grey, deep, mostly sloping on local alluvial colluvial material extensively drained.	Scattered villages surrounded cultivated areas	Arable, Suitable for dry irrigation for vegetables, groundnuts, maize cassava.	4 Sat	1844.4	7.3
2	Alluvial-colluvial soils, coarse and moderately coarse textured on surface over heavy texture in depth, yellowish brown, greyish grey, moderately deep limited by heavy textured sodic layer, on large low plains, on local alluvial colluvial material; poorly drained.	As above	As above	4 Sad	1,163.1	34.9
3	Alluvial-colluvial soils, coarse textured on surface, on middle gravelly layer, over heavy textured slightly saline and strongly sodic layer, yellow brownish grey, very shallow, limited by gravelly layer on heavy layer, mostly level on foot slopes, on alluvial-colluvial plains, poorly drained.	As above	As above	4 Sad	37.9	1.1
4	Alluvial soils, very strongly sloped, medium to heavy textured on surface over heavy texture, block prism, very shallow, limited by heavy textured and sodic layer, on valley bottoms, on alluvial material, very poorly drained.	Savannah	Arable, Rice	6 Sad	193.3	5.9
5	Residual soils, coarse textured on surface over heavy texture (sometimes with middle gravel layer), brownish grey to reddish brown, shallow and moderately deep, limited by heavy layer; mostly slopping on hillside steeps, on gravelly somewhat excessively drained.	Savannah with several cultivated areas.	Arable, Particular attention of drip irrigation. Cultivation of vegetables, fruits, groundnuts, cassava.	4 Sad	883.1	27.4

TABLE C/1 (Cont'd): SUMMARY OF SOIL SURVEY CHARACTERISTICS

Soil Unit No.	Description of Soil Unit	Present Land Use	Recommended Land Use	Land Classification for Irrigation	Area	
					ha	%
6	Residual soils, coarse textured on surface on gravels over heavy texture, grey yellowish brown, very shallow, limited by gravel layer; gently sloping on hillock slopes, on quartzite schists; excessively drained.	Savanah with several cultivated areas.	Arable, Sprinkler or drip irrigation. Cultivation of vegetables, maize, groundnuts cassava.	4 Sst	325.6	9.7
7	Skeletal soils, very coarse gravelly textured, brown, very shallow, limited by gravel layer; moderately sloping on hillocks on quartzite schists and shales; excessively drained.	Bush	Bush	6 st	23.1	0.7
8	Alluvial soils, moderately coarse textured, yellow brownish grey, deep, nearly level on upper flood plain; on alluvial materials; somewhat excessively drained.	Savanah with several cultivated areas	Arable. Vegetables maize, groundnuts, cassava.	4 Ss	35.0	1.0
9	Alluvial soils, moderately coarse textured on surface over medium texture, yellow brownish grey, deep; gently sloping on upper flood plain, on alluvial materials; imperfectly drained.	As above	As above	4 Sstd	30.8	0.9
10	Alluvial soils, medium and moderately fine textured on surface over heavy texture, yellow brownish grey, shallow, limited by heavy sodic layer, level and nearly level on upper flood plain, on alluvial materials, very poorly drained.	As above	As above	4 Ssd	69.5	2.1

TABLE 01 (cont'd): SUMMARY OF SOIL SURVEY CHARACTERISTICS

Soil Unit No.	Description of Soil Unit	Present Land Use	Recommended Land Use	Land Classification for Irrigation	Area	
					Ha	%
6	Reddish brown, coarse textured on granite on gravels over granite, very gravelly, very shallow, stony, rapidly drained by external drainage to deep gravel beds; moderately steep to steep.	Scrubland with isolated cultivated areas.	As above, Improvement by afforestation or pasture (cattle, sheep).	4 Se	3749.6	8.7
7	Skeletal soils, very coarse gravelly textured, brown, very shallow, limited by gravel layer, rapidly drained on granite and schists, moderately steep to steep.	Bush	Bush	6 et	82.1	0.2
8	Alluvial soils, moderately deep to shallow, yellow brown, deep, dark brown, gravelly, loamy, moderately well drained, on granite and schists, moderately steep.	Scrubland with isolated cultivated areas.	As above, Improvement by afforestation or pasture, Vegetable gardens.	4 Se	25.0	1.0
9	Alluvial soils, moderately coarse textured on granite gravels, yellow brown, deep, dark brown, gravelly, loamy, moderately well drained, on granite and schists, moderately steep.	As above	As above	4 Sand	356.6	0.3
10	Alluvial soils, coarse textured on granite gravels, yellow brown, gravelly, loamy, moderately well drained, on granite and schists, moderately steep.	As above	As above	+ Sand	68.5	3.1

TABLE C/1 (Cont'd): SUMMARY OF SOIL SURVEY CHARACTERISTICS

Soil Unit No.	Description of Soil Unit	Present Land Use	Recommended Land Use	Land Classification for Irrigation	Area	
					ha	%
11	Alluvial alkali soils, strongly gleyed fine textured throughout the profile, brownish grey and black, very shallow limited by heavy layer; nearly level on upper flood plains, on alluvial materials; poorly drained.	Savanah with several cultivated areas	Arable, Rice	4 Rsd	142.7	1.0
12	Alluvial-colluvial soils, medium textured on surface over heavy texture, yellow brownish grey, very shallow limited by heavy textured layer, slightly saline and sodic in depth; gently sloping on foot slopes of the hills, on alluvial-colluvial materials; poorly drained.	As above	Arable, Cultivation of vegetables, maize groundnuts, cassava.	3 std	19.7	0.6
13	Alluvial soils, heavy and moderately heavy textured on surface and throughout the profile, brownish grey, very shallow limited by heavy textured sodic layer; nearly level on oxbows, valley shaped depressions, on alluvial materials; poorly drained.	Savanah with some trees.	Savanah	6 std	57.1	1.7
14	Alluvial soils, medium textured on gravel over shales, yellow brownish grey, very shallow limited by gravels and shales; gently sloping on slightly higher areas in flood plains, on alluvial materials; well drained.	Savanah with small cultivated areas.	Arable. Vegetables, groundnuts, cassava, okro, maize.	4 Sst	48.1	1.4
15	Alluvial soils, medium textured on surface over moderately fine texture on gravels over shales, yellow brownish grey, moderately deep and deep limited by gravels layer and shales; gently sloping on slightly higher areas in the flood plains, on alluvial materials; imperfectly drained.	As above.	As above.	2 std	34.0	1.0
	Total				3,349.4	100.0

TABLE C-1 (Continued) SUMMARY OF SOIL SURVEY DATA

Map Unit Symbol	Description of Soil Unit						

TABLE C/2: CRITERIA FOR LAND CLASSIFICATION FOR IRRIGATION

Land Characteristics	Class 1 – Arable	Class 2 – Arable	Class 3 – Arable	Class 4 – Arable with Limitation	Class 6 – Not Arable
Texture	Sandy loam to friable clay loam	Loamy sand to permeable clay	Loamy sand to permeable clay	Sand to clay	Includes lands which do not meet the minimum requirements of higher classes and are unfit for irrigation. Covers soils which are very shallow, very coarse, gravelly textured on sloping topography, oxbows and valley-shaped depressions.
Depth (to bedrock, gravel heavy textured layer or to other limiting factor impeding normal roots development).	More than 90 cm of sandy loam to clay loam; 150 cm of soil easily penetrably by roots.	More than 60cm easily penetrable by roots.	A minimum of 25 cm easily penetrably by roots.	10–25 cm penetrable by roots.	
Stoniness, gravel or cobbles on the surface.	None or some, but less than 5%, or appearing below 90 cm.	None or less than 15%, or appearing below 60 cm.	Up to 25%, or appearing below 25 cm	Up to 50%, or appearing below 10 cm	

TABLE C/3: CRITERIA FOR LAND CLASSIFICATION FOR IRRIGATION

Land Characteristics	Class 1 - Arable	Class 2 - Arable	Class 3 - Arable	Class 4 - Arable with Limitation	Class 5 - Not Arable
Texture	Sandy loam to friable clay loam	Loamy sand to permeable clay	Loamy sand to impermeable clay	Sand to clay	Includes land which do not meet the minimum requirements of other classes and are unfit for irrigation.
Depth (to bedrock, gravel layer or buried layer suitable for other than poor-quality crops)	More than 90 cm of sandy loam to clay loam; 150 cm of soil generally permeable enough for most crops	More than 60 cm generally permeable by roots.	A minimum of 25 cm generally permeable by roots.	10-25 cm permeable by roots.	Covers soils which are very deficient in depth for all but very tolerant crops.
Stoniness	More or less than 5%, appearing below 60 cm.	Up to 15%, or less than 15%, appearing below 60 cm.	Up to 25%, or appearing below 25 cm	Up to 50%, or appearing below 10 cm	Includes lands which do not meet the requirements of other classes and are unfit for irrigation.

TABLE C/2: (Cont'd): CRITERIA FOR LAND CLASSIFICATION FOR IRRIGATION

Land Characteristics	Class 1 - Arable	Class 2 - Arable	Class 3 - Arable	Class 4 - Arable with Limitation	Class 6 - Not Arable
Salinity and alkalinity	EC[1/] less than 4 mmhos/cm at 25°C (may be more in very permeable soils and good drainage conditions). ESP[2/]: less than 5%.	EC[1/] less than 8 mmhos/cm at 25°C (may be more in very permeable soils and good drainage conditions). ESP[2/]: less than 10%	EC[1/] less than 8 mmhos/cm at 25°C (may be more in very permeable soils and good drainage conditions). ESP[2/]: less than 15:.	EC[1/] somewhat more than 8 mmhos/cm at 25°C permit periodic leaching by flooding. ESP[2/]: less than 15%	
pH value	6.0 - 8.5	6.0 - 8.5	5.5 - 9.0	Other values admissible.	
Slope %	0 - 1	1 - 5	1 - 5	0 - 8	

1/ EC = Electricity Conductivity

2/ ESP = Exchange Sodium Percentage.

TABLE 6/3: (continued) CRITERIA FOR LAND CLASSIFICATION FOR IRRIGATION

Land characteristics	Class 1 - Arable	Class 2 - Arable	Class 3 - Arable	Class 4 - Arable with limitation	Class 5 - Not Arable
Other factors and characteristics					
Salinity and alkalinity	ECe less than 4 mmhos/cm at 25°C (may be more in very permeable soils with good drainage conditions); ESP less than 10%	ECe less than 8 mmhos/cm at 25°C (may be more in very permeable soils with good drainage conditions); ESP less than 15%	ECe less than 8 mmhos/cm at 25°C (may be more in very permeable soils with good drainage conditions); ESP less than 15%	ECe less than 8 mmhos/cm at 25°C permit cropping by flooding	
pH value	6.0 - 8.5	6.0 - 8.5	5.5 - 8.5		
Slope %	0 - 1	1 - 3	3 - 5	Other values admissible.	0 - 3

1/ EC = Electrical Conductivity

2/ ESP = Exchange Sodium Percentage.

TABLE C/2: (Cont'd): CRITERIA FOR LAND CLASSIFICATION FOR IRRIGATION

Land Characteristics	Class 1 - Arable	Class 2 - Arable	Class 3 - Arable	Class 4 - Arable with limitation	Class 6 - Not Arable
Microrelief	No limitation	Only light levelling required	Only light levelling required	Only light levelling required but soil removal must be prevented due to shallow soil depth.	
Infiltration rate cm/hr	2.0 - 6.4	0.8 0 6.4	0.4 - 6.4	Less than 0.4, more than 6.4.	
Natural drainage	Good	Good to imperfect	Good to very poor	Excessive to very poor.	

TABLE CV2: (Contd). CRITERIA FOR LAND CLASSIFICATION FOR IRRIGATION

Land Characteristics	Class 1 - Arable	Class 2 - Arable	Class 3 - Arable with limitation	Class 4 - Not Arable
Micro-relief	No limitation	Only light levelling required	Only light levelling required but soil removal must be prevented due to shallow soil depths	
Salinity-alkalinity	E_{sp} - 6_{sp}	0.4 - 8_{sp}	Less than 0.4, Excessive to very poor.	
Nature of drainage	Good	Good to imperfect	Good to very poor.	

(2) Class 3 - Arable Land covers 19.7 ha or 0.6% of the total area. These soils are suitable for development under irrigation, but have soil, topography, and drainage problems which are more severe than those listed under Class 2.

The soil limitation is due to the very small depth limited by heavy textured slightly saline and sodic layer; the topography limitation is due to slopes of 4-5 percent and the erosion hazzard; and the drainage limitation is due to poor drainage.

Only one subclass, 3 std, was mapped.

(3) Class 4 - Arable Land with Limitations. This class covers 3,215.5 ha or 96.0% of the total area. The lands included under this class show severe deficiences that limit the growing of crops and call for application of special methods. The soil limitations stem from the moderately coarse, coarse and very coarse-texture, high percentage of gravel and generally small effective soil depth. These factors result in the soils having a very rapid to excessive infiltration rate, very rapid permeability and low to very low water retention capacity. Also included in this category are some fine-textured soils, alkali or saline in the lower layers. These conditions limit the selection of crops for these soils.

The topography limitation is due to sloping or slightly sloping topography. The drainage limitations are due to excessive and somewhat excessive or poor and very poor drainage.

Five sub-classes were mapped, as follows:

(i) Subclass 4 Ss covers 39.0 ha. It consists of moderately coarse-textured soils, nearly level, somewhat excessively drained. The slopes are 1-2 percent, the infiltration rate is excessively rapid (27.0 cm/hr) and the water retention capacity is low. The soils are limited to sprinkler or drip irrigation.

(ii) Subclass 4 Sst covers 1,601.2 ha. It consists of lands with coarse and very coarse-textured soils, with a high gravel content, gently and moderately sloping, excessively and somewhat excessively drained.

Infiltration rates are excessively rapid (12.0 - 45.2 cm/hr) and the topography is gently to moderately sloping with 3 - 8 percent slopes.

Under these conditions, irrigation by gravity would result in high water losses and no levelling is advisable due to the danger of exposing or bringing to the surface the lower horizons of gravel: Moreover, surface irrigation method also entails erosion hazards for these coarse-textured soils. For these reasons, irrigation in these soils is limited to sprinkler or drip methods.

(iii) Subclass 4 Ssd covers 1,270.5 ha. It includes very coarse, coarse, moderately and medium-textured soils in the upper part of the profile, over heavy textured sodic layer, level and nearly level, poor and very poor drained soils.

The effective soil depth is very shallow, shallow or moderately deep.

The second layer is slightly saline and strongly alkali; the infiltration rates are excessively rapid (8.0 - 22.8 cm/hr) on the surface, while in the second layer it is less than 0.2 cm/hr.

The topography is level or nearly level with less than 2 percent slopes. Owing to the flat topography and almost impervious second layer, drainage is poor and very poor. Under these conditions of excessively rapid infiltration, irrigation by gravity would result in high water losses and sprinkler or drip irrigation is recommended. Special care must be taken when irrigating these soils; water should be applied in accordance with crop requirements and excess applications must be avoided in order not to aggravate the drainage conditions, since the slow internal drainage and the low hydraulic conductivity make drainage of the subsoil very difficult. For this reason an adequate drainage system should be provided to remove all excess water.

(iv) Subclass 4 Sstd covers 30.8 ha. Lands included in this subclass are of moderately coarse textures, show very rapid infiltration rates with slightly sloping topography with slopes of 3-5 percent and imperfect drainage.

(v) Subclass 4 Rsd covers 278.0 ha. The texture is heavy from the surface and throughout the profile. The soil is very slightly saline and strongly alkali.

Infiltration rates are very slow, 0.1 - 0.3 cm/hr. The topography is level with less than 1 percent slopes. Drainage is poor and very poor.

The land is limited to rice cultivation.

(4) Class 6 Non-arable Lands. This class covers 80.2 ha or 2.4% of the total area. The lands of this class do not comply with the minimum requirements of Class 4 and are unsuitable for development.

Two sub-classes were mapped as follows:

(i) Subclass 6 st covers 23.1 ha and consists of the skeletal very coarse gravelly textured soils, very shallow with a high percentage of gravel. The topography is moderately sloping with 7 percent slopes and drainage is excessive.

(ii) Subclass 6 std covers 57.1 ha and consists of oxbows and valley-shaped depressions. The main limitations stem from the very high cost of levelling and reclamation.

Table C/3 summerizes the soils classes in the study area in respect to their irrigation adaptability.

TABLE C/3: LAND CLASSIFICATION FOR IRRIGATION

Class	Sub-class	Area of sub-class ha	Area of class ha	%
1 Arable	-	-	-	-
2 Arable	2 std	34.0	34.0	1.0
3 Arable	3 std	19.7	19.7	0.6
4 Arable limited	4 Ss 4 Sst 4 Ssd 4 Sstd 4 Rsd	35.0 1,601.2 1,270.5 30.8 278.0	3,215.5	96.0
6 Non-arable	6 st 6 std	23.1 57.1	80.2	2.4
Total arable			3,269.2	97.6
Total non-arable			80.2	2.4
Total Classified area			3,349.4	100.0

4. Present Land Use

a. Crops and Farming Practice

Most of the villagers living in the Project Area subsist from rainfed agriculture. Crop growing generally takes the form of shifting cultivation; the dominant crops being vegetables - tomatoes, peppers, okro and eggplants (garden eggs) - and to a lesser extent cassava and maize. A variety of other crops are grown on a small scale, primarily for home consumption; these include groundnuts, cowpeas, rice, cotton, yam, plantain, shallots and water-melon. It is customary to plant a companion crop along with the main crop and it is not uncommon to interplant several crops in the same field.

Few farmers use fertilizers in any appreciable quantity and plant protection measures are practically unknown, in spite of the considerable damage caused by pests and diseases.

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Few farmers use fertilizers in any appreciable quantity and plant protection measures are practically unknown, in spite of the considerable damage caused by pests and diseases.

It is customary to hire tractors for ploughing and harvesting, whilst planting, weeding and harvesting are carried out manually. Depending on the size of the farm, family labour is often supplemented by the hiring of seasonal labourers.

It appears that reasonably high yields are obtained only for the first crops following the clearing of land. Thereafter, yields decrease rapidly as soil fertility declines and pests and disease take their toll. On the average, yields are generally low and the area under cultivation during the cropping season has been estimated at less than half of the total Project Area (see Table C/4).

TABLE C/4: ESTIMATED PRESENT CROP AREAS AND YIELDS

Crop	Area ha	Yield ton/ha
Cassava	80	9.0
Maize	50	0.9
Tomatoes	220	6.0
Peppers	200	4.0
Okro	100	5.0
Egplants	30	4.0
Other crops	50	-
Total	730	-

There are about 500 ha natural grasslands used for cattle grazing; the herds are tended by Fulanis and not by their owners. Almost all farmers keep some poultry, sheep and goats, but these are kept seperately in the village compound and no mixed farming is practiced in the accepted sense of the term.

The limited utilization of the cultivable area and the low crop yields may be attributed to a number of constraining factors:

- Total dependence on rainfall to supply crop water requirements.
- Shortage of working capital and difficulties in obtaining credit on reasonable terms.
- Deficiencies in the supply of agricultural inputs, particularly improved seeds, fertilizers and pesticides.
- Lack of an organized agricultural extension service to guide farmers in the adoption of improved production methods.
- Lack of organized marketing facilities, including storage, grading and transportation of produce.

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Other crops	50	-
Total	730	-

In recent years certain improvements in farming practices have been introduced in the Area by the Food Production Corporation Farm, however, much remains to be done towards the fuller utilization of the available human and physical resources.

b. Land Tenure

Most farmers in the Greater Accra Region, including the Project Area, till their own land, however, there are others who lease holdings under various forms of contractual arrangements. There are three prevalent types of agreement: (1) leasing the land for cash payment; (2) payment in kind - either a prearranged quantity of produce or a share of the crop harvested; (3) a combination of a fixed sum of cash and a fixed amount of produce.

In the Eastern Region, which includes Greater Accra and the Project Area only 11.4 percent of the 480,000 farms are rented. Usually, the indegenous tribes own their farms whilst other tribes lease the land by paying an initial fee and one of the forms of annual rent, depending on tribal and local customs.

c. Size of Holdings

According to the findings of a survey conducted during the rainy season of 1974, the average size of farm holdings in the Greater Accra Region was about 0.73 ha, as against 1.75 ha for Ghana as a whole. At that time there were in Greater Accra about 45,100 such small-holdings.

In the Project Area the cropped area cultivated by a household is generally divided into two or three plots, varying in size between 0.4 and 1.5 ha and averaging about 1 ha 1/. The average number of persons per household is 7 to 11 and it appears that the size of the family, i.e. the available family labour force, determines the farm size.

5. The Weija New Dam and Reservoir

a. Source and Availability of Water

Water for the irrigation project will be supplied from the Weija impounding Reservoir, now under construction. The design of the Weija New Dam originally planned as a municipal water supply works - has been revised, to meet the anticipated irrigation requirements in addition to the urban demands. The capacity of the reservoir was increased by raising the height of the dam and thereby the normal water level in the reservoir by 1.85 m (6 ft. - from 41 to 47 ft).

1/ Weija Socio-economic Survey of Settlements Affected by the Reservoir and Irrigation System. University of Science and Technology, Kumasi.

To ascertain the feasibility and characteristics of the reservoir, in line with its dual function, a simulated reservoir operation study was conducted, 1/ simulating monthly reservoir operation over a 33-year period on the basis of the following parameters:

(i) Rainfall: based on historic daily rainfall values, recorded at the Nsawam gauge.

(ii) Evaporation: based on measurements in Accra, as per the Design Report, Accra-Tema Water Supply Project, First and Second Stages, Tahal Consulting Engineers Limited, March, 1970.

(iii) Seepage: estimated at 25.4 mm (1 inch) per month.

(iv) Upstream water demand: estimated at a maximum of 53,500 cu.m/day (11.8 mgd). In instances when the minimum river flows were less than 52,500 cu.m/day (11.5 mgd) the upstream demands were restricted to the minimum flows.

(v) Accra-Tema municipal supply: 182,000 cu.m/day (40 mgd).

(vi) Irrigation demand: 36.7 MCM per annum, with monthly distribution as shown in Table C/5. Irrigation was stopped whenever the water level in the reservoir dropped below El. 9.15 m (30 ft).

TABLE C/5: MONTHLY WATER DEMANDS FOR IRRIGATION

MCM

Study	Annual total	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct.	Nov.	Dec.
Reservoir Operation Study	36.7	Nil	Nil	4.72	4.72	3.81	1.59	1.18	Nil	5.56	4.90	5.56	4.72
Present Feasibility Study	15.6	1.00	0.19	0.47	1.56	1.87	0.05	1.01	0.33	0.94	2.06	3.32	2.81

The simulation revealed that the demand for the Accra-Tema municipal supply could be met throughout the entire study period. The irrigation demand was likewise satisfied, except during the entire month of March 1947, 14 days in April 1947 and 25 days in May 1947. (These deficiencies occurred following the critical dry period of the 1946/47 hydrologic year). However, when plotted as a probability curve, it was found that such a deficiency is likely to recur only once in 50 years.

This reservoir operation study preceded the present Feasibility Study, hence it took into account much higher irrigation requirements than those recommended in this report, as shown in Table C/5. The lower irrigation demands of the proposed crops will eliminate shortages for irrigation or reduce them to negligible proportions.

1/ Accra-Tema Water Supply Project, Second Stage - Weija New Dam Reservoir Operation Studies, Tahal Consulting Engineers Ltd., 1975.

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1/ Accra-Tema Water Supply Project, Second Stage - Weija New Dam Reservoir Operation Studies, Tahal Consulting Engineers Ltd., 1975.

b. Sedimentation

The effect of sedimentation on the Weija Reservoir was investigated within the framework of the Operation Studies mentioned above.[1/] The study analysed both suspended and bed load sedimentation effects by simulating relevant historic conditions for a period of 33 years (1940/41 through 1972/73) with the aid of a computer.

With the mean concentration of suspended matter estimated at 150 ppm and trap efficiency of 90% (with regard to both suspended and bed load materials) the reduction in the reservoir's capacity due to sedimentation in the course of 50 years was found to be only about 0.7%.

Clearly, this rate of decline in reservoir capacity would have a negligible effect on the functional efficiency of the reservoir.

c. Water Quality

A survey was carried out to determine the properties of the water throughout the Densu river basin.[2/] Samples were taken at 9 sampling stations during the period February 1974 through January 1975. Although the survey was conducted from the point of view of municipal use, its results can be applied equally well to irrigation uses. The results of the survey are summarized in Table C/6.

Other sources,[3/] quoting laboratory analyses of water samples taken at the Weija Dam site from 1965 through December 1975, confirm these findings.

1/ Accra-Tema Water Supply Project, Weija New Dam. Sedimentation Study.
A.E.S.C. in joint venture with Tahal, November, 1975 (04/75/32).

2/ Amuzu, A.T.: A Survey of the Water Quality of the River Densu. Water Resources Research Unit, The Council for Scientific and Industrial Research (C.S.I.R.), Accra, 1975.

3/ Accra-Tema Water Supply Project, Second Stage: Pumping Plant and Treatment Works, Design Review Summary. Associated Engineering Services Limited, January, 1976.

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TABLE C/6: MEAN WATER PROPERTIES IN THE DENSU RIVER

Property		Monitored values		
		Average	Maximum	Minimum
pH		7.0	8.1	6.7
Total dissolved solids	ppm	264	308	70
Conductivity	micromhos/cm	320	1,000	125
Alkalinity (as $CaCO_3$)	ppm	105	284	48
Total hardness (as $CaCO_3$)	ppm	84	192	48
Chloride (Cl)	ppm	30	224	5
Sulphate (SO_4)	ppm	19	134	3
Bicarbonate (HCO_3)	ppm	120	335	58
Calcium (Ca)	ppm	19	73	9
Magnesium (Mg)	ppm	9	30	4

6. Existing Infrastructure

The Project Area lies alongside one of the busiest highways in the country, providing easy access to Accra in the east to Winneba in the west. Two good roads - one paved and the other unpaved but in very good condition - connect the villages of Area No.1 to the main highway. Branching off from the highway there is also a road leading into Area No.2: this road, however, is inferior to the others, nor does it traverse the entire length of the Area.

In spite of the proximity of the Project Area to the largest urban concentration in the country, villagers have continued to pursue their traditional way of life, paying little heed to the changes taking place in the nearby city. There are signs, however, that the growth of Accra and improved communications are beginning to exert their influence.

The villages are not connected to the elettricity supply grid, although the ultra-high-tension power lines pass through both Areas. Provisions will have to be made, therefore, to meet the power requirements of project facilities.

There are at present no domestic water supply works in the villages and the villagers draw their water from sundry local sources, such as ponds and streams. Plans have been drawn up to provide piped water and work has already begun on a water supply scheme in the southern part of Area No.1.

Administratively the Project Area comes under the jurisdiction of the Greater Accra sub-region, although the boundary with the Central Region cuts right across Area No. 1. This division has not posed any problems so far but it will have to be taken into consideration in order to forestall possible administrative conflicts in the future.

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PART II - THE PROJECT

D. PLANNING CONSIDERATIONS

1. Development Programme

The proposed development programme has been planned to embrace all those activities which are needed in order to intergrate prepared land, and irrigation system, and a group of farm families, into an organized, properly operating and productive agricultural system.

The programme must, by its nature, be multi-disciplinary, dynamic, and at the same time flexible. It envisages the working of the land as complemented by the concomitant advancement of the human element involved in the project, and by the organization of the project at its various levels so as to bring about the gradual evolvement of a coherent society of productive farmers.

In view of the uncertainties it involves, especially with regard to the human element, development of the type proposed for the project must be kept flexible and proceed by a succession of steps, each aimed at attaining a more advanced intermediate development target. Such intermediate targets cannot be set in advance, since they depend on the capability of the human element involved in the project and on the market's capacity to absorb project produce. No attempt has, therefore, been made to set out these targets in the present report; only the simpler type of farm programme, which might be suitable for adoption as a first intermediate target, and the possible ultimate target to be reached upon complete development of the project, are more fully described. On the other hand, the proposed Project Organization to be set up should be capable of analysing the position and indicating new intermediate targets as soon as conditions permit, while adapting both the farmer training and guidance programme and the agricultural programme to the changed conditions, as the project proceeds.

2. Specific Planning Organizations

A number of basic problems had to be evaluated and decisions reached before actual planning of the project could proceed. The most important of these were the following:

(i) Delineation of the Project Area

The original allocation of water envisaged a high water demand for irrigation, under the presumption that the are would be predominantly under rice cultivation. However, the findings of the soil survey and land use evaluation clearly demonstrated that the light soils prevailing in most parts of the surveyed area are unsuitable for rice growing. Consequently, an alternative cropping plan was drawn up - based principally on vegetables and other field crops - allocating only about 7 percent of the total cropped area to paddy rice. Since the water requirement of these crops is considerably less than that of rice, the water available for irrigation exceeds the demand and the surplus could be utilized for extending the agricultural development area to beyond the boundaries

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laid down in the terms of reference. However, any substantial enlargement of the irrigated area would have to be preceded by additional soil and topographical surveys and in the meantime planning has been confined to the originally proposed Project Area of 1,500 ha (net). The possible future incorporation of additional irrigated land has, however, been taken into consideration in the planning of the irrigation and drainage systems.

(ii) Irrigation Method

While the cost of installation and operation of a sprinkler irrigation system is higher than that of surface methods (such as furrow or border irrigation), the former was adopted in view of the manifest advantages of sprinkler irrigation in this particular project. The motives underlying this decision may be summed up as follows: (1) The soils are predominantly sandy, with high infiltration rates; (2) shallow topsoil, which would be impaired by the extensive land levelling required for surface irrigation; (3) surface irrigation demands highly skilled operators, whereas sprinkler irrigation can be mastered much more readily by farmers who have had no prior experience in any form of irrigation.

Rice will, however, be cultivated in traditional paddies, irrigated in levelled basins.

(iii) Supply of Water

The division of the project into two geographically separate units - Area No.1 and Area No.2 - calls for two independent water supply schemes. In selecting the mode of conveyance from the reservoir to the irrigated areas, two alternative schemes were compared: (1) gravity - canal conveyance, in which the pressure required for sprinkler irrigation is supplied by a series of pumping stations along the canals; (2) piped delivery, with the pressure provided by the intake pumps at the headworks.

A tentative economic analysis of the two alternatives demonstrated that canal conveyance is by far the more economical method and this alternative has been adopted in the present study.

(iv) Institutional Aspects

Various alternatives have been weighed with respect to farmers' organizations and project management - ranging from the establishment of new agricultural settlements to the running of the project as a single, centrally directed production unit. After due consideration of the relevant demographic, social and economic factors, it has been concluded that the introduction of drastic changes in the existing social and organizational pattern of the village would

not serve the objectives of the project, at least during the initial stages.

The farming will remain the basic unit to be provided with sufficient land, irrigation water and other production inputs by a central project organization.

(v) Size of the Farm Unit

A farm unit of 2.5 ha has been recommended for the mixed farm types, taking into consideration the available family and the fact that production per unit area is expected to increase significantly as skills are acquired and experience accumulates. The labour requirements of a holding of this size can be met by the average farming family and the recommended cropping plan is expected to yield a reasonable return. For the rice farm type a 5 ha holding is proposed in view of the lower anticipated income per hectare.

The influence of markets and consequent changes in the production pattern may make it advisable to modify the size of the farm units sometime in the future. Such modification, if implemented judiciously and within bounds, need not affect the development of the project as a whole, as land and water are not expected to impose constraints to development within the designated area.

(vi) Cropping Pattern

The crops recommended in the cropping plan have been selected on the basis of ecological suitability, marketing prospects and profitability. Bearing in mind the advantages of diversification and sound crop rotation, the recommended crops include vegetables - tomatoes, pepper, eggplants and okro - and field crops - maize, rice, tobacco and groundnuts. The economic effect of including cassava in the cropping plan has been evaluated separately. The suggested cropping pattern should not be regarded as a substitute for annual cropping plans in the later stages of project development.

3. Comprehensive Agricultural Project

The Weija Irrigation Project is envisaged as a comprehensive agricultural scheme involving engineering, agriculture and organization. It will have to cover all facets of land and water development while taking into account the socio-economic aspects and laying stress on the development of the human element at all levels. It will seek to attain the following aims:

(i) Creation of suitable conditions for the formation of modern rural communities through the provision of appropriate services.

(ii) Creation of the physical, socio-economic, and organizational conditions that will permit the implementation of a progressive transformation process among the villagers, and at the same time will allow the economic advantages which, in general, only result from large-scale production, to be achieved on the individual farms without sacrificing freedom of private initiative.

(iii) Absorption of unemployed or underemployed manpower in productive agriculture.

(iv) Development of local leadership.

(v) Creation of patterns of regional cooperation which will permit efficient handling of the supply of inputs, and efficient marketing of the farm produce.

(vi) Integration of agriculture, services and industry in the area, with the appropriate interrelationships between farmer, village and town.

The success of the Project can be measured by the extent to which it will manage to transform groups of individual farmers into a modern rural community. Ultimately, the true measure of success of the project as a whole will be the rate at which it will prove possible to transfer to the farmers' own shoulders the various tasks connected with further progress of their community and the related modern agricultural techniques, and the extent to which they will succeed in adopting effective patterns of cooperation among themselves in production, services and community life.

The establishment of such a comprehensive project requires the setting up of a suitable Project Organization for its effective implementation and guidance.

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(v) Creation of patterns of regional cooperation which will permit efficient handling of the supply of inputs, and efficient marketing of the farm produce.

(vi) Integration of agriculture, services and industry in the area, with the appropriate interrelationships between farmer, village and town.

The success of the Project can be measured by the extent to which it will manage to transform groups of individual farmers into a modern rural community. Ultimately, the true measure of success of the project as a whole will be the rate at which it will prove possible to transfer to the farmers' own shoulders the various tasks connected with further progress of their community and the related modern agricultural techniques, and the extent to which they will succeed in adopting effective patterns of cooperation among themselves in production, services and community life.

The establishment of such a comprehensive project requires the setting up of a suitable Project Organization for its effective implementation and guidance.

In the initial stages, while the project is being established, this organization will have to cover a wider range of activities relating to the management of the various construction contracts, the agricultural development, the training and guidance of the farmers, and the setting up and running in of the various subsidiary organizations required for project operation. In later stages, after completion of the construction process, the work of the organization will consist primarily of routine annual production planning, training and guidance of the personnel of the subsidiary organizations and supervision of their operations, as well as co-ordination with other organizations operating in the Area.

As development proceeds and the farmers gain experience, the project authority will gradually transfer many of its functions to the evolving farmers' organizations. The character and spirit of personnel of the initial organization, and the freedom of action and guidance which it will receive, will be major factors determining the success of the project.

4. Proposed Initial Procedure

It will be shown in the following chapters that the Consultants consider the schemes planned for the two areas, Area No.1 and Area No.2, technically and economically feasible. In order to derive the full benefit from this Feasibility Study, it is suggested that it be acted upon as early as possible, starting with the following steps:

(i) Should the Government decide to seek financial assistance in the implementation of the project, submit a foreign currency loan application to the International Bank for Reconstruction and Development for the amount of US.$6,927,000 representing 45.9 percent of the total financing requirement. The Government may elect to abstain from developing Area No.2 at this stage, in which event the foreign currency requirement would be reduced to US.$6,067,000.

(ii) Take steps to ensure the necessary funds in local currency.

(iii) Engage a firm of consultants to assist the Ministry of Agriculture staff in the preparation of engineering designs and specifications, drawing up of tender documents, analysis of tenders and contract management.

(iv) Appoint the Director of the Project Authority and initiate the setting up of a project organization along the lines suggested in Chapter H of this Report.

(v) Commission detailed soil and topographical surveys of Area No.1 as a preliminary to the design of the irrigation and drainage systems.

(vi) Finalize the electricity supply contract with the ECG, covering electricity rates and quantitites to be supplied to project installations.

Other planning considerations and recommendations of a more specific nature presented in the relevant chapters in the following.

E. AGRICULTURAL DEVELOPMENT

1. Concept of the Agricultural Plan

Agricultural development is not just a question of increasing production and not even a matter of raising the farmer's income, though this must unquestionably play an important part in the process. Agricultural development must be viewed as an integral part of rural regional development, whose primary task is to contribute to the welfare of the rural population. In order to achieve its goals, a rural development programme should have recourse to a set of interdisciplinary policies aimed at the promotion of the well-being of the rural population, along with the production of goods needed for the fulfillment of national development requirements.

Rural development policies encompass, among others, economic decisions, such as what to produce, how much to produce and in what way; questions of credit, investments, taxation and incentives, etc. More specifically, consideration must be given to investments in irrigation and drainage works, research, extension services, infrastructure, supply of inputs and the establishments of marketing channels. Particular attention should be given to the following:

- Facilitating the timely and orderly supply of inputs at a reasonable price to the farmer, particularly seeds of improved varieties, fertilizers, insecticides and water.
- Improving and building up the extension and research services to farmers. These services will provide guidelines on suitable crop varieties, agrotechniques, optimal input levels, methods of plant protection, ways of sorting and packing the produce, etc.
- Extending and streamlining the supply of credits to enable farmers to obtain necessary loans with minimum time delay.
- Improving the marketing channels in order to ensure farmers fair returns for their produce.

Under the present practice of shifting cultivation, land utilization in the Project Area is much below capacity. In any given year, less than 30 percent of the area is under crops and cropping intensity on the cultivated land is below 150 percent. Therefore, the introduction of

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- Extending and streamlining the supply of credits to enable farmers to obtain necessary loans with minimum time delay.
- Improving the marketing channels in order to ensure farmers fair returns for their produce.

Under the present practice of shifting cultivation, land utilization in the Project Area is much below capacity. In any given year, less than 30 percent of the area is under crops and cropping intensity on the cultivated land is below 130 percent. Therefore, the introduction of

irrigation can promote agricultural production in the Project Area in three ways: (1) by expanding the overall area under cultivation; (2) by increasing cropping intensity; and (3) by raising crop yields per unit area.

The intensification of farm production made possible by irrigation - in conjunction with new cropping patterns, improved agrotechniques and high-yielding crop varieties - will not only raise the income of individual farmers, but will contribute to the development of the region and, eventually, of the national economy.

2. Crops and Crop Budgets

a. Proposed Crops

The selection of crops under the present agricultural plan has been guided by two main considerations: natural ecological conditions of the Project Area as described in Chapter C and economic considerations such as crop profitability and marketing prospects.

The proposed agricultural plan lists four field crops - maize, groundnuts, rice and tobacco, four vegetable species - tomatoes, pepper, okro and eggplants; and cassava. These crops may be grouped under two categories:

- Crops well known to the majority of the farmers in the Project Area; in this group cassava, maize and vegetables may be included.
- Crops generally unknown to the majority of the farmers: rice, tobacco and groundnuts.

The proposed list of crops should not be regarded as final or irrevocable; the crops were selected as being representative of their kind and with the view of refraining from avoidable risks. In this respect, as in other planning considerations, a conservative approach was adopted, in order to present a realistic assessment of project feasibility.

Despite the shortcomings of experimental data available at present, there is every assurance that all the crops recommended in this report, and no doubt other crops as well, can be successfully grown in the Project Area.

The proposed crops are described in Appendix E-1.

Crop yields were evaluated in three situations: present average yields in the Project Area, the anticipated level of improvement without project implementation, and the forecast yields with project implementation. The figures are given in Table E/1. It should be noted that the yield levels planned for the final stage of development are below the maximum yields that can be attained. Again, this is in keeping with the conservative approach adopted in the agricultural planning. For details of crop yields in the course of project development see Appendix E-2.

TABLE E/1: YIELD ESTIMATES OF PROPOSED CROPS

tons/ha

Crops	Present yields	Forecast Yields	
		Without Project	With Project
Cassava	9.0	10.50	35.0
Maize	0.9	1.15	3.5
Groundnuts	-	-	2.5
Rice	-	-	4.5
Tobacco	-	-	1.4
Tomatoes	6.0	7.50	25.0
Pepper	4.0	5.00	8.0
Okro	5.0	6.25	16.0
Eggplants	4.5	6.00	25.0

b. Input Requirements

Generally, there is little reliable information on the response of crops grown in the Project Area to various inputs, especially to fertilizers and irrigation water. For the purpose of the crop budgets tentative estimates were made by analysing and comparing the available data.

The three basic fertilizers - nitrogen, phosphorus and potassium - are expressed quantitatively in terms of N, P_2O_5 and K_2O, respectively. Monthly water and labour requirements are summarized Tables E/2 and E/3.

c. Crop Budgets and Gross Returns

The budgets for each of the recommended crops are tabulated in Appendix E-3, giving output values, input costs and gross returns per hectare, at the present stage and at the ultimate stage, with and without project implementation. See Chapter J for the calculation of output and input prices.

Output values represent farm-gate prices. In the budgets for the ultimate stage, the crops have been debited with the full input costs, without subsidies. In the "with project" budgets, crops were debited with unforeseen expenditures (contingencies) at the rate of 10 percent of the input costs and at the rate of 15 percent in the "without project" alternative. The crops were debited with 11 percent p.a. interest on the working capital.

Water duties are not included in the production costs of individual crops, since irrigation costs as a whole have been allowed for in the estimate of the project's gross returns. Crops have not been debited with the cost of farmyard manure, as it is not a marketable commodity.

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tons/ha

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		Without Project	With Project
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Maize	0.9	1.15	3.5
Groundnuts	-	-	2.3
Rice	-	-	4.8
Tobacco	-	-	1.4
Tomatoes	6.0	7.50	25.0
Pepper	4.0	5.00	8.0
Okro	5.0	6.25	16.0
Eggplants	4.8	6.00	25.0

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The three basic fertilizers - nitrogen, phosphorous and potassium - are expressed quantitatively in terms of N, P_2O_5 and K_2O, respectively. Monthly water and labour requirements are summarized Tables E/2 and E/3.

c. Crop Budgets and Gross Returns

The budgets for each of the recommended crops are tabulated in Appendix E-3, giving output values, input costs and gross returns per hectare, at the present stage and at the ultimate stage, with and without project implementation. See Chapter 4 for the calculation of output and input prices.

Output values represent farm-gate prices. In the budgets for the ultimate stage, the crops have been debited with the full input costs, without subsidies. In the "with project" budgets, crops were debited with unforeseen expenditures (contingencies) at the rate of 10 percent of the input costs and at the rate of 15 percent in the "without project" alternative. The crops were debited with 11 percent p.a. interest on the working capital.

Water duties are not included in the production costs of individual crops, since irrigation costs as a whole have been allowed for in the estimate of the project's gross returns. Crops have not been debited with the cost of farmyard manure, as it is not a marketable commodity.

TABLE E/2: CROP WATER REQUIREMENTS BY MONTHS

cu.m/ha

Crop	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Total
Cassava	650	800	200	-	700	1,050	950	1,000	1,350	1,150	1,000	450	9,300
Maize	-	600	1,050	-	550	100	-	-	-	-	-	-	2,300
Groundnuts	-	-	-	-	-	-	600	1,100	1,650	1,350	200	-	4,900
Tobacco	600	1,150	1,150	-	400	250	-	-	-	-	-	-	3,550
Rice	-	1,840	2,850	450	1,750	800	-	1,050	3,800	3,100	2,300	900	18,840
Vegetables*	450	700	450	-	450	150	500	950	1,500	1,500	850	150	7,650
Okro	-	750	1,000	-	200	-	-	950	2,050	1,150	350	-	6,450

Note: See Chapter F, Section 1 for the computation of irrigation requirements.

* Tomatoes, pepper and eggplants.

TABLE 6/3: CROP WATER REQUIREMENTS BY MONTHS

cu.m/ha

Crop	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Total
Cassava	650	800	700	-	700	1 000	950	1 000	1 450	1 150	1 000	450	9 300
Maize	-	600	1 050	-	850	100	-	-	-	-	-	-	2 700
Groundnuts	-	-	-	-	-	-	600	1 100	1 550	1 350	300	-	4 900
Toeedee	600	1 150	1 150	-	400	250	-	-	-	-	-	-	3 550
Rice	-	1 850	2 850	450	1 750	800	-	1 050	3 800	3 100	2 300	900	16 850
Vegetables*	450	700	900	-	450	150	500	950	1 500	1 500	650	150	7 850
Okra	-	750	1 000	-	200	-	-	950	2 050	1 150	350	-	6 450

Note: See Chapter 8, Section 1 for the computation of irrigation requirements.

* Tomatoes, pepper and eggplants.

TABLE E/3: MONTHLY LABOUR REQUIREMENTS OF THE PLANNED CROPS

man-days/ha

Crop	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Total
Cassava	20	–	15	10	–	15	10	–	15	15	30	20	150
Maize	–	4	6	20	20	10	–	–	–	–	–	–	60
Groundnuts	–	–	–	–	–	–	16	16	10	16	8	–	60
Tobacco	25	15	30	40	30	30	–	–	–	–	–	10	180
Rice	–	35	10	10	5	30	20	–	–	–	–	–	110
	20	–	–	–	–	–	–	35	10	10	5	30	110
Tomatoes	20	35	20	20	35	–	–	–	–	–	–	–	130
	–	–	–	–	–	–	20	35	20	20	35	–	130
Pepper	15	30	15	10	15	15	–	–	–	–	–	–	100
	–	–	–	–	–	–	15	30	15	10	15	15	100
Okro	–	40	30	30	10	–	–	–	–	–	–	–	110
	–	–	–	–	–	40	30	30	10	–	–	–	110
Eggplant	20	30	20	20	30	–	–	–	–	–	–	–	120
	–	–	–	–	–	–	20	30	20	20	30	–	120

Note: Of rice and vegetables two crops per year will be grown; the Table shows the monthly labour requirements of both crops.

TABLE E3: MONTHLY LABOUR REQUIREMENTS OF THE PLANNED CROPS

man-days/ha

Crop	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Total
Cassava	20	-	15	10	-	15	10	-	15	15	20	40	160
Maize	-	40	6	20	20	10	-	-	-	-	-	-	80
Groundnuts	-	-	-	-	-	-	15	15	10	15	-	-	60
Tobacco	25	15	30	40	30	30	-	-	-	-	-	30	180
Rice	20	35	10	10	5	20	35	-	10	10	40	30	110
Tomatoes	20	35	20	20	25	15	25	35	20	20	35	-	130
Pepper	-	30	15	10	15	15	30	30	15	10	15	15	100
Okro	-	40	30	30	10	40	30	30	10	10	40	-	110
Eggplant	-	30	20	20	30	15	20	30	20	20	30	30	120

Note: Of rice and vegetables two crops per year will be grown; the Table shows the monthly labour requirements of both crops.

TABLE E/4: VALUE OF PRODUCT, INPUT COSTS AND GROSS RETURNS BY CROPS

¢/ha

Crop	Present			Without project implementation			With project implementation		
	Value of product	Input costs	Gross return	Value of product	Input costs	Gross return	Value of product	Input costs	Gross return
Cassava	738.00	453.50	284.50	861.00	486.75	374.25	2,870.00	1,100.05	1,769.95
Maize	176.40	143.85	32.55	225.40	152.40	73.00	686.00	492.55	193.45
Groundnuts	-	-	-	-	-	-	1,190.00	469.00	721.00
Rice	-	-	-	-	-	-	918.00	681.90	236.10
Tobacco	-	-	-	-	-	-	2,520.00	1,056.30	1,463.70
Tomatoes	1,584.00	437.05	1,146.95	1,980.00	479.80	1,500.20	6,600.00	1,591.80	5,008.20
Pepper	4,800.00	422.90	4,377.10	6,000.00	457.40	5,542.60	9,600.00	1,103.10	8,496.90
Eggplants	900.00	397.70	502.30	1,200.00	427.80	772.20	5,000.00	1,203.00	3,797.00
Okro	690.00	467.90	222.10	862.50	508.00	354.50	2,208.00	1,133.15	1,074.85

Note: For detailed crop budgets see Appendix E-3.

TABLE 6(A): VALUE OF PRODUCT, INPUT COSTS AND GROSS RETURNS BY CROPS

(Rs/ha)

Crop	Per season			Without project implementation			With project implementation		
	Value of product	Input costs	Gross return	Value of product	Input costs	Gross return	Value of product	Input costs	Gross return
Cassava	256.00	132.40	124.00	861.00	485.76	374.24	2,870.00	1,100.05	1,769.95
Maize	170.40	143.85	26.55	255.60	183.40	72.00	886.00	466.45	419.55
Groundnuts	-	-	-	-	-	-	1,150.00	666.00	484.00
Rice	-	-	-	-	-	-	918.00	681.90	236.10
Tobacco	-	-	-	-	-	-	2,250.00	1,050.30	1,199.70
Coffee	1,284.00	457.05	827.00	1,926.00	476.00	1,450.00	6,300.00	1,251.80	5,048.20
Bananas	4,200.00	800.00	3,400.00	6,300.00	452.40	5,847.60	6,600.00	1,161.10	5,438.90
Pineapple	800.00	307.70	492.30	1,200.00	807.80	392.20	5,000.00	1,802.00	3,198.00
Sugarcane	660.00	467.30	192.70	990.00	509.00	481.00	2,538.00	1,313.15	1,224.85

Source: Survey data

Figures for derived crop budgets are Appendix Tab. 3.

and farmers do not use purchased manure. Whenever available, farmyard manure will be applied mainly to vegetable crops.

Land taxes and rents have not been included in the crop budgets since they are payable whether the project is implemented or not.

A summary of the outputs, inputs and gross returns is presented in Table E/4.

3. Cropping Patterns and Farm Types

The agricultural programme envisages the growing of two crops per year on the same area, although there is little doubt that the more efficient farmers will be able to utilize their land at a higher cropping intensity. The introduction of irrigation will permit greater flexibility in the choice of crops and in planting times, enabling farmers to attain higher aggregate net returns from the factors of production.

The following two cropping patterns are proposed for the Project Area:

(i) Mixed cropping plan without rice;

(ii) Monoculture, consisting of two rice crops per year.

The first cropping plan, which is proposed for most of the Project Area, will be practiced in two variants, namely, with and without cassava. The second, rice farming, is considered to be suited to the conditions prevailing in parts of Area 2.

Corresponding to the two cropping patterns, the agricultural plan puts forward two representative farm types:

- Mixed farm types - one with and one without cassava; occupying an area of 2.5 ha gross each (2.25 ha net), representing the average size of holding in the Project Area;
- A 5-ha rice farm, as the typical farm type for adoption in part of Area 2 only.

The two cropping patterns based on mixed farming are illustrated schematically in Figs E/1 and E/2 and the areas covered by the crops are shown in Table E/5. Appendix E-4 shows the distribution of crops by months. It will be noted that the cropping intensity is 200 percent when cassava is not included in the crop rotation and 180 percent with cassava.

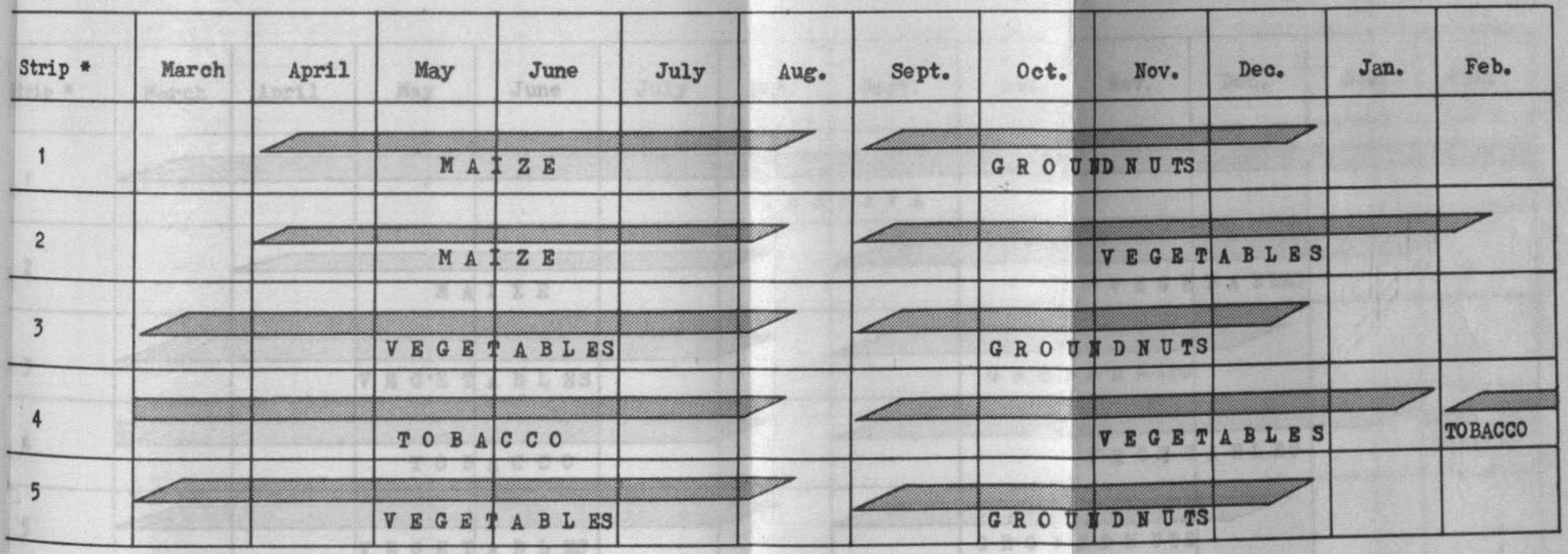
The crops will be planted in the following ratios:

(i) Cropping plan with cassava: maize and tobacco 10% each, cassava and groundnuts 20% each, vegetables 40%.

(ii) Cropping plan without cassava: tobacco 10%, maize 20%, groundnuts 30%, vegetables 40%.

Under both alternatives of the mixed farm type the proposed vegetables mix is as follows: tomatoes 45%, pepper 30%, okro 20% and eggplants 5%.

FIG. E/2: CROPPING PATTERN OF MIXED FARM TYPE - WITHOUT CASSAVA



* Each strip 0.45 ha net.

FIG. E/2

which case farmers will be able to switch to the more profitable crops.

(ii) Cropping plan without cassava: tobacco 10%, maize 20%, groundnuts 30%, vegetables 40%.

Under both alternatives of the mixed farm type the proposed vegetables mix is as follows: tomatoes 45%, pepper 30%, okro 20% and eggplants 5%.

FIG. E/1: CROPPING PATTERN OF MIXED FARM TYPE - WITH CASSAVA

Strip *	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
1						CASSAVA						
2			MAIZE						VEGETABLES			
3			VEGETABLES					GROUNDNUTS				
4			TOBACCO						VEGETABLES			TOBACCO
5			VEGETABLES					GROUNDNUTS				

* Each strip 0.45 ha net.

FIG. E/1

which case farmers will be able to switch to the more profitable crops.

Nov.	Dec.	Jan.	Feb.
V E G E	T A B L E S		
N D N U T S			
V E G E T	A B L E S		TOBACCO
N D N U T S			

FIG. E/1

(ii) Cropping plan without cassava: tobacco 10%, maize 20% groundnuts 30%, vegetables 40%.

Under both alternatives of the mixed farm type the proposed vegetables mix is as follows: tomatoes 45%, pepper 30%, okro 20% and eggplants 5%.

The recommended cropping patterns should not be regarded as rigid formulae to be adopted in the Project Area under all circumstances; they are mainly intended to demonstrate the possibilities of introducing relatively little known crops such as rice and tobacco alongside such well known ones, as tomatoes and cassava. At the same time, they were designed to ensure a minimum build-up of pests and diseases which are common in rotation with a high percentage of vegetables.

TABLE E/5: NET CROP AREAS ON MIXED FARM TYPES

ha

Crop	With cassava alternative	Without cassava alternative
Cassava	0.45 1/	-
Maize	0.45	0.90
Groundnuts	0.90	1.35
Tobacco	0.45	0.45
Tomatoes	0.80	0.80
Pepper	0.55	0.55
Eggplants	0.10	0.10
Okro	0.35	0.35
Total	4.05	4.50

1/ Two seasons.

The adoption of these crop rotations should contribute to the stabilization of the farmers' income and to a balanced distribution of labour throughout the year, permitting the farmers to use more productively the two main production factors; land and water.

The proposed cropping patterns are not necessarily optimal from the economic point of view. They include crops such as maize and rice which are less profitable than vegetables. On the other hand, maize and rice have a large national market, while vegetables are perishable and their main outlet is the Greater Accra Region. This market is likely to expand in the future, in which case farmers will be able to switch to the more profitable crops.

(ii) Cropping plan without cassava: tobacco 10%, maize 20%, groundnuts 20%, vegetables 40%.

Under both alternatives of the mixed farm type the proposed vegetables is as follows: tomatoes 45%, pepper 20%, okro 20% and eggplants 5%.

The recommended cropping patterns should not be regarded as rigid formulae to be adopted in the Project Area under all circumstances; they are mainly intended to demonstrate the possibilities of introducing relatively little known crops such as rice and tobacco alongside such well known ones, as tomatoes and cassava. At the same time, they were designed to ensure a minimum build-up of pests and diseases which are common in rotation with a high percentage of vegetables.

TABLE E/5: NET CROP AREAS ON MIXED FARM TYPES

ha

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Cassava	0.45 1/	-
Maize	0.45	0.90
Groundnuts	0.90	1.35
Tobacco	0.45	0.45
Tomatoes	0.80	0.80
Pepper	0.55	0.55
Eggplants	0.10	0.10
Okro	0.35	0.35
Total	4.05	4.50

1/ Two seasons.

The adoption of these crop rotations should contribute to the stabilization of the farmers' income and to a balanced distribution of labour throughout the year, permitting the farmers to use more productively the two main production factors; land and water.

The proposed cropping patterns are not necessarily optimal from the economic point of view. They include crops such as maize and rice which are less profitable than vegetables. On the other hand, maize and rice have a large national market, while vegetables are perishable and their main outlet is the Greater Accra Region. This market is likely to expand in the future, in which case farmers will be able to switch to the more profitable crops.

The representative farm types are intended to represent typical individual farms in the Project Area, and their main purpose is to determine the economic viability of the project. They should, therefore, be used as guidelines for the financial evaluations, but they cannot be taken, at least at this stage, as a basis for drawing up a detailed plan of operations.

As stated, the two mixed farm types (with and without cassava) are proposed for all of Area 1 and part of Area 2 - altogether 626 such farm units. Twenty of the 5-ha rice farm units could be set up in Area 2.

4. Farm Budgets

Estimated annual inputs, outputs and gross returns for the three representative farm types are presented in Table E/6. The budgets in this table relate to the final stage of development when maximum crop returns are attained. As in the crop budgets, the output values as well as the input costs are given at farm gate prices.

TABLE E/6: OUTPUT VALUE, INPUT COSTS AND GROSS RETURNS OF THE ENVISAGED FARM TYPES AT FULL PRODUCTION STAGE

¢

Farm Type	Net yearly cropping area, ha	Output value	Input costs 1/	Gross return
Mixed farm with cassava	4.5	15,638	3,779	11,859
Mixed farm without cassava	4.5	15,191	3,743	11,448
Rice farm	9.0	8,262	5,818	2,444

1/ Not including cost of water and interest on working capital.

The annual water and labour requirements of the three farm types are given in Table E/7; the distribution of water and labour by months and crops is shown in Appendix E-4.

TABLE E/7: ANNUAL WATER AND LABOUR REQUIREMENTS OF THE PLANNED FARM TYPES

F a r m Type	Water 1/ cu.m	Labour man-days
Mixed farm with cassava	21,310	439.0
Mixed farm without cassava	20,180	425.5
Rice farm	84,780	990.0

1/ Including losses in the main irrigation canal

The representative farm types are intended to represent typical individual farms in the Project Area, and their main purpose is to determine the economic viability of the project. They should, therefore, be used as guidance for the financial evaluations, but they cannot be taken, at least at this stage, as a basis for drawing up a detailed plan of operations.

As stated, the two mixed farm types (with and without cassava) are proposed for all of Area 1 and part of Area 2 - altogether 626 such farm units. The remainder of the 5-ha rice farm units could be set up in Area 2.

Farm Budgets

Estimated annual inputs, outputs and gross returns for the three representative farm types are presented in Table E/6. The budgets in this table relate to the final stage of development when maximum crop returns are attained. As in the crop budgets, the output values as well as the input costs are given at farm gate prices.

TABLE E/6: OUTPUT VALUE, INPUT COSTS AND GROSS RETURNS OF THE ENVISAGED FARM TYPES AT FULL PRODUCTION STAGE

Farm Type	Net yearly cropping area, ha	Output value	Input costs 1/	Gross return
Mixed farm with cassava	4.5	15,632	3,779	11,899
Mixed farm without cassava	4.5	15,191	3,743	11,448
Rice farm	9.0	8,282	5,818	2,464

1/ Not including cost of water and interest on working capital.

The annual water and labour requirements of the three farm types are given in Table E/7; the distribution of water and labour by months and crops is shown in Appendix E-4.

TABLE E/7: ANNUAL WATER AND LABOUR REQUIREMENTS OF THE PLANNED FARM TYPES

Farm Type	Water 1/ cu.m	Labour man-days
Mixed farm with cassava	21,310	439.0
Mixed farm without cassava	20,160	435.5
Rice farm	84,980	999.0

1/ Including losses in the main irrigation canal

5. Project-Wide Agricultural Development

It is expected that the physical construction of the New Weija Dam will be concluded within about two years. However, agricultural benefits will start to accrue only after irrigation facilities and land development in a given area are completed. Land development is planned to begin in Area 1, to be continued in Area 2 until all development works are completed within a period of four years. Table E/8 gives the anticipated rate of physical expansion of the irrigated areas in annual increments. The difference between the gross and the net areas is 13 percent, to allow for land utilized for roads, drainage canals, ditches, etc.

TABLE E/8: ESTIMATED RATE OF PHYSICAL DEVELOPMENT

ha/year

Year of development	Developed area, ha	
	Gross	Net
1	460	400
2	460	400
3	460	400
4	345	300
Total	1,725	1,500

Full development, in terms of crop yields and generated income, is expected to be reached in the 9th year from the inception of implementation.

The total areas occupied by the various crops and the volume of agricultural output at the ultimate stage are summed up in Table E/9. Table E/10 presents the project-scale budget estimate at full production stage. The gross return in this table is expressed in terms of generated income, as input costs do not included water charges and interest on working capital.

Total labour requirement will amount to about 295,000 man-days if cassava is included in the cropping plan and to about 286,000 man-days without cassava (see Appendix E-5), with the peak monthly demand in June under both alternatives. The total demand for irrigation water at the ultimate development stage will come to about 15.5 MCM (with cassava) and to 14.8 MCM (without cassava), as shown in Chapter F.

5. Project-wide Agricultural Development

It is expected that the physical construction of the new weir, Dam will be concluded within about two years. However, agricultural benefits will start to accrue only after irrigation facilities and land development in a given area are completed. Land development is planned to begin in Area 1, to be continued in Area 2 until all development works are completed within a period of four years. Table E/8 gives the anticipated rate of physical expansion of the irrigated areas (annual increments). The difference between the gross and the net areas is 13 percent, to allow for land utilized for roads, drainage canals, ditches, etc.

TABLE E/8: ESTIMATED RATE OF PHYSICAL DEVELOPMENT

ha/year

Year of development	Developed area, ha	
	Gross	Net
1	460	400
2	460	400
3	460	400
4	345	300
Total	1,725	1,500

Full development, in terms of crop yields and generated income, is expected to be reached in the sixth year from the inception of implementation.

The total areas occupied by the various crops and the volume of agricultural output at the ultimate stage are summarized in Table E/9. Table E/10 presents the project-cash budget estimate at full production stage. The gross returns in this table is expressed in terms of generated income, as inputs/costs do not include water charges and interest on working capital.

Total labour requirement will amount to about 286,000 man-days if cassava is included in the cropping plan and to about 286,000 man-days without cassava (see Appendix E-5), with the peak monthly demand in June under both alternatives. The total demand for irrigation water at the ultimate development stage will come to about 15.5 MCM (with cassava) and to 14.9 MCM (without cassava), as shown in Chapter F.

TABLE E/9: CROP AREAS AND OUTPUTS AT FULL PRODUCTION STAGE

Crop	Area, ha		Output, tons	
	With Cassava	Without Cassava	With Cassava	Without Cassava
Cassava	282	-	9,869	-
Maize	282	564	986	1,972
Groundnuts	563	845	1,407	2,111
Rice	180	180	810	810
Tobacco	282	282	395	395
Tomatoes	503	503	12,573	12,573
Pepper	345	345	2,760	2,760
Eggplants	63	63	1,575	1,575
Okro	218	218	3,488	3,488
Total	2,718	3,000	-	-

TABLE E/10: TOTAL VALUE OF OUTPUT, INPUT COSTS AND GENERATED INCOME AT FULL PRODUCTION STAGE

¢ thousands

Crop	Output value		Input costs		Generated income	
	With cassava	Without cassava	With cassava	Without cassava	With cassava	Without cassava
Cassava	809	-	280	-	529	-
Maize	193	387	132	264	61	123
Groundnuts	670	1,005	251	377	419	628
Rice	165	165	116	116	49	49
Tobacco	711	711	282	282	429	429
Tomatoes	3,320	3,320	755	755	2,565	2,565
Pepper	3,300	3,300	361	361	2,939	2,939
Eggplants	315	315	72	72	243	243
Okro	482	482	235	235	247	247
Total	9,965	9,685	2,484	2,462	7,481	7,223

TABLE E/9: CROP AREAS AND OUTPUTS AT FULL PRODUCTION STAGE

Crop	Area, ha		Outputs, tons	
	With Cassava	Without Cassava	With Cassava	Without Cassava
Cassava	282	-	9,869	-
Maize	282	564	985	1,972
Groundnuts	563	845	1,407	2,111
Rice	180	180	810	810
Tobacco	282	282	395	395
Tomatoes	503	503	12,573	12,573
Pepper	345	345	2,760	2,760
Eggplants	63	63	1,575	1,575
Okro	218	218	3,488	3,488
Total	2,718	3,000	-	-

TABLE E/10: TOTAL VALUE OF OUTPUT, INPUT COSTS AND GENERATED INCOME AT FULL PRODUCTION STAGE

₵ thousands

Crop	Output value		Input costs Generated Income			
	With cassava	Without cassava	With cassava	Without cassava	With cassava	Without cassava
Cassava	805	-	280	-	529	-
Maize	193	387	132	264	61	123
Groundnuts	870	1,005	251	377	619	628
Rice	185	165	116	116	49	49
Tobacco	711	711	282	282	429	429
Tomatoes	3,320	3,320	755	755	2,565	2,565
Pepper	3,300	3,300	361	361	2,939	2,939
Eggplants	315	315	72	72	243	243
Okro	482	482	236	235	247	247
Total	9,265	9,265	2,484	2,462	7,281	7,223

F. THE IRRIGATION PLAN

1. Water Requirements

As no direct measurement have been carried out on the consumptive - use requirements of the crops included in the cropping plan, they have been evaluated indirectly, using meteorological data for computing potential evapotranspiration (ETP), and empirical crop coefficients for converting ETP into actual evapotranspiration (ET), which represents the water requirement of the crop.

The net irrigation requirements of the crops been calculated from the ET, taking into account the effective rainfall, and irrigation efficiencies of 70 percent for rice and 75 percent for all other crops. Monthly average rainfall were obtained from the rainfall data recorded at the Accra Meteorological Station; effective rainfall was taken as 75 percent of the rainfall less 25 mm, provided that it did not exceed the ETP (see Table F/1).

The monthly crop irrigation requirements are listed in Table E/2, expressed as the average farm-gate demand (F.G.D.) of early and late-planted crops, as described in the cropping programme in chapter E.

TABLE F/1: MONTHLY EVAPORATION AND RAINFALL DATA

mm

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Evaporation 1/	168	182	204	189	200	137	151	146	157	194	170	146	2,044
ETP 2/	149	156	187	181	186	138	133	134	158	189	182	160	1,953
Mean Monthly rainfall 3/	17	33	71	94	135	238	64	20	53	69	34	18	840
Effective rainfall	0	0	35	52	83	138	29	0	21	33	0	0	391

The procedure for computing consumptive-use requirements and irrigation demands is described in detail in Appendix F-1.

Monthly and annual irrigation requirements for Areas 1 and 2 and for the entire Project Area are shown in Table F/2. A breakdown of the total water demand by crops is presented in Appendix Table F-1/7. It will be seen that the total annual water demand amounts to about 13.0 MCM with the cassava alternative and about 12.4 MCM without cassava. These tables represent the farm gate demand; in calculating the water supply requirements, some 15 percent have been added for operational losses, as shown in Chapter G. In both alternatives the peak irrigation demand is in the month of November.

1/ Class "A" pan, Accra Meteorological Service.

2/ Hargreaves radiation method.

3/ Average 1936-1974, Accra Meteorological Service.

F. THE IRRIGATION PLAN

Water Requirements

As no direct measurement have been carried out on the consumptive - use requirements of the crops included in the cropping plan, they have been evaluated indirectly, using meteorological data for computing potential evapotranspiration (ETP), and empirical crop coefficients for converting ETP into actual evapotranspiration (ET), which represents the water requirement of the crop.

The net irrigation requirements of the crops been calculated from the ET, taking into account the effective rainfall, and irrigation efficiencies of 70 percent for rice and 75 percent for all other crops. Monthly average rainfall were obtained from the rainfall data recorded at the Accra Meteorological Station; effective rainfall was taken as 75 percent of the rainfall less 25 mm, provided that it did not exceed the ETP (see Table F/1).

The monthly crop irrigation requirements are listed in Table F/2, expressed as the average farm-gate demand (F.G.D.) of early and late-planted crops described in the cropping programme in chapter E.

TABLE F/1: MONTHLY EVAPORATION AND RAINFALL DATA

mm

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Evaporation 1/	168	182	204	189	200	179	151	146	157	194	170	146	2,094
ETP 2/	149	150	167	161	186	159	123	134	150	169	162	160	1,922
Mean Monthly Rainfall 3/	17	33	71	94	135	239	94	39	83	59	34	16	840
Effective Rainfall	0	0	35	52	83	159	29	0	21	33	0	0	363

The procedure for computing consumptive-use requirements and irrigation demands is described in detail in Appendix F-1.

Monthly and annual irrigation requirements for Areas 1 and 2 and for the entire Project Area are shown in Table F/3. A breakdown of the total water demand by crops is presented in Appendix Table F-1/7. It will be seen that the total annual water demand amounts to about 13.0 MCM with the usual alternative and about 12.4 MCM without cassava. These tables represent the farm gate demand; in calculating the water supply requirements, some 15 percent have been added for operational losses, as shown in Chapter G. In both alternatives the peak irrigation demand is in the month of November.

1/ Class 'A' pan, Accra Meteorological Service.

2/ Harpreaves radiation method.

3/ Average 1953-1974, Accra Meteorological Service.

TABLE F/2: TOTAL MONTHLY AND ANNUAL WATER DEMAND

1,000 cu.m

Item	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1. WITH CASSAVA													
Area 1	765.4	182.1	519.9	1,048.1	929.5	-	656.7	432.9	778.6	1,346.4	2,077.9	1,771.3	10,498.8
Area 2	259.2	93.4	35.4	237.1	319.9	40.5	201.6	101.5	53.1	267.3	483.7	399.8	2,492.5
Total	1,024.6	275.5	555.3	1,285.2	1,249.4	40.5	848.3	534.4	831.7	1,613.7	2,561.6	2,171.1	12,991.3
Percentage	7.9	2.1	4.3	9.9	9.6	0.3	6.6	4.1	6.4	12.4	19.7	16.7	100
2. WITHOUT CASSAVA													
Area 1	554.2	63.3	348.3	995.3	1,153.9	-	607.1	182.1	686.2	1,372.8	2,157.1	1,824.1	9,944.4
Area 2	244.8	85.3	23.7	233.5	335.2	40.5	198.9	84.4	46.8	269.1	489.1	403.3	2,454.6
Total	799.0	148.6	372.0	1,228.8	1,489.1	40.5	806.0	266.5	733.0	1,641.9	2,646.2	2,227.4	12,399.0
Percentage	6.4	1.2	3.0	10.0	12.0	0.3	6.5	2.1	6.0	13.2	21.3	18.0	100

TABLE F\12: TOTAL MONTHLY AND ANNUAL WATER DEMAND

1,000 cu.m

Item	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1. WITH CASSAVA													
Area 1	765.4	691.1	816.0	1,046.1	886.8	-	585.7	1,152.6	1,256.9	1,346.4	1,077.6	1,771.4	10,398.0
Area 2	252.5	89.4	36.4	221.1	319.6	40.0	201.6	101.3	58.1	267.3	489.7	309.8	2,595.2
Total	1,017.9	780.5	852.4	1,267.2	1,206.4	40.0	787.3	1,253.9	1,315.0	1,613.7	1,567.3	2,081.2	12,993.2
Percentage	7.8	6.0	6.6	9.8	9.3	0.3	6.1	9.6	10.1	12.4	12.1	16.0	100
2. WITHOUT CASSAVA													
Area 1	554.4	691.5	816.0	1,046.1	886.8	-	585.7	1,152.6	1,256.9	1,346.4	1,077.6	1,771.4	10,398.0
Area 2	244.0	89.4	36.4	221.1	319.6	40.0	201.6	101.3	58.1	267.3	489.7	309.8	2,595.2
Total	798.0	780.9	852.4	1,267.2	1,206.4	40.0	787.3	1,253.9	1,315.0	1,613.7	1,567.3	2,081.2	12,993.2
Percentage	6.4	6.0	6.6	9.8	9.3	0.3	6.1	9.6	10.1	12.4	12.1	16.0	100

2. Irrigation Methods

a. Sprinkler Irrigation

(1) The Merits of Sprinkler Irrigation

The choice of the sprinkler method of irrigation for about 94 percent of the Project Area - excepting the 90 ha under rice - has been dictated by the following considerations:

(i) High infiltration rates. Typical infiltration rates as measured in the Project Area:

Soil type 1 - 0.10 cm/min.

Soil type 2 - 0.07 cm/min.

Soil type 7 - 0.09 cm/min.

Soils with high to very high infiltration rates require frequent and small doses of water, which cannot be efficiently applied by surface irrigation methods. High irrigation efficiency is a question not only of economy, i.e. reducing water losses, but also involves the prevention of waterlogging on the underlying heavier subsoil and the undue leaching of fertilizers by surplus water in soils with low cation exchange capacity.

(ii) Shallow topsoil. The fertile topsoil is shallow - 20 to 30 cm - in most of the Project Area and the land levelling that would be required for surface irrigation methods would significantly reduce the production potential of the soil.

(iii) Erosion hazard. A surface irrigation system laid out in the direction of the prevailing slope, which is the simplest scheme to construct and operate, would expose the soil to serious erosion hazard, especially when bare of vegetation. Cross-slope irrigation, on the other hand, involves much more earthwork and require highly skilled operators.

(iv) Skilled labour. One of the lessons learnt from the experience accumulated in various irrigation projects is that good surface irrigation requires trained, reliable operators. In sprinkler irrigation, the problems of efficient distribution are solved at the design stage and the simple routine of day-to-day operations is readily acquired even by farmers who have had no previous experience of irrigation.

(v) Interference with cultivations. Sprinkler systems can be designed so that they interfere less with cultivations and other farming operations and less land is taken out of production than with surface methods.

(vi) Winds. High wind velocities can interfere excessively with distribution of the water by the sprinklers. A study of wind records in the Accra area shows that wind velocities are within the permissible range for sprinkler irrigation.

Irrigation Methods

a. Sprinkler Irrigation

(i) The Merits of Sprinkler Irrigation

The choice of the sprinkler method of irrigation for about 3/4 per cent of the Project Area - excepting the 80 ha under rice - has been dictated by the following considerations:

(i) High infiltration rates. Typical infiltration rates measured in the Project Area:

Soil type 1 - 0.10 cm/min.

Soil type 2 - 0.02 cm/min.

Soil type 3 - 0.06 cm/min.

Soils with high to very high infiltration rates require frequent and small doses of water, which cannot be efficiently applied by surface irrigation methods. High irrigation efficiency is a question not only of economy, i.e. reducing water losses, but also involves the prevention of waterlogging or the underlying heavier subsoil and the undue leaching of fertilizers by surplus water in soils with low cation exchange capacity.

(ii) Shallow topsoil. The fertile topsoil is shallow - 20 to 30 cm - in most of the Project Area and the land levelling that would be required for surface irrigation methods would significantly reduce the productive potential of the soil.

(iii) Erosion hazard. A surface irrigation system laid out in the direction of the prevailing slope, which is the simplest scheme to construct and operate, would expose the soil to serious erosion hazard, especially when bare of vegetation. Cross-slope irrigation, on the other hand, involves much more earthwork and requires highly skilled operation.

(iv) Skilled labour. One of the lessons resulting from the experience accumulated in various irrigation projects is that good surface irrigation requires trained, reliable operators. In sprinkler irrigation, the problems of efficient distribution are solved at the design stage and the simple routine of day-to-day operations is readily achieved even by farmers who have had no previous experience of irrigation.

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(vi) Winds. High wind velocities can interfere excessively with distribution of the water by the sprinklers. A study of wind records in the Accra area shows that wind velocities are within the permissible range for sprinkler irrigation.

(2) Water Distribution and Irrigation

Area No.1 and 2 being two distinct geographical units, each will have a separate water supply and irrigation system (see Fig. G/1 and G/2). For Area 1, the water will be pumped from the Weija impounding reservoir into a canal, whose two branches surround the Area on three sides - east, north and west. Seven pumping stations located along the main canal will provide the necessary head for the sprinkler irrigation of each of the seven irrigation blocks which comprise Area No.1. The irrigation blocks, ranging in size from about 90 to 270 ha, have been laid out in accordance with topographical considerations, with due regard to the rational utilization of the pumping stations. The irrigation network within a typical block is described in Section 3-a of this Chapter.

Area No.2 - one-half of which will be sprinkler irrigated - will receive its water directly from an outlet built into the spillway of the Weija dam via a 36" pipe leading to the head of the Area and discharging into the main canal system. Conveyance in the main canals is by gravity flow. Of the ten blocks comprising Area 2, five will be sprinkler irrigated and to these water will be delivered by four pumping stations located along the main canal. Land suitability and topographical characteristics were the main considerations in defining the boundaries of the ten irrigation blocks.

Peak design values for the irrigation system have been determined by the demand of the crops recommended in the agricultural plan (Chapter E).

The system consists of a permanent, buried A.C. pipe network and portable aluminium sprinkler lines. The sprinkler lines will be 150 to 200 m long, depending on plot parcellation, which in turn is dictated by topography, geometry and farm size. It is preferable to design an even number of plots in the irrigation block in order to economize on permanent pipelines. Because of the small size of the holdings, each farm will have only a few sprinkler lines - sometimes not more than one - and as a consequence it will be practically impossible to adjust the line to the requirements of each crop. Thus, the design cannot be based on the average demand but has to take into consideration the needs of the highest consumer significant crop. By reason of the generally high infiltration rate, considerable savings can be effected on sprinkler lines by increasing the irrigation intensity and by moving the lines more frequently; however, this calls for a degree of co-ordination and co-operation among the irrigators that is not easy to achieve.

The proposed ratio between irrigation cycles and intervals is 5:7. The sprinklers will be of the medium pressure type - 25 to 30 m operational head, with the head loss in the sprinkler line limited to 20 percent.

(2) Water Distribution and Irrigation

Areas No.1 and 2 being two distinct geographical units, each will have separate water supply and irrigation system (see Fig. G\1 and G\2). For Area No.1, the water will be pumped from the Weila impounding reservoir into a main canal, whose two branches surround the Area on three sides - east, north and west. Seven pumping stations located along the main canal will provide the necessary head for the sprinkler irrigation of each of the seven irrigation blocks which comprise Area No.1. The irrigation blocks, ranging in size from about 210 to 270 ha, have been laid out in accordance with topographical considerations, and due regard to the rational utilization of the pumping stations. The irrigation network within a typical block is described in Section 3-a of this Chapter.

Area No.2 - one-half of which will be sprinkler irrigated - will receive water directly from an outlet built into the spillway of the Weila dam via a pipe leading to the head of the Area and discharging into the main canal system. Conveyance in the main canals is by gravity flow. Of the ten blocks comprising Area 2, five will be sprinkler irrigated and to these water will be delivered by four pumping stations located along the main canal. Land suitability and topographical characteristics were the main considerations in defining the boundaries of the ten irrigation blocks.

Peak design values for the irrigation system have been determined by the demand of the crops recommended in the agricultural plan (Chapter E).

The system consists of a permanent, buried A.C. pipe network and portable aluminium sprinkler lines. The sprinkler lines will be 150 to 200 m long, depending on plot parcellation, which in turn is dictated by topography, geometry and farm size. It is preferable to design an even number of plots in the irrigation block in order to economize on permanent pipelines. Because of the small size of the holdings, each farm will have only a few sprinkler lines - sometimes not more than one - and as a consequence it will be practically impossible to adjust the timing to the requirements of each crop. Thus, the design cannot be based on the average demand but has to take into consideration the needs of the highest consumer significant crop. By reason of the generally high infiltration rate, considerable savings can be effected on sprinkler lines by increasing the irrigation intensity and by moving the lines more frequently; however, this calls for a degree of co-ordination and co-operation among the irrigators that is not easy to achieve.

The proposed ratio between irrigation cycles and intervals is 6:7. The sprinklers will be of the medium pressure type - 25 to 30 m operational head, with the head loss in the sprinkler line limited to 20 percent.

percent. The lines and the sprinklers will be spaced at 12m intervals. The maximum number of irrigation hours per day will be 15, taking into account that it will be possible to continue irrigation after dark and to stop the sprinklers by shutting off the main valves. However, no other work, such as moving the lines, will be done at night.

In order to assure even emergence and a full stand of plants, germination irrigation will be applied to all sprinkler irrigated crops at the rate of 800 cu.m/ha. The last irrigation will usually be applied about 20 days before harvest.

(b) Surface Irrigation of Rice

As stated in the agricultural plan, 90 ha net of the 180 ha Area 2 have been earmarked for rice farms, growing two crops of rice per year under irrigation. On the basis of soil suitability and topography five irrigation blocks have been laid out for rice cultivation (see Fig. G/2), which will be surface irrigated by the levelled basin paddy method. Water will be conveyed by gravity from the main canals supplying Area 2 into secondary canals and diverted into the paddies by means of syphons.

The size of the paddies will be determined by local topographical conditions; on level land the recommended paddy dimensions are 30 x 100 m. In order to keep land levelling operations to a minimum, the vertical distance between neighbouring paddies will be less than 7 cm. Each paddy will have access to an irrigation and a drainage canal. The choice of syphons in favour of fixed gates was made in order to prevent leakage into the canal when it is empty. Portable canvas checks will be used.

Rotational irrigation will be practiced; although this requires bigger flow volumes it is easier to manage. A rather large quantity of water, 1,800 cu.m/ha, has been allotted for pre-irrigation before puddling and for the initial ponding. For agronomic reasons it is recommended to fill the paddies 10 days before transplanting and the demand of these 10 days has been taken into account in calculating the irrigation requirements of rice. A relatively small amount of water, 200 cu.m/ha, was allotted for nursery irrigation because the nursery occupies only 10 percent of the area and it too is subsequently planted to rice. The percolation rate has been estimated at 2 mm/day in the first month and at 1 mm/day from the second month on. The last irrigation is applied 20 days before harvest.

3. On-farm Development

The main features of the water supply and drainage systems of Area 1 and 2 are described in the engineering plan in Chapter G. On-farm development, as outlined in the following, refers to all works concerned

with irrigation and drainage within the boundaries of a designated irrigation block, and it comprises:

- Land clearing and levelling
- Water distribution and irrigation network
- Drainage system
- Field roads.

Two sample irrigation blocks have been selected for presenting the design and the cost estimates of the two farm types: sprinkler irrigated mixed farms and surface irrigated rice farms.

a. Sprinkler Irrigated Sample Block

This block occupies 268 ha in Area 1; its layout is illustrated in Fig. F/1.

(1) Land Clearing and Levelling

The Project Area is covered by savannah-type vegetation - tall grasses, some bushes and scattered trees (about 6 trees per ha), which have to be cleared before irrigated farming can be undertaken.

Little land levelling will be needed because sprinkler irrigation does not require as accurately levelled ground as do surface irrigation methods, and also because the generally flat topography presents very few obstructions to cultivations. Nor will it be necessary to undertake specific soil conservation measures, provided that the land-forming practice, described in paragraph (3) of this Section, is adopted.

(2) The Irrigation System

The water will be supplied from pumping station C to three main A.C. pipes of 20" to 8" diameter, after metering and pressure regulation. Secondary, (hydrant) A.C. pipes of 8" to 4" diameter will branch off from the mains along the dominant slope. The hydrants, to which the portable sprinkler lines will be coupled, will be spaced at 36m. intervals, which means that extensions will be required for two of three irrigation positions of the sprinkler line (see Fig. F/2).

Design data:

Peak gross demand per day	6 mm
Interval between irrigations	7 days
Gross demand per irrigation	42 mm
Duration of irrigation cycle	5 days
Maximum daily irrigation hours	15
No. of sprinkler positions per day	2
No. of sprinkler positions per farm (2.5 ha)	10
No. of sprinkler lines per farm	1

tion and drainage within the boundaries of a designated irrigation
it comprises:
Land clearing and levelling
Water distribution and irrigation network
Drainage system
Field roads.

sample irrigation blocks have been selected for presenting the design
cost estimates of the two farm types: sprinkler irrigated mixed farms
ce irrigated rice farms.

Sprinkler Irrigated Sample Block

e block occupies 288 ha in Area 1; its layout is illustrated in Fig. F/1.

Land Clearing and Levelling

The Project Area is covered by savannah-type vegetation - tall
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ions. Nor will it be necessary to undertake specific soil conservation
provided that the 'land-forming practices' described in paragraph (3)
ection' is adopted.

The Irrigation System

The water will be supplied from pumping station C to three main
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econdary' (hydrant) A,C, pipes of 8" to 4" diameter will branch off from
ains along the dominant slope. The hydrants, to which the portable
lines will be coupled, will be spaced at 36m intervals, which means
ersions will be required for two of three irrigation positions of the
r line (see Fig. F/2).

ation data:

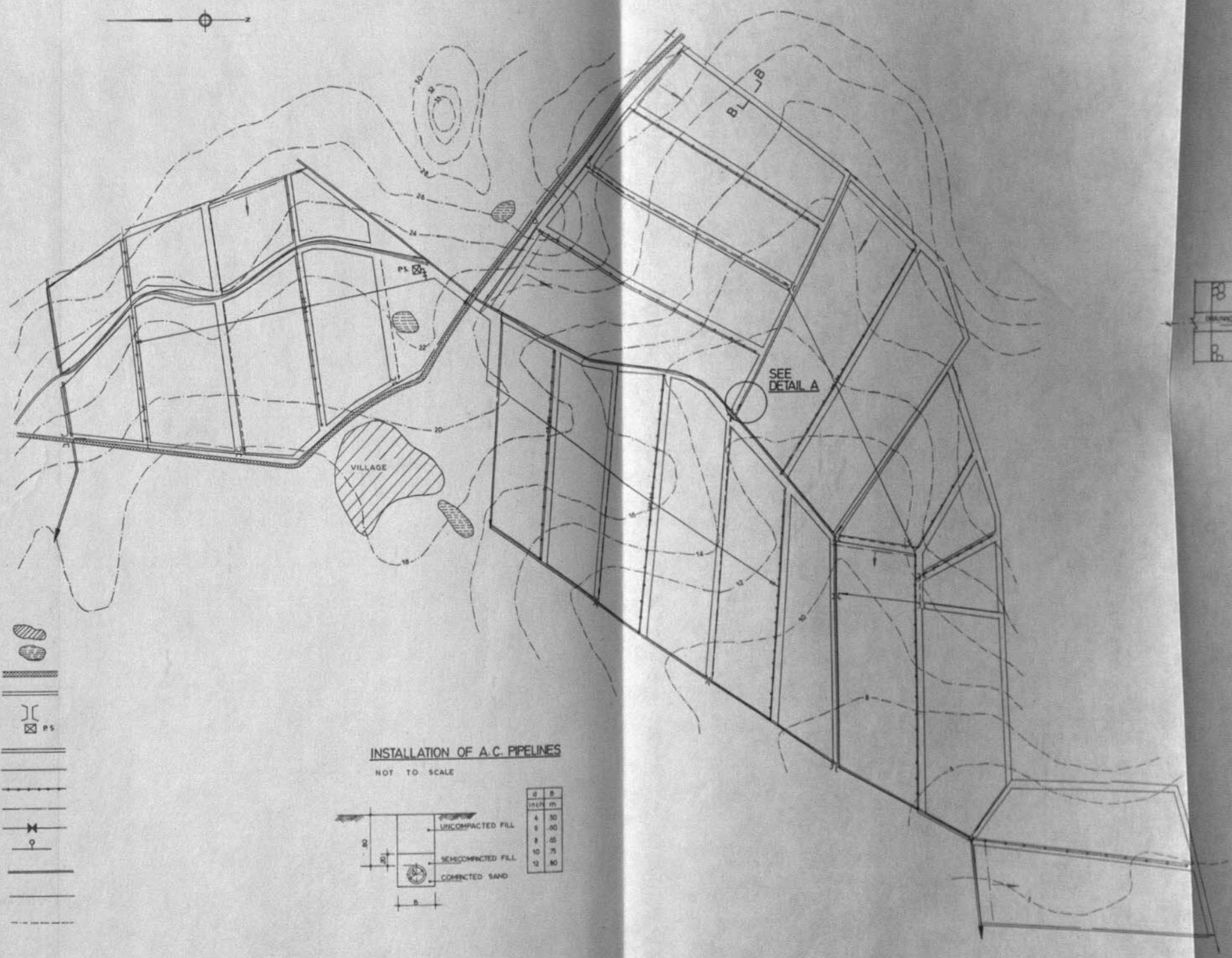
k gross demand per day	7 days
rval between irrigations	42 mm
ss demand per irrigation	5 days
ation of irrigation cycle	15
imum daily irrigation hours	2
of sprinkler positions per day	10
of sprinkler positions per farm (2,5 ha)	1
of sprinkler lines per farm	

SAMPLE AREA OF MIXED FARM TYPE IRRIGATION AND DRAINAGE SCHEMES

PLAN

SCALE

50 0 100 200 m



LEGEND

- VILLAGE
- EXISTING POND
- MAIN ROAD
- FIELD ROAD
- CULVERT
- PUMPING STATION (PS)
- CONVEYANCE CANAL
- A.C. PIPELINE
- A.C. PIPE WITH HYDRANTS
- PORTABLE ALUMINUN PIPE
- SLUICE VALVE
- AIR VALVE
- MAIN DRAINAGE CHANNEL
- DRAIN LATERAL AND INTERCEPTOR
- SECONDARY DRAIN

INSTALLATION OF A.C. PIPELINES

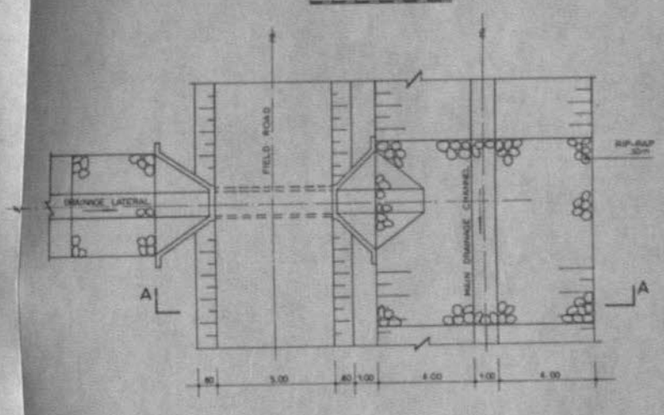
NOT TO SCALE

d (inch)	B (m)
4	.50
6	.60
8	.65
10	.75
12	.80

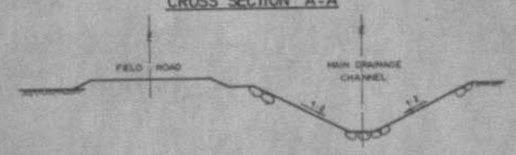
DETAIL A

SCALE

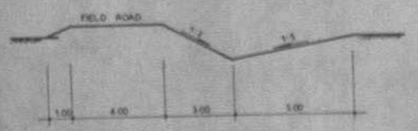
1.00 0 1.00 2.00 3.00 4.00 5.00 m



CROSS SECTION A-A



CROSS SECTION B-B



WEJA IRRIGATION PROJECT
A. E. S. C. — TAHAL

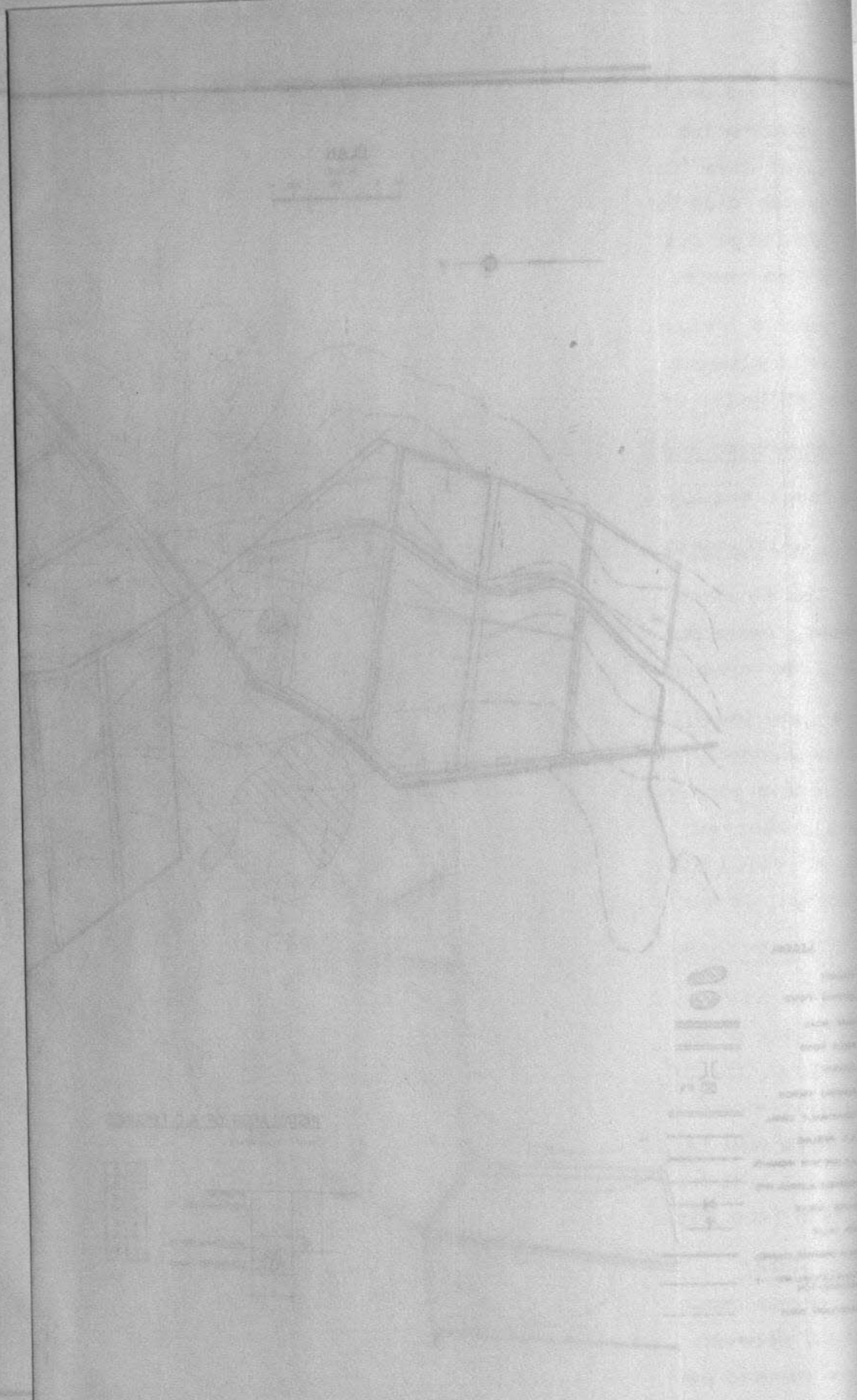


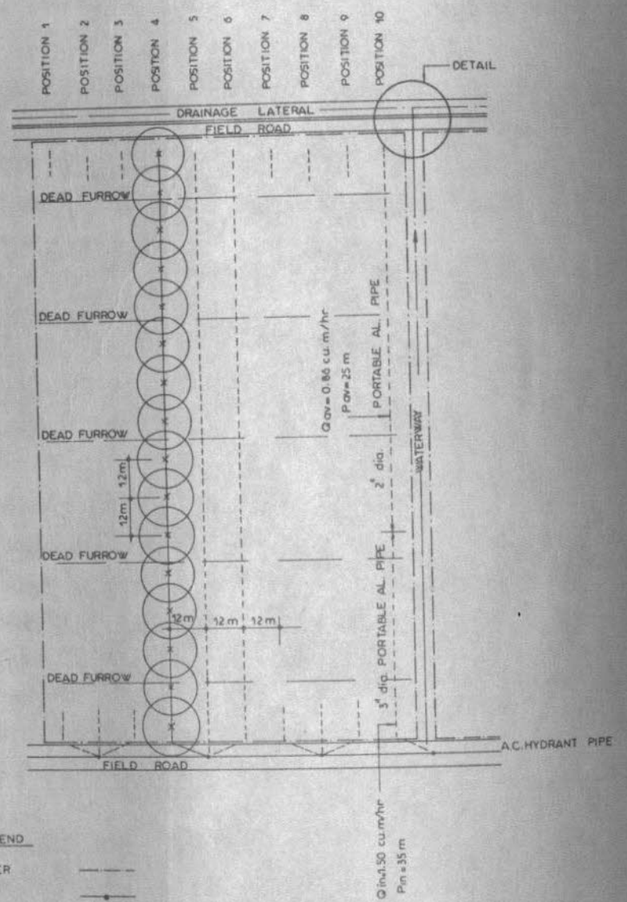
FIG. F/2

LAYOUT OF SPRINKLER IRRIGATION SYSTEM ON A 2.5 - ha FARM

PLAN

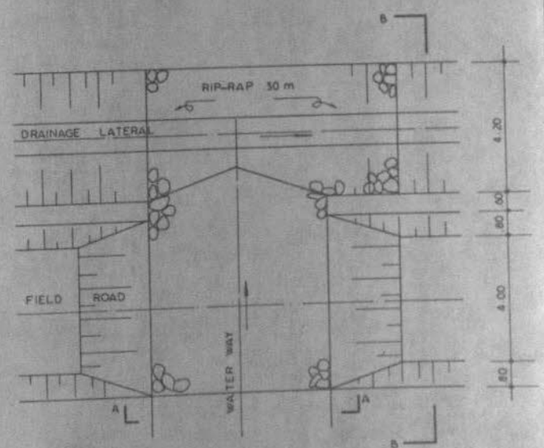
SCALE

5 0 10 20 30 40 50 m

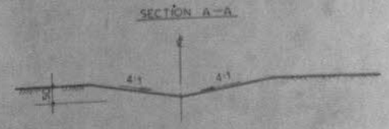


LEGEND

PLOT BORDER	
HYDRANT	
SPRINKLER	
SPRINKLER DISCHARGE	Q
SPRINKLER PRESSURE	P



SECTION A-A

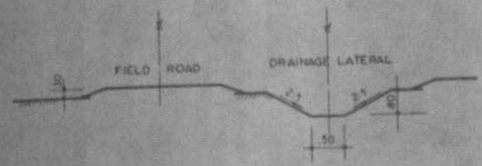


DETAIL

SCALE

.50 0 1.00 2.00 m

SECTION B-B



WEIJA IRRIGATION PROJECT
A. E. S. C. — TAHAL

No. of hours per sprinkler position	7
Irrigation intensity	6 mm/ha
Sprinkler spacing	12 x 12 m
Discharge per average sprinkler	0.87 cu.m/ha
No. of sprinklers per line	17
Discharge per sprinkler line	15 cu.m/ha
Average operating pressure	25 m
Head-loss in sprinkler line (64m of 3" and 128m of 2" dia).	5 m
Head in the first sprinkler	29 m.

(3) The Drainage System

As defined here, the on-farm surface drainage system consists of: (1) interceptor canals along the boundaries of the irrigation blocks, to intercept runoff originating outside the Project Area; (2) secondary drainage canals, which drain surplus water from the block into the main drains; (3) waterways for collecting surplus water from individual parcels. Other components of the drainage system are described in Chapter G (Section 2). Here only land forming by the bedding method of surface drainage will be mentioned, which is the practice recommended at the farm level. This method consists of narrow plough lands separated by dead furrows running parallel to the prevailing slope. The beds will be constructed gradually and improved each season as the land is ploughed. All other cultivations will be performed in the cross-slope direction. The dead furrows will be at least 30 cm deep and they will also help to drain the water perched on the underlying heavier subsoil. A waterway will collect the runoff from the dead furrows and convey it to a drainage lateral or directly to a main drainage canal via a small culvert.

The cost estimate in Table F/3 include secondary and tertiary canals (waterways) but not land forming, which should be charged to the normal seasonal cultivations.

(4) Field Roads

Each farm will have access to two field roads, usually constructed along the secondary drainage canal and the secondary irrigation pipeline.

(5) Cost Estimate.

The estimated costs of on-farm development works on the 268 ha sample irrigation block are listed in Table F/3. It will be noted that the cost of field roads is not listed separately, as it is included in the cost of construction of the drainage canals.

No. of hours per sprinkler position	7
Irrigation intensity	6 mm/ha
Sprinkler spacing	12 x 18 m
Discharge per average sprinkler	0.67 cu.m/ha
No. of sprinklers per line	17
Discharge per sprinkler line	15 cu.m/ha
Average operating pressure	25 m
Head-loss in sprinkler line (64m of 3" and 128m of 2½" dia).	5 m
Head in the first sprinkler	35 m.

(3) The Drainage System.

As defined here, the on-farm surface drainage system consists of:

(1) interceptor canals along the boundaries of the irrigation blocks, to intercept runoff originating outside the Project Area; (2) secondary drainage canals, which drain surplus water from the block into the main drains; (3) waterways for collecting surplus water from individual parcels. Other components of the drainage system are described in Chapter C (Section 2). Here only land forming by the bedding method of surface drainage will be mentioned, which is the practice recommended at the farm level. This method consists of narrow ploughlands separated by dead furrows running parallel to the prevailing slope. The beds will be constructed gradually and improved each season as the land is ploughed. All other cultivations will be performed in the cross-slope direction. The dead furrows will be at least 30 cm deep and they will also help to drain the water ponded on the undeveloping heavier subsoil. A waterway will collect the runoff from the dead furrows and convey it to a drainage lateral or directly to a main drainage canal via a small culvert.

The cost estimate in Table F/3 include secondary and tertiary canals (waterways) but not land forming, which should be charged to the normal seasonal cultivations.

(4) Field Roads

Each farm will have access to two field roads, usually constructed along the secondary drainage canal and the secondary irrigation pipeline.

(5) Cost Estimate.

The estimated costs of on-farm development works on the 269 ha sample irrigation block are listed in Table F/3. It will be noted that the cost of field roads is not listed separately, as it is included in the cost of construction of the drainage canals.

b. Surface Irrigated Sample Block

This sample irrigation block occupies 17 ha in the south-western part of Area No.2 and is intended to serve as a model for the entire area of 90 ha proposed for rice cultivation. The layout of the irrigation block is presented in Fig. F/3.

(1) Land Clearing and Levelling

Light land clearing operations will have to be carried out as in the sprinkler irrigated areas.

Land levelling in this case involves the construction of the levelled basins bounded by dykes for each individual rice paddy.

(2) The Irrigation System

The Secondary irrigation canal with a minimum head of 30 cm will convey the water to the farm irrigation canals, which will have a minimum head of 25 cm. Water from the irrigation canals will be diverted into the paddies by means of 4" dia syphons; for checking portable canvas checks will be used.

Design data:

Peak daily gross demand	12.7 mm
Irrigation days per month	20
Irrigation hours per day	10
Required discharge	19 cu.m/hr/ha.

(3) Drainage System

The water level in the paddy will be controlled by a simple earth notch protected by grass cover. The excess water from the paddies will be conveyed to drainage laterals and then through culverts to the main drainage system.

(4) Field Roads

Farm roads will run between the drainage ditches and will have access to the service roads running along the irrigation and drainage canals.

(5) Cost Estimate

The estimated costs of on-farm development for the 17 ha surface irrigated block are given in Table F/4.

Surface Irrigated Sample Block

This sample irrigation block occupies 17 ha in the southwestern part of Area No.2 and is intended to serve as a model for the entire area of 30 ha proposed for rice cultivation. The layout of the irrigation block is presented in Fig. F/3.

(1) Land Clearing and Leveling

Light land clearing operations will have to be carried out as in the sprinkler irrigated areas.

Land levelling in this case involves the construction of the levelled basins bounded by dykes for each individual rice paddy.

(2) The Irrigation System

The Secondary irrigation canal with a minimum head of 30 cm will convey the water to the farm irrigation canals, which will have a minimum head of 25 cm. Water from the irrigation canals will be diverted into the paddies by means of 4" dia syphons; for checking portable canvas checks will be used.

Design data:

Peak daily gross demand	12.7 mm
Irrigation days per month	20
Irrigation hours per day	10
Required discharge	19 cu.m/hr/ha.

(3) Drainage System

The water level in the paddy will be controlled by a simple earth notch protected by grass cover. The excess water from the paddies will be conveyed to drainage laterals and then through culverts to the main drainage system.

(4) Field Roads

Farm roads will run between the drainage ditches and will have access to the service roads running along the irrigation and drainage canals.

(5) Cost Estimate

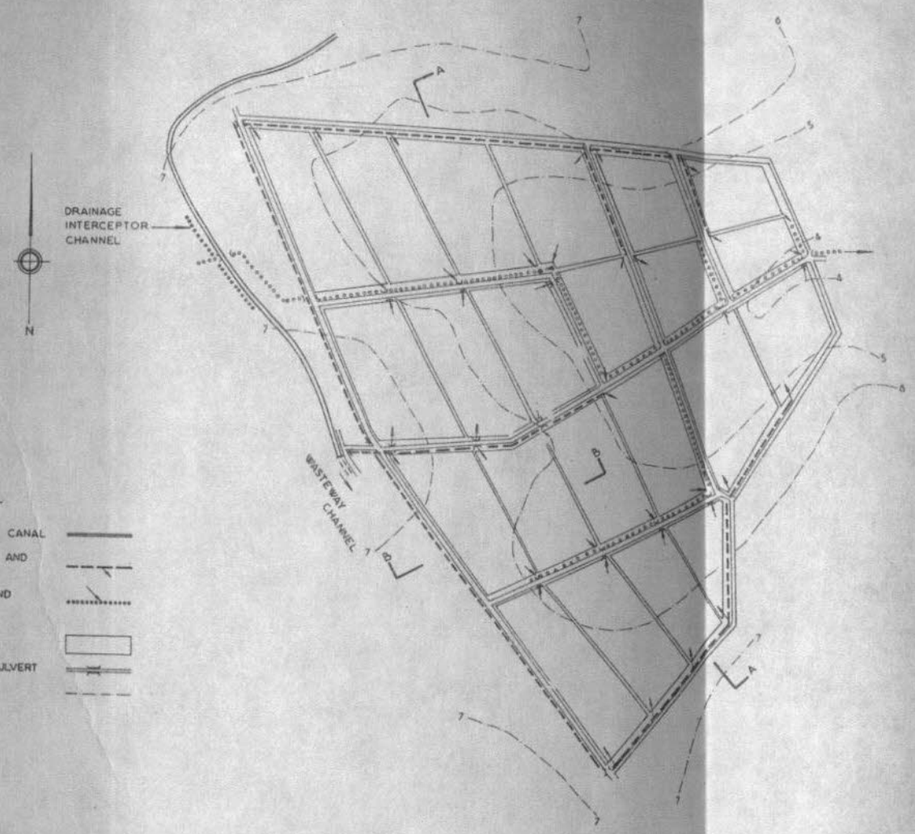
The estimated costs of on-farm development for the 17 ha surface irrigated block are given in Table F/4.

SAMPLE RICE AREA
LAYOUT AND SCHEMATIC CROSS-SECTION

PLAN

SCALE

50 0 100 200 m

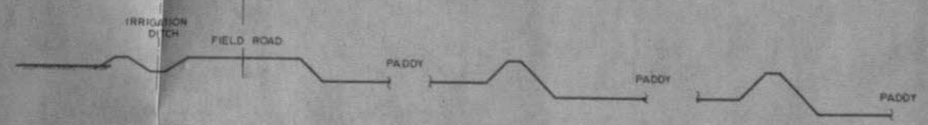


LEGEND

- MAIN CONVEYANCE CANAL
- IRRIGATION DITCH AND PADDY INLET
- DRAINAGE DITCH AND PADDY OUTLET
- PADDY BOUNDARIES
- FIELD ROAD AND CULVERT
- CONTOUR LINE

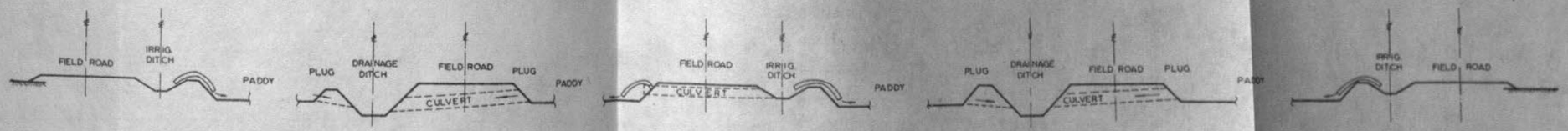
SCHEMATIC SECTION B – B

NOT TO SCALE



SCHEMATIC SECTION A – A

NOT TO SCALE



WEJA IRRIGATION PROJECT
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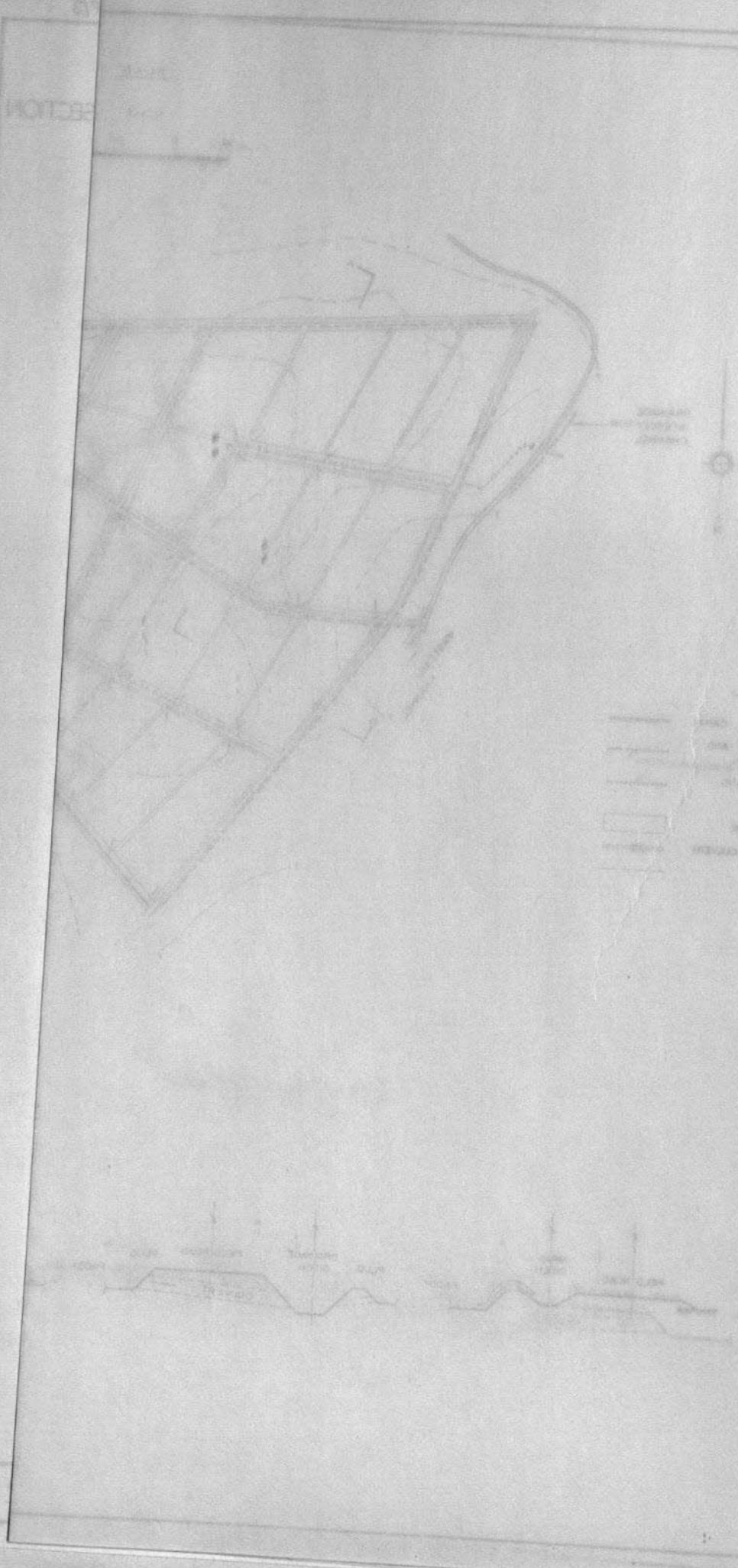


TABLE F/3: COST ESTIMATE OF ON-FARM DEVELOPMENT ON SPRINKLER IRRIGATED SAMPLE BLOCK OF 268 ha

Item	Unit	Quantity	Unit Cost ¢	Total Cost ¢
Land Preparation				
Land clearing	ha	268	375	100,500
Land levelling	cu.m	13,400	3.50	46,900
Sub-total				147,400
Irrigation System				
A.C. pipes, including accessories and installation:				
20" dia	m	350	134	46,900
18" dia	m	200	105	21,000
16" dia	m	650	90	58,500
14" dia	m	550	70	38,500
12" dia	m	1,480	52	76,960
10" dia	m	200	41	8,200
8" dia	m	2,060	30	61,800
6" dia	m	2,830	20	56,600
4" dia	m	2,130	12	25,560
Gated vaives of various dimensions	No.	10	-	2,630
Risers and vaives	No.	200	27	5,400
Air vent	No.	1	100	100
Aluminium pipes with couplings, 6m, 3" dia	No.	1,560	22.90	35,500
Aluminium pipes with couplings, 6m 2" dia	No.	2,640	16.10	42,500
Accessories to portable network Sprinklers	No.	2,040	5.50	11,220
Sub-total				491,590
Drainage System				
Interceptor canals, 5,200 m	cu.m	18,200	3.50	63,700
Lateral canals, 3,750 m	cu.m	7,900	3.50	27,700
Waterways, 22,000 m	cu.m	66,000	3.50	231,000
Culverts, 1 x 2 ft	No.	11	1,000	11,000
Sub-total				333,400
Total				972,390
Cost per ha				3,628

TABLE F/3: COST ESTIMATE OF ON-FARM DEVELOPMENT ON SEMI-LEVER IRRIGATED SAMPLE BLOCK OF 268 ha

Item	Unit	Quantity	Unit Cost ¢	Total Cost ¢
Land Preparation				
Land clearing	ha	268	375	100,500
Land levelling	cu.m	13,800	3.50	46,900
Sub-total				147,400
Irrigation System				
A.C. pipes, including accessories and installations:				
20" dia	m	350	134	46,900
18" dia	m	200	105	21,000
16" dia	m	350	80	28,300
14" dia	m	350	70	24,500
12" dia	m	1,180	64	76,000
10" dia	m	200	41	8,200
8" dia	m	2,060	30	61,800
6" dia	m	2,810	20	56,600
4" dia	m	2,130	12	25,560
Gated valves of various dimensions	Nos.	10	-	2,030
Risers and valves	Nos.	200	27	5,400
Air vent	Nos.	1	100	100
Aluminium pipes with couplings, 6m. 3" dia	No.	1,610	22.90	35,500
Aluminium pipes with couplings, 6m. 2" dia	No.	2,640	16.10	42,500
Accessories to portable network Sprinklers	No.	2,040	5.50	11,220
Sub-total				491,220
Drainage System				
Interceptor canals, 5,200 m	cu.m	18,200	3.50	63,700
Lateral canals, 3,750 m	cu.m	7,900	3.50	27,700
Waterways, 22,000 m	cu.m	66,000	3.50	231,000
Culverts, 1 x 2 ft	No.	11	1,000	11,000
Sub-total				333,400
Total				972,020
Cost per ha				3,626

TABLE F/4: COST ESTIMATE OF ON-FARM DEVELOPMENT ON SURFACE IRRIGATED SAMPLE BLOCK OF 17 ha

Item	Unit	Quantity	Unit cost ¢	Total cost ¢
Land Preparation				
Land clearing	ha	17	375	6,380
Land levelling	cu.m	3,400	3.50	11,900
Sub-total				18,280
Irrigation System				
Irrigation canals, 910m	cu.m	910	3.50	3,200
Portable checks	No.	4	100	400
Syphons, 4" dia	No.	8	70	560
Gated inlets	No.	3	1,000	3,000
Sub-total				7,160
Drainage System				
Drainage laterals, 1,570 m	cu.m	3,300	3.50	11,550
Culverts, 1 x 2 ft	No.	8	1,000	8,000
Sub-total				19,550
Total				44,990
Cost per ha				2,646

c. Cost of On-farm Development

The cost of on-farm development per hectare and the total costs for Areas 1 and 2 and for the entire Project Area have derived from the two sample irrigation blocks (Tables F/3 and F/4).

The total costs of on-farm development are presented in Table F/5. To the basic cost estimate 15% have been added to cover physical contingencies and an additional 10% for engineering services.

TABLE F/4: COST ESTIMATE OF ON-FARM DEVELOPMENT ON SURFACE IRRIGATED SAMPLE BLOCK OF 17 ha

Item	Units	Quantity	Unit cost ₫	Total cost ₫
Land Preparation				
Land clearing	ha	17	375	6,380
Land levelling	cu.m	3,400	3,50	11,900
Sub-total				18,280
Irrigation System				
Irrigation canals, 810m	cu.m	910	3,50	3,200
Portable checks	No.	4	100	400
Syphons, 4" dia	No.	8	70	560
Gated inlets	No.	3	1,000	3,000
Sub-total				7,160
Drainage System				
Drainage laterals, 1,570 m	cu.m	3,300	3,50	11,550
Culverts, 1 x 2 ft	No.	8	1,000	8,000
Sub-total				19,550
Total				44,990
Cost per ha				2,646

c. Cost of On-farm Development

The cost of on-farm development per hectare and the total costs for Areas 1 and 2 and for the entire Project Area have derived from the two sample irrigation blocks (Tables F/3 and F/4).

The total costs of on-farm development are presented in Table F/5. To the basic cost estimate 15% have been added to cover physical contingencies and an additional 10% for engineering services.

TABLE 4: TOTAL COSTS OF ON-FARM DEVELOPMENT WORKS

Item	Net Area ha	Basic cost ¢/ha	Basic cost Total ¢1,000	Contingencies 15% ¢1,000	Field cost ¢1,000	Engineering services 10% ¢1,000	Total cost ¢1,000
Area No.1							
- Sprinkler irrigated mixed farms	1,320	3,628	4,789.0	718.4	5,507.4	550.7	6,058.1
Area No.2							
- Sprinkler irrigated mixed farms	90	3,628	326.5	49.0	375.5	37.6	413.1
- Surface irrigated rice farms	90	2,646	238.1	35.7	273.8	27.4	301.2
- Total for Area No.2	180		564.6	84.7	649.3	65.0	714.3
Grand Total for the Project	1,500		5,353.6	803.1	6,156.7	615.7	6,772.4

SKIRON DEVELOPMENT WORKS

TABLE

Item	Area	Land acquisition		Construction cost			Engineering services 10% ¢1,000	Total cost ¢1,000
		Quantity	Total ¢1,000	Contingencies 15% ¢1,000	Field cost ¢1,000	Total ¢1,000		
Area No.1 - Upper intake and integrated piping terms	1,320	3,029	4,760.0	714.4	5,507.4	550.7	6,058.1	
	90	3,629	326.5	49.0	375.5	37.6	413.1	
	90	2,649	239.1	35.7	274.8	27.4	302.2	
	180		554.6	84.7	650.3	65.0	715.3	
	1,500		5,553.6	834.1	6,457.7	645.8	7,103.5	
Area No.2 - Upper intake integrated piping terms								
- Surface intake terms								
- Total for Area No.2								
Grand Total for the Project								

G. ENGINEERING WORKS

1. The Irrigation System

a. General

Area No. 1 and Area No. 2 of the Project both lie along the Accra-Winneba road but are physically separated from each other by a distance of about 7.5 km (4.7 miles). Although the two areas have a common water source, the Weija Impounding Reservoir, they will be supplied through two separate and independent water supply schemes, outlined in the following. Notwithstanding the separate supply facilities, the two schemes have several common features; they form parts of a single project and come under the same implementation schedule. Therefore, the basic design criteria refer to both of the schemes and the same is true of the typical structures, in as much as conditions are similar. General layouts of the two areas are presented in Fig. G/1 and G/2.

Since the entire Area No.1 and one-half of Area No.2 will be sprinkler irrigated and only 90 ha of rice lands in Area No.2 will be irrigated by surface irrigation method, the Project in its entity may be regarded as being sprinkler irrigated. This implies that at least at the heads of the irrigated fields, the system has to be under pressure, necessitating piped conveyance. The decision whether to use pipelines also from the source and along the irrigation lands was made by considering the following points:

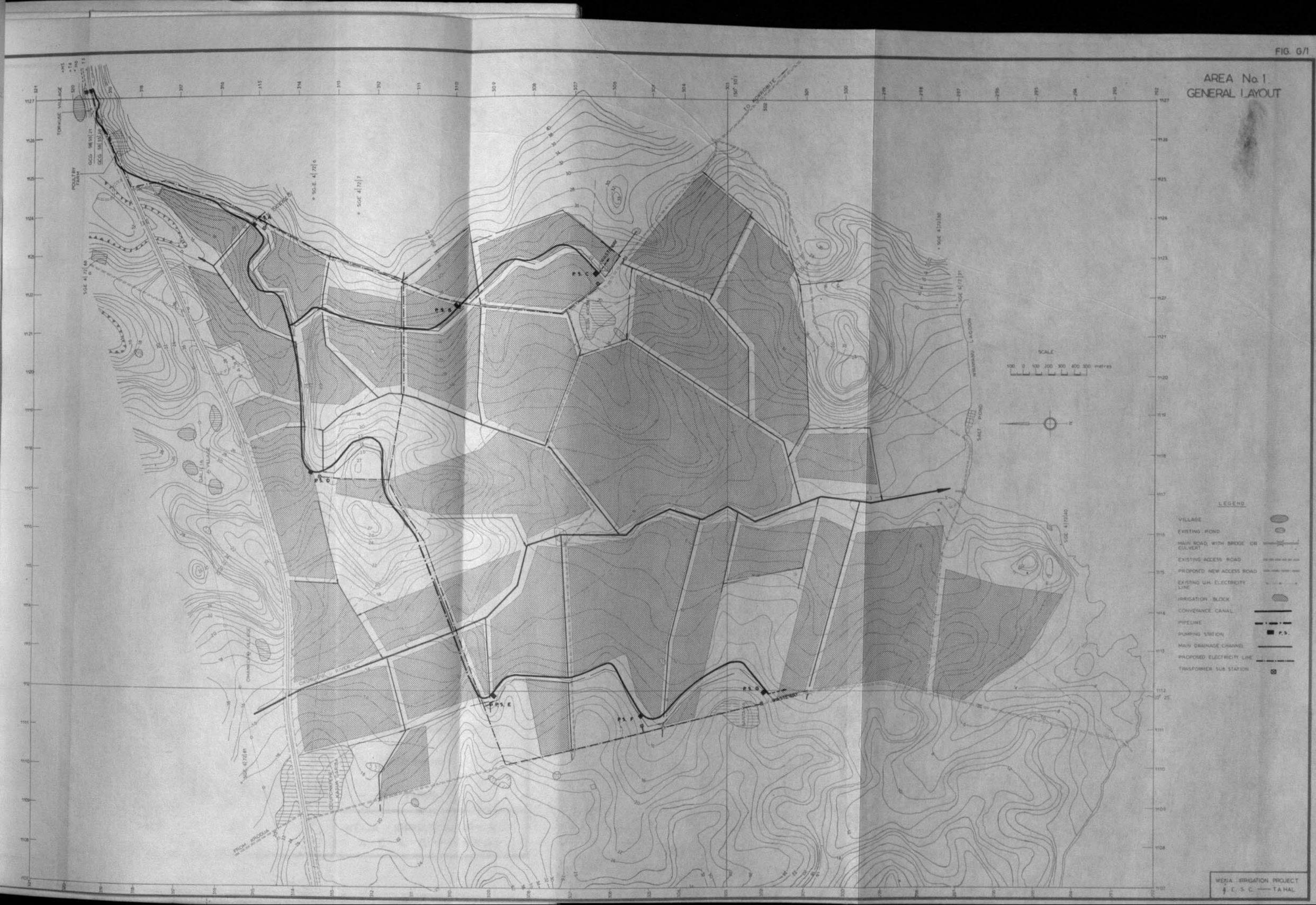
- In Area No.2, where the rice growing farm lands will be gravity irrigated, the topography is flat and the soils somewhat heavier, hence a gravity-canal conveyance system is the obvious choice.
- In Area No.1, where the terrain is relatively level, yet the alignment of a gravity-canal conveyance system would encounter some difficulties, a preliminary comparison was conducted between two alternatives: Alternative 1, gravity-canal conveyance, and Alternative II, pipeline conveyance. The pressure required for sprinkler irrigation in Alternative I was to be supplied by pumping stations located along the canals while in Alternative II it was to be provided directly by the intake pumps, operating against a head determined and controlled by an operational reservoir to be built on the hill at the eastern border of the area.

Although the comparison of the two alternatives was provisional, the findings were so decisively in favour of Alternative I[1/] that no further consideration of the second alternative seemed justified. Consequently, Alternative I was adopted for the conveyance system.

1/ When comparing estimated investment costs, Alternative I proved to be cheaper than Alternative II by a factor of about 1:3.

FIG. G/1

AREA No. 1
GENERAL LAYOUT



AREA No. 2
GENERAL LAYOUT

N

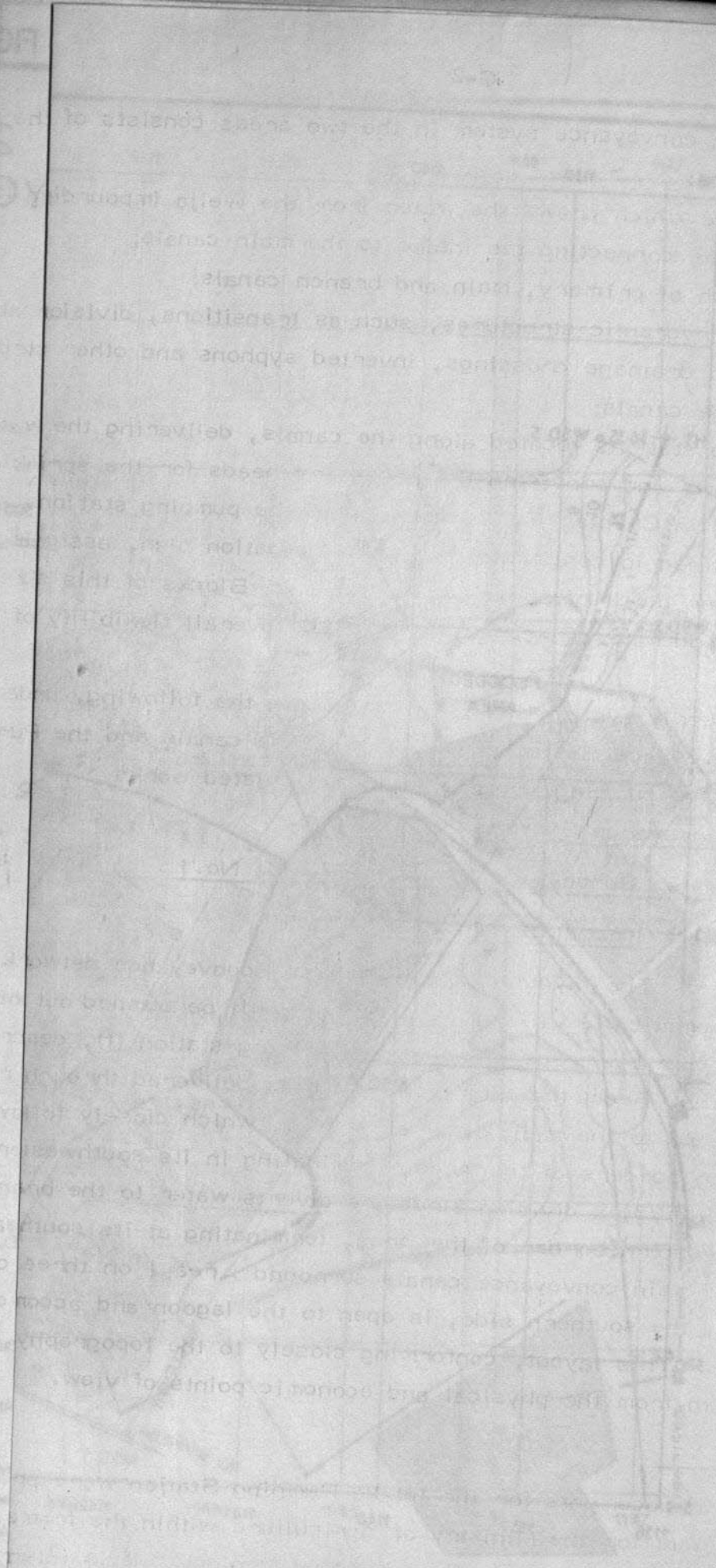
SCALE:

100 0 100 200 300 400 500 metres

LEGEND

- MAIN ROAD WITH BRIDGE OR CULVERT
- EXISTING ACCESS ROAD
- PROPOSED NEW ACCESS ROAD
- EXISTING U.H. ELECTRICITY LINE
- IRRIGATION BLOCK
- CONVEYANCE CANAL
- PIPELINE
- PUMPING STATION — P.S.
- MAIN DRAINAGE CHANNEL
- PROPOSED ELECTRICITY LINE
- TRANSFORMER SUB-STATION
- M.F. = MIXED FARMS
- R = RICE FARMS

WEIJA IRRIGATION PROJECT
A. E. S. C. — TAHAL



Thus the main conveyance system in the two areas consists of the following principal components:

- An intake which draws the water from the Weija Impounding Reservoir;
- A pipeline connecting the intake to the main canals;
- A stretch of primary, main and branch canals;
- Related hydraulic structures, such as transitions, division structures, road and drainage crossings, inverted syphons and other structures along the canals;
- Pumping stations located along the canals, delivering the water from the canals and providing the necessary heads for the sprinkler system.

As explained in Chapter F, the location of the pumping stations along the canals was determined in conjunction with the irrigation plan, assigning to each station an irrigation block of about 100 to 200 ha. Blocks of this size require pumping units of moderate capacity, adding to the overall flexibility of the scheme.

The water supply system will be discussed in the following, under two main heading: the Conveyance Systems, dealing with the canals and the Pumping Stations, describing the pumping stations and their related works.

b. The Conveyance Systems

(1) Water Conveyance Scheme for Area No.1

(a) General Description

The layout of the main water conveyance network for Area 1 is illustrated schematically in Fig. G/3. Water will be pumped out of the Weija Impounding Reservoir by means of an intake pumping station (I), described in detail elsewhere. 1/ From the intake the water is delivered through rising mains and a primary canal to the main canal of Area 1, which closely follows the northern and western borders of the Area, terminating in its southwestern corner. At point 'T' (Fig. G/3) a division structure diverts water to the branch canal that flows along the eastern border of the Area, terminating at its southeastern extremity. Thus, the main conveyance canals surround Area 1 on three of its sides, while the fourth, the southern side, is open to the lagoon and accomodates the drainage outlets. This layout, conforming closely to the topography, is considered to be optimal both from the physical and economic points of view.

1/ Construction documents for the Intake Pumping Station were prepared by this Consultant for the Ministry of Agriculture within the framework of the Agreement pertaining to the Irrigation Project. It is intended for immediate implementation while this report covers the feasibility of the Irrigation Project.

the main conveyance system in the two areas consists of the following
components:

An intake which draws the water from the Wells impounding Reservoir;

A pipeline connecting the intake to the main canals;

A stretch of primary, main and branch canals;

Related hydraulic structures, such as transitions, division structures,
road and drainage crossings, inverted syphons and other structures
along the canals;

Pumping stations located along the canals, delivering the water from
the canals and providing the necessary heads for the sprinkler system.

explained in Chapter F, the location of the pumping stations along the
s determined in conjunction with the irrigation plan, assigning to each
irrigation block of about 100 to 200 ha. Blocks of this size require
nits of moderate capacity, adding to the overall flexibility of the sche-

water supply system will be discussed in the following, under two main
the Conveyance Systems, dealing with the canals and the Pumping Sta-
cribing the pumping stations and their related works.

The Conveyance Systems

(1) Water Conveyance Scheme for Area No.1

(a) General Description

The layout of the main water conveyance network for Area 1
ted schematically in Fig. G/3. Water will be pumped out of the Wells
g Reservoir by means of an intake pumping station (1), described in
ewhere. [1] From the intake the water is delivered through rising mains
tary canal to the main canal of Area 1, which closely follows the nor-
western borders of the Area, terminating in its southwestern corner.
T1 (Fig. G/3) a division structure diverts water to the branch canal that
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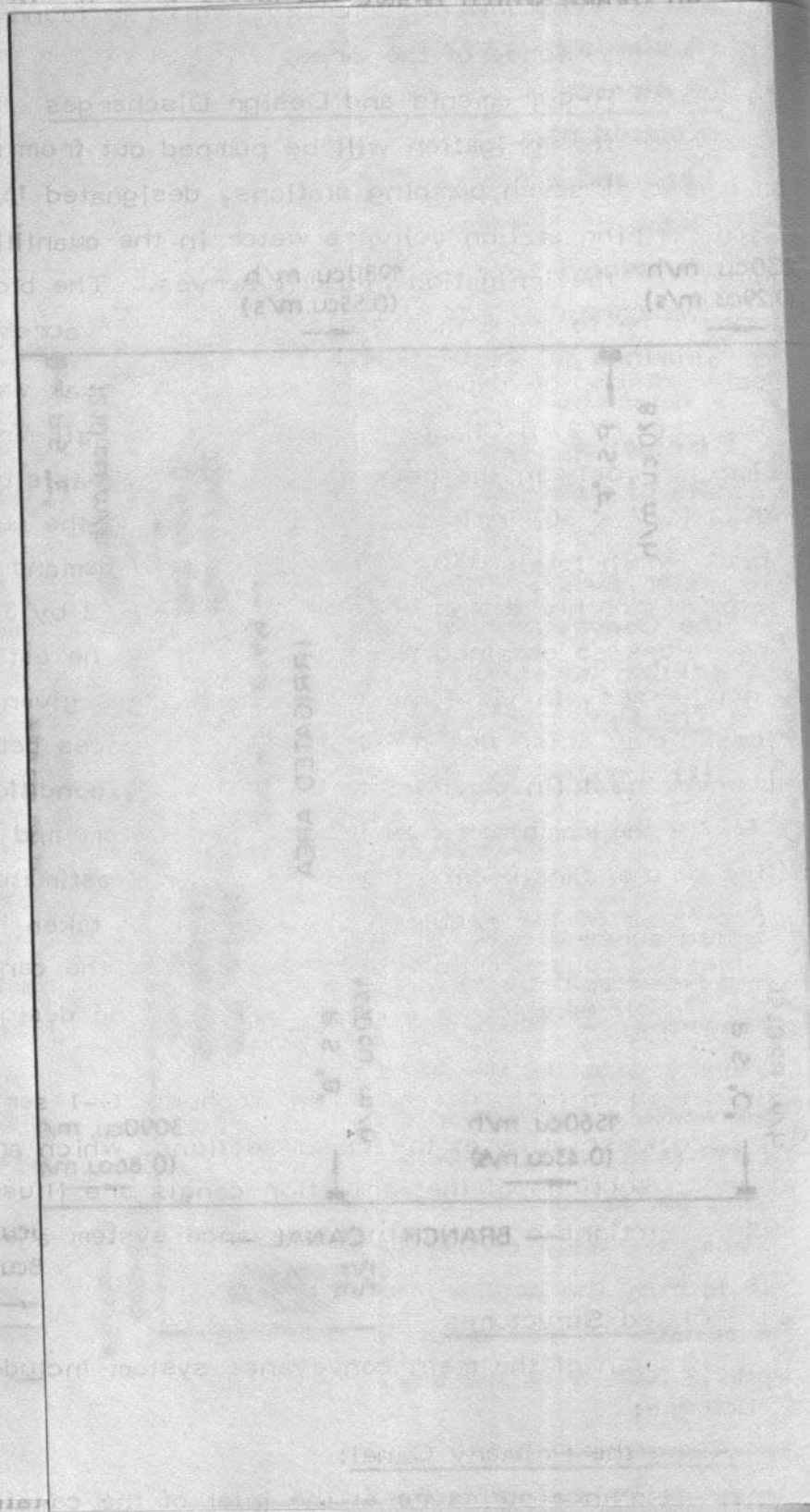
Agreement pertaining to the Irrigation Project. It is intended for
diate implementation while this report covers the feasibility of the
ation Project.

The canals are trimmed earth canals lined with a layer of a plastic clayey

FIG. G/3

- Inverted syphon inlet structure at poultry farm (chainage 0 + 400)
- Inverted syphon outlet structure at poultry farm (chainage 0 + 600);



The canals are trimmed earth canals lined with a layer of a plastic clayey silty material of very low permeability, which is found in abundance mainly in the southern, lower reaches of the Area.

(b) Water Requirements and Design Discharges

Water for irrigation will be pumped out from the main and branch canals by means of seven pumping stations, designated 'A' to 'G' in Fig. G/3. Each pumping station delivers water in the quantities and to the head required for the irrigation block it serves. The block vary in size from some 90 ha to more than 260 ha (225 to 675 acres) each (see Table G/1).

Design discharge capacities correspond to peak water requirements, as shown in Table F/2 in Chapter F, assuming that all farm units are being irrigated simultaneously in the peak month. On the basis of 15 irrigation hours per day and 22 (5/7 x 30) irrigation days per month, the number of irrigation hours in the peak month totals 330. The peak hourly demand was determined by dividing the peak monthly demands listed in Table F/2 by 330.

The values so obtained were augmented by the estimated operational and conveyance losses, to yield the design discharges given in Table G/1. Operational losses may arise due to discharge differences between the various pumping stations under real (in contrast to the "design") conditions, losses due to inaccuracies in the combined operation of the system and accounting for the initial filling of the canals each day. An average estimated operational loss of about 15 percent of the required discharges was taken into account. The conveyance losses, caused mainly by seepage along the canals, were estimated by use of the Pavolovsky formula as mentioned in the design criteria in Appendix G-1.

The design criteria described in Appendix G-1 served to determine the hydraulic characteristics of the canal sections, which are listed in Table G/2. Typical cross-sections of the irrigation canals are illustrated in Fig. G/4. Longitudinal sections of the main conveyance system are shown in Fig. G/5 and G/6.

(c) Related Structures

The plan of the main conveyance system includes the following structures:

(i) Along the Primary Canal:

- Entrance structure at the inlet of the canal (chainage 0 + 000);
- Inverted syphon inlet structure at poultry farm (chainage 0 + 400)
- Inverted syphon outlet structure at poultry farm (chainage 0 + 600);

The canals are trimmed earth canals lined with a layer of a plastic clayey material of very low permeability, which is found in abundance mainly in the Jezern, lower reaches of the Ares.

(b) Water Requirements and Design Discharges

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Design discharge capacities correspond to peak water requirements, as shown in Table F/2 in Chapter F, assuming that all farm units are being irrigated simultaneously in the peak month. On the basis of 15 irrigation hours per day and 22 (5/7 x 30) irrigation days per month, the number of irrigation hours in the peak month totals 330. The peak hourly demand was determined by dividing the peak monthly demands listed in Table F/2 by 330.

The values so obtained were augmented by the estimated operational and conveyance losses, to yield the design discharges given in Table G/1. Operational losses may arise due to discharge differences between the various pumping stations under real (in contrast to the "design") conditions, losses due to inaccuracies in the combined operation of the system and accounting for the initial filling of the canals each day. An average estimated operational loss of about 15 percent of the required discharges was taken into account. The conveyance losses, caused mainly by seepage along the canals, were estimated by means of the Pavlovsky formula as mentioned in the design criteria in Appendix F.

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The plan of the main conveyance system includes the following structures:

(i) Along the Primary Canal:

- Entrance structure at the inlet of the canal (chainage 0 + 000);
- Inverted syphon inlet structure at poultry farm (chainage 0 + 400)
- Inverted syphon outlet structure at poultry farm (chainage 0 + 600);

TABLE G/1: DESIGN DISCHARGES FOR AREA NO.1 - "WITHOUT CASSAVA" ALTERNATIVE 1/

cu.m/hr

Total irrigated area: 1,320 ha

Total water demand in the peak month (November): 2,157,100 cu.m (Table F/2)

Peak unit water demand: 4.95 cu.m/hr/ha

Pumping station	Area of irrigation block ha	irrigation requirement	Operational losses	Conveyance losses	Discharge	Cumulative discharge 2/	Remarks
Main Canal							
G	175.7	870	130	30	1,030	1,030	
F	152.2	753	117	80	950	1,980	
E	212.0	1,049	161	80	1,290	3,270	
D	169.3	838	132	90	1,060	4,330	At the division structure
Branch Canal							
C	265.5	1,314	196	50	1,560	1,560	
B	254.9	1,262	188	80	1,530	3,090	At the division structure
Primary Canal	-	-	-	120	-	7,540	Downstream from P.S. 'A'
A	90.4	447	73	160	680	8,220	Downstream from the Intake

1/ The peak water demand for this alternative is the highest and was adopted for the determination of design discharge values.

2/ The discharges in fact refer to a point just downstream of the next higher pumping station, but are considered as the design value for the whole corresponding stretch of the canal.

TABLE G/1: DESIGN DISCHARGES FOR AREA NO.1 - "WITHOUT CASSAVA" ALTERNATIVE 1/

cu.m/hr

Total irrigated area: 1,230 ha

Total water demand in the peak month (November): 2,157,100 cu.m (Table F/2)

Peak unit water demand: 4.95 cu.m/hr/ha

Pumping station	Area of irrigation block ha	Irrigation requirement	Operational losses	Conveyance losses	Distribution	Cumulative discharge 2/	Remarks
Main Canal							
G	178.7	970	130	30	1,030	1,030	
F	152.2	753	117	60	950	1,980	
E	212.0	1,049	161	60	1,290	3,270	
D	169.3	838	132	60	1,080	4,350	At the division structure
Branch Canal							
C	265.3	1,318	196	50	1,560	1,560	
B	254.9	1,262	194	80	1,730	3,290	At the division structure
Filter-y Canal							
A	90.4	447	73	100	580	4,320	Deviation from the intake
	-	-	-	120	-	7,940	Down-stream from P.S. 1A/

1/ The peak water demand for this alternative is the highest and was adopted for the determination of design discharges values.

2/ The discharges in fact refer to a point just downstream of the next higher pumping station, but are considered as the design value for the whole corresponding stretch of the canal.

TABLE G/2: AREA No.1: HYDRAULIC CHARACTERISTICS OF THE CANAL SECTIONS

Section 1/	Discharge Q (cu.m/sec)	Bottom width b (m)	Normal water depth d (m)	b/d	Flow velocity V (m/s)	Embankment depth h (m)	Energy slope J o/oo	Remarks
IA	2.28	2.70	1.00	2.70	0.44	1.40	0.32	Intake to P.S. "A"
AT	2.09	2.70	0.95	2.84	0.43	1.40	0.40	Main canal
TD	1.20	1.80	0.76	2.37	0.43	1.20	0.45	
DE	0.91	1.80	0.64	2.81	0.42	1.10	0.50	
EF	0.55	1.20	0.52	2.31	0.42	0.95	0.70	
FG	0.29	0.90	0.40	2.25	0.38	0.80	0.85	
TB	0.86	1.50	0.65	2.31	0.42	1.10	0.50	Branch canal
BC	0.43	1.20	0.45	2.67	0.41	0.90	0.90	

Note: For all the sections the side slope m = 2½ and Manning's n = 0.030

1/ See Fig. G/3.

TABLE 6/2: AREA No.1: HYDRAULIC CHARACTERISTICS OF THE CANAL SECTIONS

Section	Discharge Q (cu.m/sec)	Bottom width b (m)	Normal water depth h (m)	b/d	Flow velocity V (m/s)	Embankment depth h (m)	Energy slope J o/oo	Remarks
1A	2.38	2.70	1.00	2.70	0.79	1.40	0.33	Intake to P.S. "A"
AT	2.38	2.70	0.85	3.18	0.83	1.40	0.40	Main canal
T1	2.20	1.60	0.70	2.29	0.87	1.20	0.45	
D1	0.91	0.80	0.60	1.33	0.84	1.10	0.60	
BT	0.63	1.20	0.35	3.43	0.61	0.60	0.70	
R9	0.29	0.60	0.30	2.00	0.53	0.60	0.85	
T9	0.86	1.50	0.65	2.31	0.52	1.10	0.30	Branch canal
BC	0.43	1.20	0.45	2.67	0.47	0.80	0.58	

Note: For the sections the side slope n = 1½ and Manning's n = 0.020

b/d = dia. d/s.

FIG. G/6

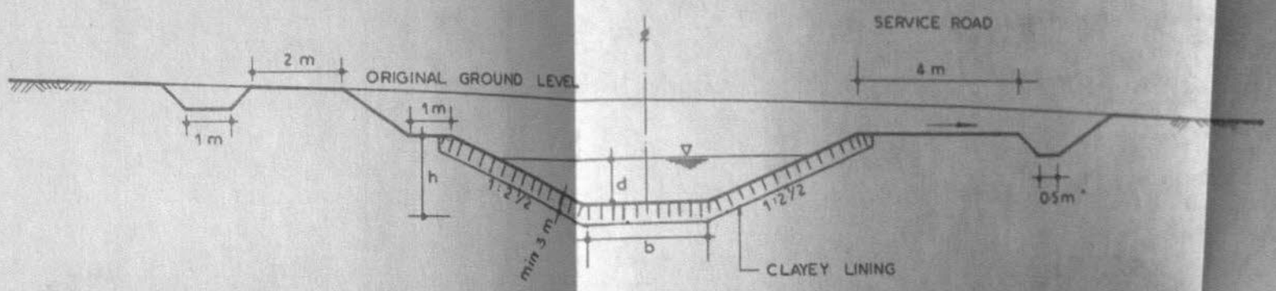
AREA No. 1: BRANCH CANAL

FIG. G/4

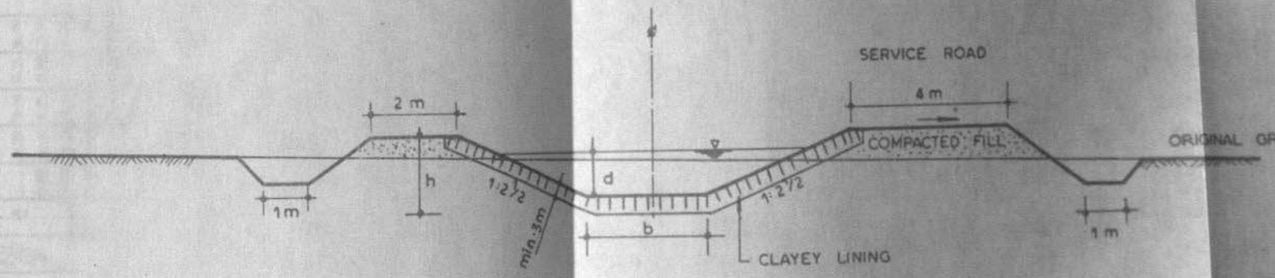
TYPICAL CROSS-SECTIONS OF MAIN CONVEYANCE CANALS

(NOT TO SCALE)

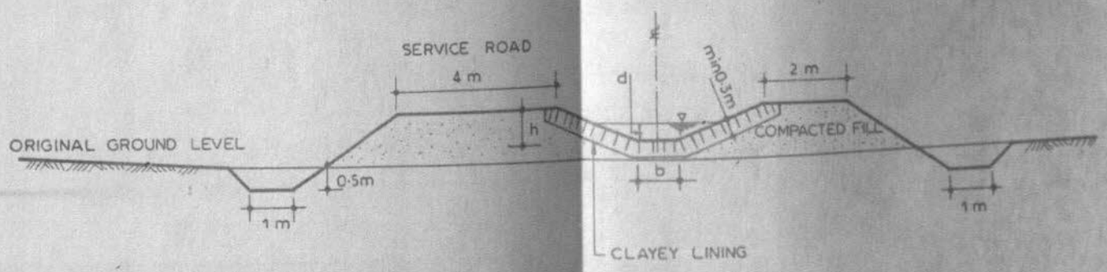
EXCAVATED



PARTLY EXCAVATED



FILL



NOTE: THE SERVICE ROAD IS USUALLY LOCATED ON THE LOWER BANK OF THE CANAL, ALTHOUGH FOR REASONS OF TOPOGRAPHY IT MAY SOMETIMES BE CONSTRUCTED ON THE OTHER SIDE

WEIJA IRRIGATION PROJECT
A. E. S. C. — TAHAL

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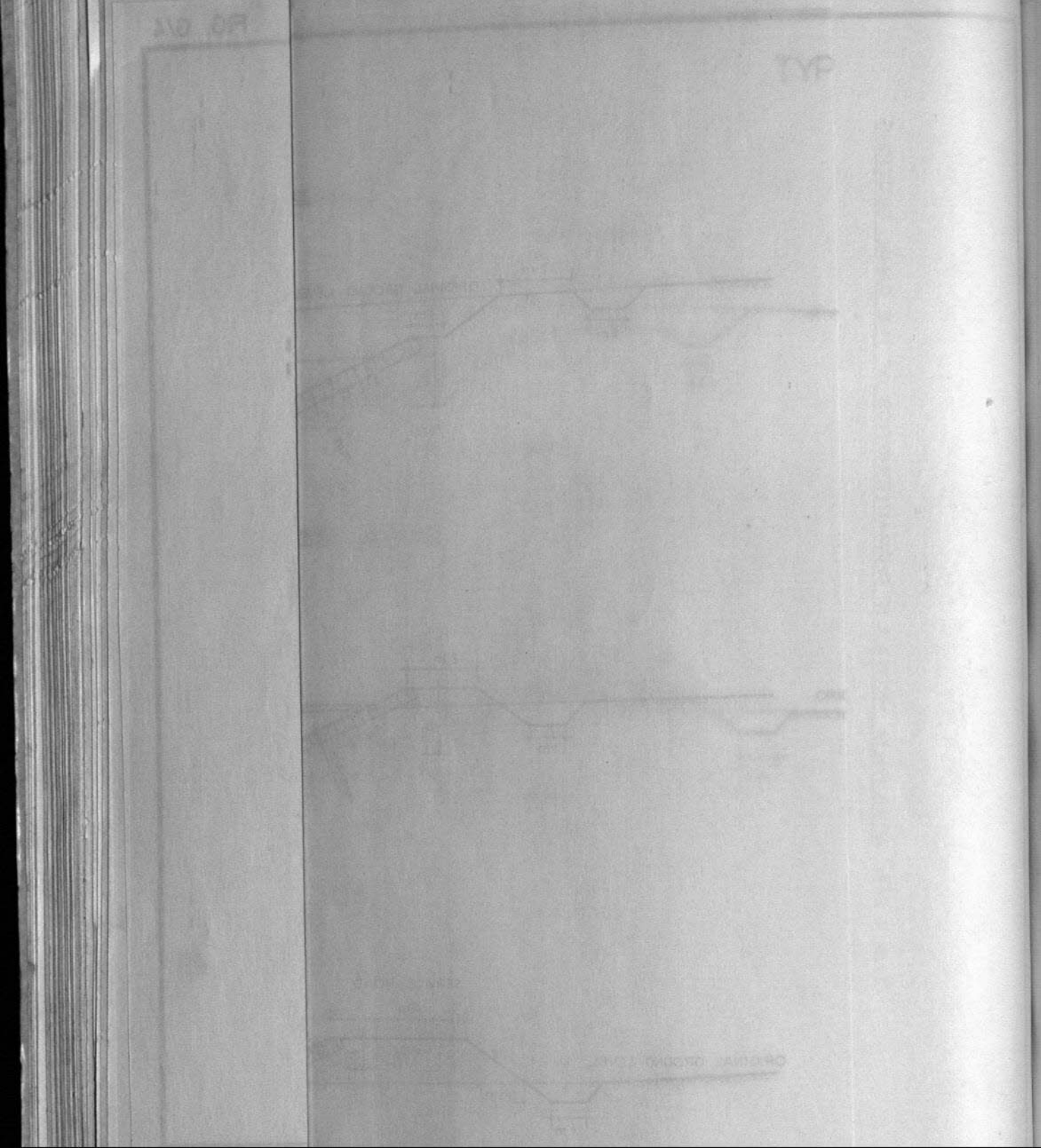
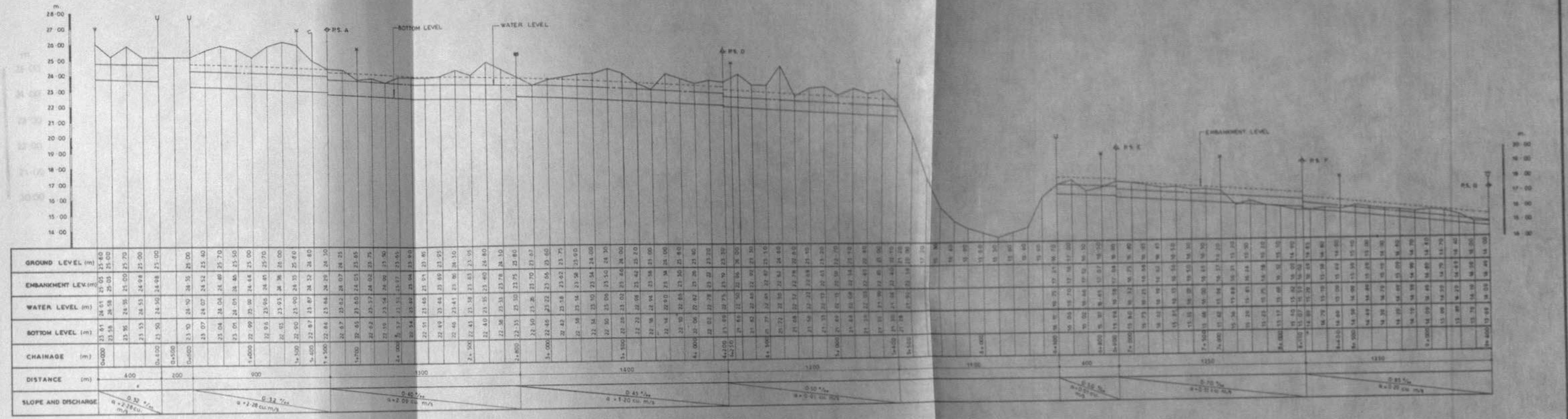


AREA No. 1 : PRIMARY AND MAIN CANALS
LONGITUDINAL SECTION



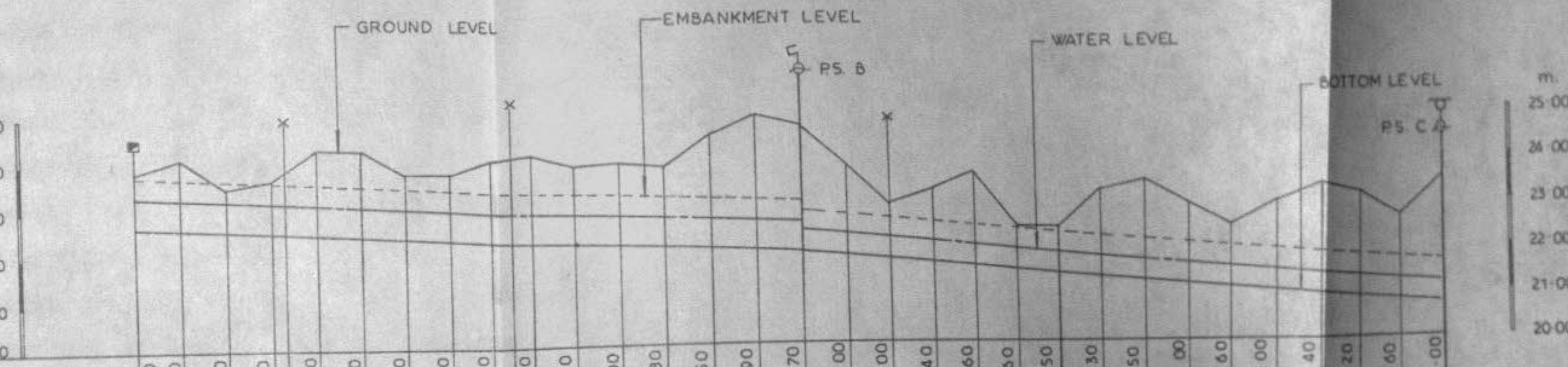
LEGEND

- Pumping station
- Division structure
- Inverted syphon
- Drop structure
- Drainage crossing
- Outlet structure
- Road crossing
- Entrance structure
- End structure

WEIJA IRRIGATION PROJECT
A. E. S. C. — TAHAL

FIG. G/6

AREA No. 1: BRANCH CANAL LONGITUDINAL SECTION



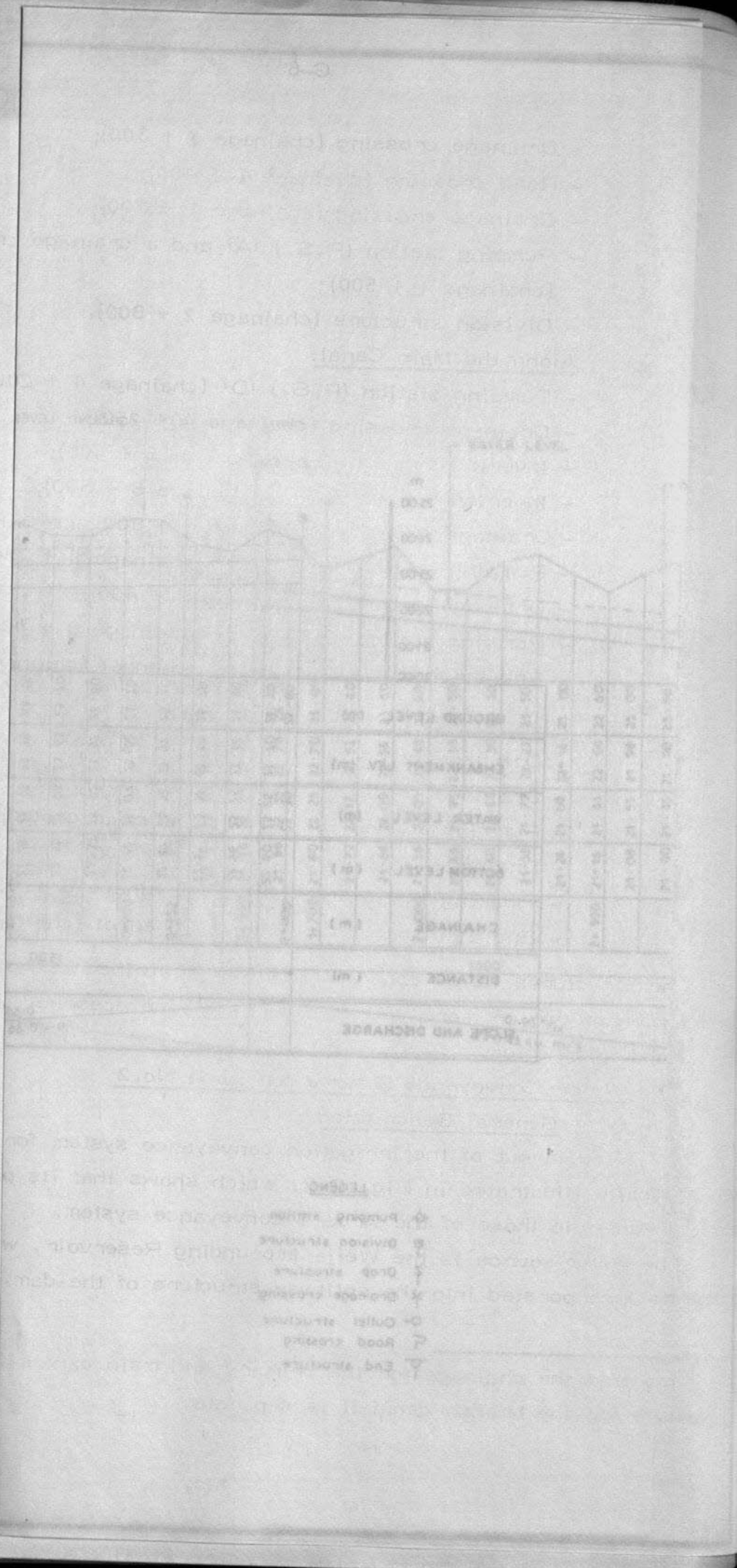
GROUND LEVEL (m)	23·80 24·10	23·50	23·70	23·70	24·20	23·80	23·70	24·10	24·20	23·90	24·00	23·80	24·50	24·90	24·70
EMBANKMENT LEV. (m)	23·70	23·66	23·61	23·57	23·52	23·47	23·43	23·38	23·34	23·29	23·25	23·20	23·16	23·11	23·06
WATER LEVEL (m)	23·30 23·25	23·21	23·16	23·12	23·07	23·02	22·98	22·93	22·89	22·84	22·80	22·75	22·71	22·66	22·61
BOTTOM LEVEL (m)	22·60	22·56	22·51	22·47	22·42	22·37	22·33	22·28	22·24	22·19	22·15	22·10	22·06	22·01	21·96
CHAINAGE (m)	0+000			0+325	0+500				0+850	1+000					1+500
DISTANCE (m)	1500														
SLOPE AND DISCHARGE	0·50 ‰ Q = 0·86 cu. m/s														

GROUND LEVEL (m)	24·00	23·00	23·40	23·60	22·60	22·50	23·30	23·50	23·00	22·60	23·00	23·40	23·20	22·60	24·00
EMBANKMENT LEV. (m)	22·78	22·70	22·62	22·54	22·46	22·38	22·30	22·22	22·14	22·06	21·98	21·90	21·82	21·68	21·66
WATER LEVEL (m)	22·33	22·25	22·17	22·09	22·01	21·93	21·85	21·77	21·69	21·61	21·53	21·45	21·37	21·29	21·21
BOTTOM LEVEL (m)	21·88	21·80	21·72	21·64	21·56	21·48	21·40	21·32	21·24	21·16	21·08	21·00	20·92	20·84	20·76
CHAINAGE (m)		1+700			2+000					2+500					3+000
DISTANCE (m)	1500														
SLOPE AND DISCHARGE	0·90 ‰ Q = 0·43 cu. m/s														

LEGEND

- Pumping station
- Division structure
- Drop structure
- Drainage crossing
- Outlet structure
- Road crossing
- End structure

WEIJA IRRIGATION PROJECT
A. E. S. C. — TAHAL



- Drainage crossing (chainage 1 + 300);
- Road crossing (chainage 1 + 400);
- Drainage crossing (chainage 1 + 700);
- Pumping station (P.S.) 'A' and a drainage crossing (chainage 1 + 500);
- Division structure (chainage 2 + 800).

(ii) Along the Main Canal:

- Pumping station (P.S.) 'D' (chainage 4 + 200);
- Drainage crossing (chainage 4 + 250);
- Inverted syphon inlet (chainage 5 + 400);
- Inverted syphon outlet (chainage 6 + 500);
- Drainage crossing (chainage 6 + 800);
- Pumping station (P.S.) 'F' (chainage 8 + 150);
- Drainage crossing (chainage 8 + 400);
- Pumping station (P.S.) 'G' (chainage 9 + 400);
- End structure and wasteway channel (chainage 9 + 420).

(iii) Along the Branch Canal: 1/

- Drainage crossing (chainage 0 + 325);
- Drainage crossing (chainage 0 + 850);
- Pumping station (P.S.) 'B' and road crossing (chainage 1 + 500)
- Drainage crossing (chainage 1 + 700);
- Pumping station (P.S.) 'C' (chainage 3 + 000);
- End structure and wasteway channel (chainage 3 + 050).

The structures listed above are briefly described in Appendix G-2. Combination of two or more unit structures in one does not change their basic design characteristics.

(2) Water Conveyance Scheme for Area No.2

(a) General Description

The layout of the irrigation conveyance system for Area No.2 is schematically illustrated in Fig. G-7, which shows that its principal features closely resemble those of the Area 1 conveyance system.

The water source is the Weija Impounding Reservoir, where an irrigation outlet is incorporated into the spillway structure of the dam.

1/ Note that the chainage for the primary and main canals is continuous while for the branch canal it is separate.

- Drainage crossing (chainage 1 + 300);
- Road crossing (chainage 1 + 400);
- Drainage crossing (chainage 1 + 700);
- Pumping station (P.S.) 1A1 and a drainage crossing (chainage 1 + 500);
- Division structure (chainage 2 + 800).

(ii) Along the Main Canal:

- Pumping station (P.S.) 1D1 (chainage 4 + 200);
- Drainage crossing (chainage 4 + 250);
- Inverted syphon inlet (chainage 5 + 400);
- Inverted syphon outlet (chainage 8 + 500);
- Drainage crossing (chainage 6 + 800);
- Pumping station (P.S.) 1F1 (chainage 8 + 150);
- Drainage crossing (chainage 8 + 400);
- Pumping station (P.S.) 1G1 (chainage 9 + 400);
- End structure and wasteway channel (chainage 9 + 420).

(iii) Along the Branch Canal: 1/

- Drainage crossing (chainage 0 + 325);
- Drainage crossing (chainage 0 + 850);
- Pumping station (P.S.) 1B1 and road crossing (chainage 1 + 500)
- Drainage crossing (chainage 1 + 700);
- Pumping station (P.S.) 1C1 (chainage 3 + 000);
- End structure and wasteway channel (chainage 3 + 050).

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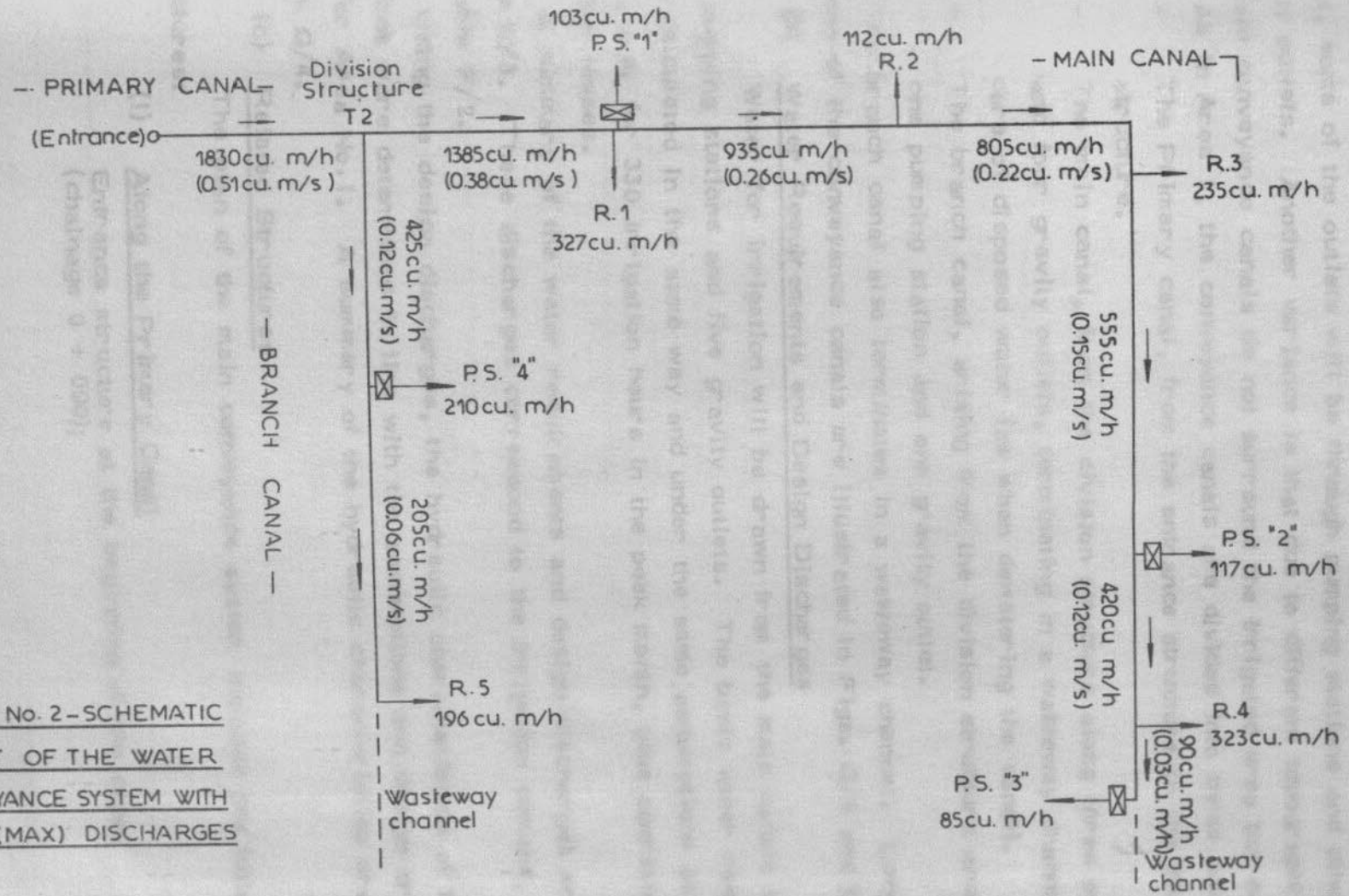


AREA No. 2 – SCHEMATIC LAYOUT OF THE WATER CONVEYANCE SYSTEM WITH DESIGN (MAX) DISCHARGES

FIG. G/7

A 36" dia. pipe will convey the water from the outlet to the entrance of the irrigation network proper.

The main difference between the conveyance system of Area 1 and Area 2 is that the latter serves both sprinkler irrigated mixed farms and gravity irrigated rice farms. Therefore, whilst here too the water is conveyed by earth canals, some of the outlets will be through pumping stations and others through gravity outlets. Another variance is that due to different topographic conditions the main conveyance canals do not surround the irrigated area but cut through it.

As in Area 1, the conveyance canals are divided into three nominal lengths:

- The Primary canal, from the entrance structure to the division structure.
- The main canal, from the division structure along three pumping stations and four gravity outlets, terminating in a wasteway channel to take care of disposed water (as when dewatering the canal).
- The branch canal, arising from the division structure and incorporating one pumping station and one gravity outlet.

The branch canal also terminates in a wasteway channel. Longitudinal sections of the conveyance canals are illustrated in Figs. G/8 and G/9.

(b) Water Requirements and Design Discharges

Water for irrigation will be drawn from the main canals by means of four pumping stations and five gravity outlets. The basic water requirements were calculated in the same way and under the same assumptions as for Area No.1, i.e. for 330 irrigation hours in the peak month, plus operational and conveyance losses.

A summary of the water requirements and design discharges are given in Table G/3. These discharges correspond to the irrigation demand, as shown in Table F/2.

Using the design discharges, the hydraulic characteristics of the canal sections were determined in line with the assumptions and design criteria adopted for Area No.1. A summary of the hydraulic characteristics are given in Table G/4.

(c) Related Structures

The plan of the main conveyance system includes the following structures:

(i) Along the Primary Canal

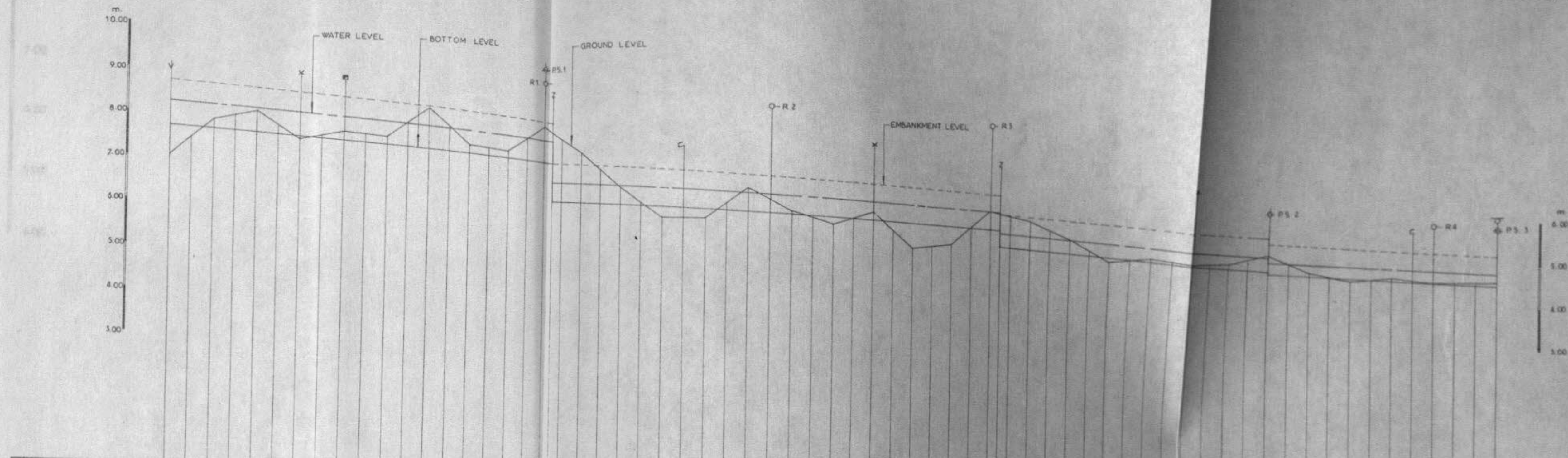
Entrance structure at the beginning of the canal (chainage 0 + 000);

(i) Along the Primary Canal

Entrance structure at the beginning of the canal (chainage 0 + 000);

FIG. G/8

AREA No. 2: PRIMARY AND MAIN CANALS LONGITUDINAL SECTION



CHAINAGE (m)	GROUND LEVEL (m)	EMBANKMENT LEV. (m)	WATER LEVEL (m)	BOTTOM LEVEL (m)
0+000	7.00	8.66	8.22	7.66
0+100	7.80	8.60	8.16	7.60
0+200	8.00	8.54	8.10	7.54
0+300	7.40	8.48	8.04	7.48
0+400	7.60	8.40	7.95	7.42
0+500	7.50	8.33	7.88	7.35
0+600	8.20	8.25	7.85	7.30
0+700	7.40	8.17	7.76	7.24
0+800	7.30	8.09	7.68	7.18
0+900	7.90 / 7.80	8.01 / 8.00	7.65 / 7.62	7.11 / 7.10
0+925		7.10	6.66	6.25
1+000	7.30	7.01	6.60	6.16
1+100	6.50	6.96	6.55	6.11
1+200	5.80	6.91	6.50	6.06
1+250				
1+300	5.80	6.86	6.45	6.01
1+400	6.50	6.81	6.40	5.96
1+450				
1+500	6.00	6.75	6.35	5.93
1+600	5.70	6.68	6.30	5.88
1+700	6.00	6.63	6.25	5.83
1+800	5.20	6.58	6.20	5.78
1+900	5.30	6.53	6.15	5.73
2+000	6.10 / 6.05	6.31 / 6.40	6.10 / 6.00	5.70 / 5.68
2+025		6.08	5.62	5.32
2+100	5.90	5.99	5.55	5.24
2+200	5.50	5.93	5.50	5.18
2+300	5.00	5.86	5.44	5.11
2+400	5.10	5.79	5.35	5.04
2+500	5.00	5.73	5.30	4.98
2+600	5.00	5.66	5.22	4.91
2+700	5.20	5.62	5.15 / 5.05	4.87
2+800	4.80	5.43	5.00	4.75
2+900	4.60	5.38	4.95	4.68
3+000	4.69	5.34	4.92	4.64
3+050				
3+100	4.80	5.29	4.87	4.59
3+200	4.60	5.25	4.82	4.53
3+250	4.60	5.21	4.80	4.51

DISTANCE (m)	SLOPE AND DISCHARGE
400	0.80 ‰, Q = 0.51 cu. m/s
525	0.80 ‰, Q = .38 cu. m/s
525	1.00 ‰, Q = 0.26 cu. m/s
575	1.15 ‰, Q = 0.22 cu. m/s
675	1.35 ‰, Q = 0.15 cu. m/s
400	1.70 ‰, Q = 0.12 cu. m/s
100	2.30 ‰, Q = 0.03 cu. m/s

LEGEND

- Pumping station
- Division structure
- Drop structure
- Drainage crossing
- Outlet structure
- Road crossing
- Entrance structure
- End structure

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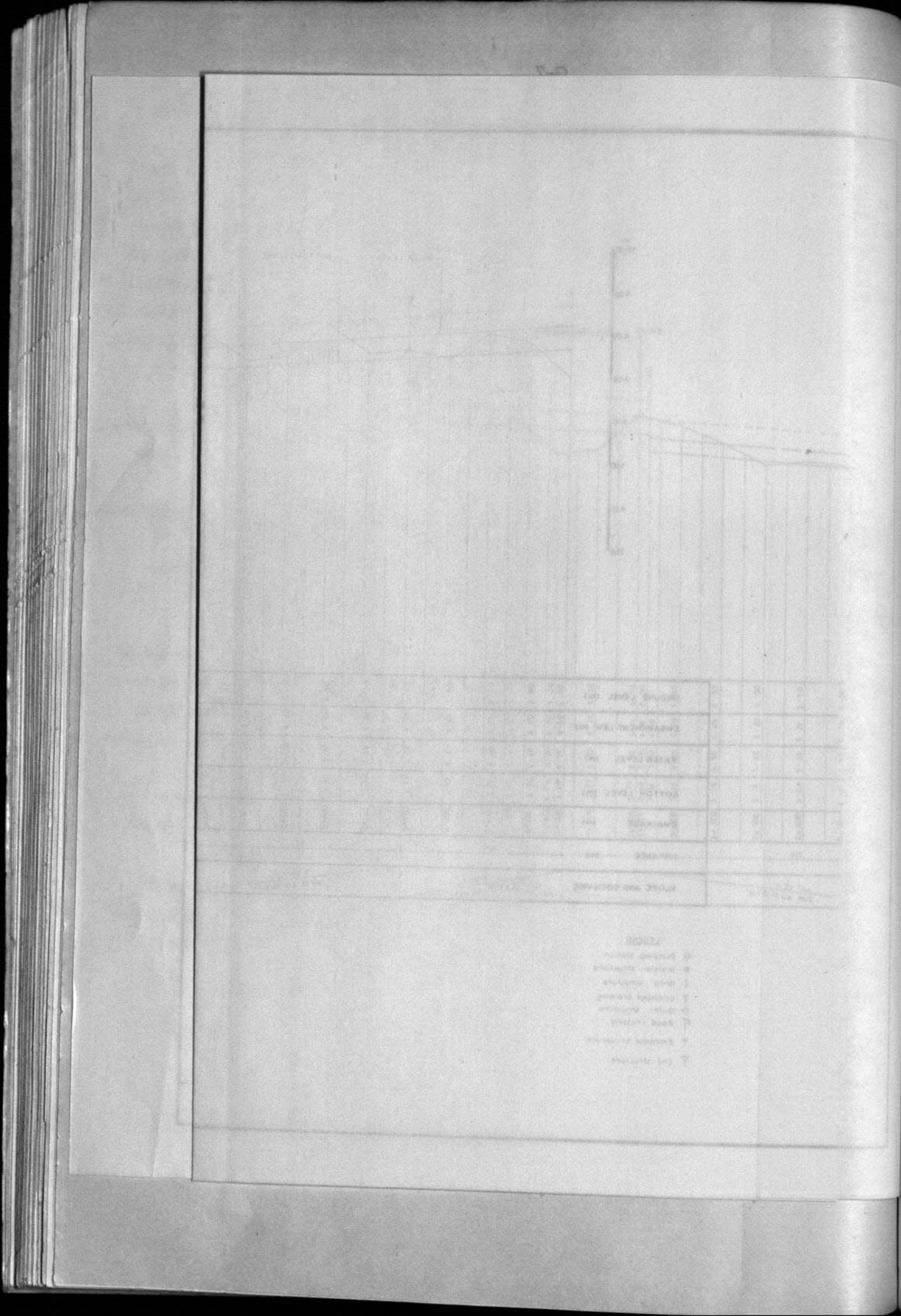
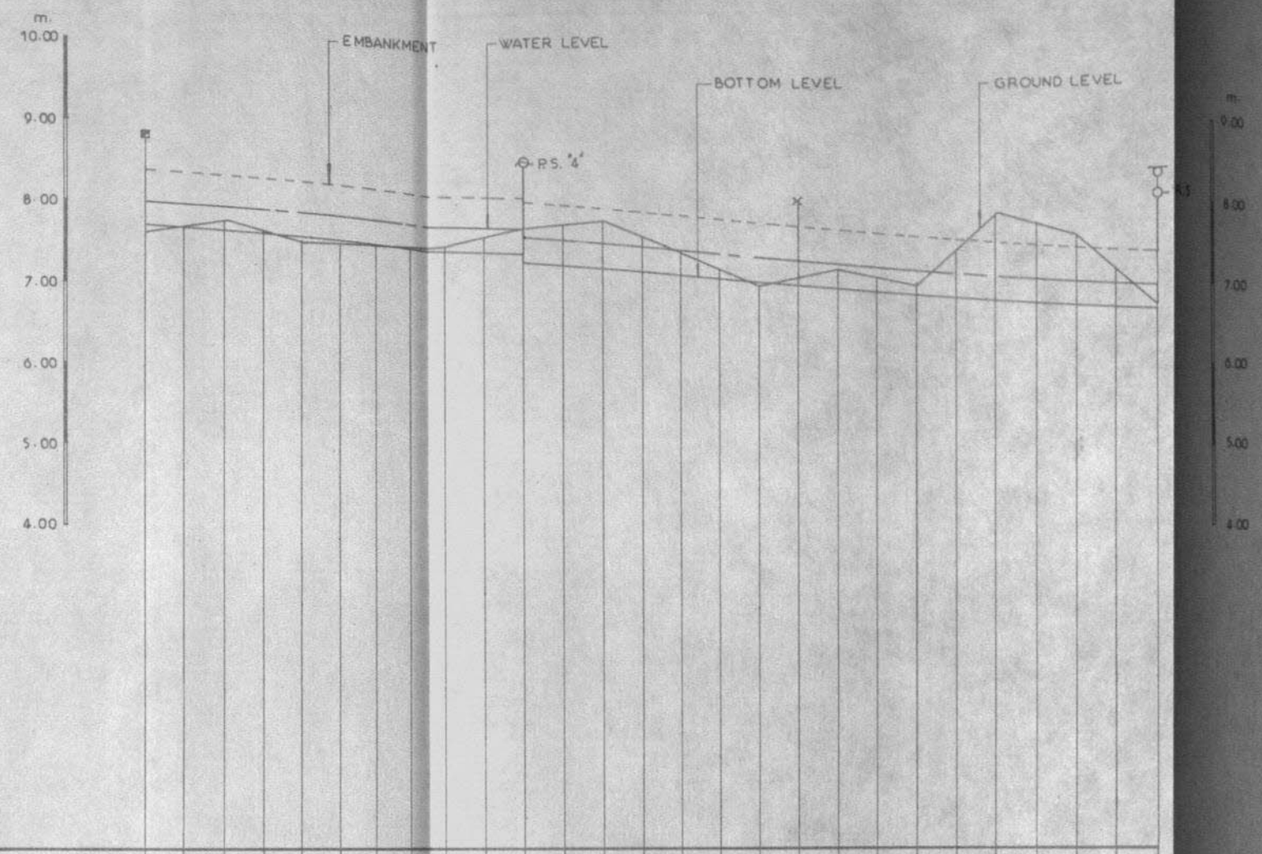


AREA No. 2 : BRANCH CANAL LONGITUDINAL SECTION



CHAINAGE (m)	0+000	0+100		0+200		0+300		0+400		0+500		0+600		0+700		0+800	0+850	0+900		1+000		1+100		1+200		1+300
GROUND LEVEL (m)	7.60	7.75		7.50		7.50		7.50		7.70		7.80		7.40		7.00		7.20		7.00		7.90		7.60		6.70
EMBANKMENT LEV. (m)																										
WATER LEVEL (m)	7.98	7.92		7.87		7.81		7.76		7.70	7.60	7.52		7.44		7.36		7.28		7.20		7.11		7.03		6.95
BOTTOM LEVEL (m)	7.67	7.61		7.56		7.50		7.45		7.39	7.29	7.20		7.14		7.06		6.98		6.90		6.81		6.74		6.65
DISTANCE (m)	500 m										800 m															
SLOPE AND DISCHARGE	1:70 °/₀ Q = 0.12 cu. m/s										2.70 °/₀ Q = 0.06 cu. m/s															

LEGEND
- Pumping station
- Division structure
- Drop structure
- Drainage crossing
- Outlet structure
- Road crossing
- End structure

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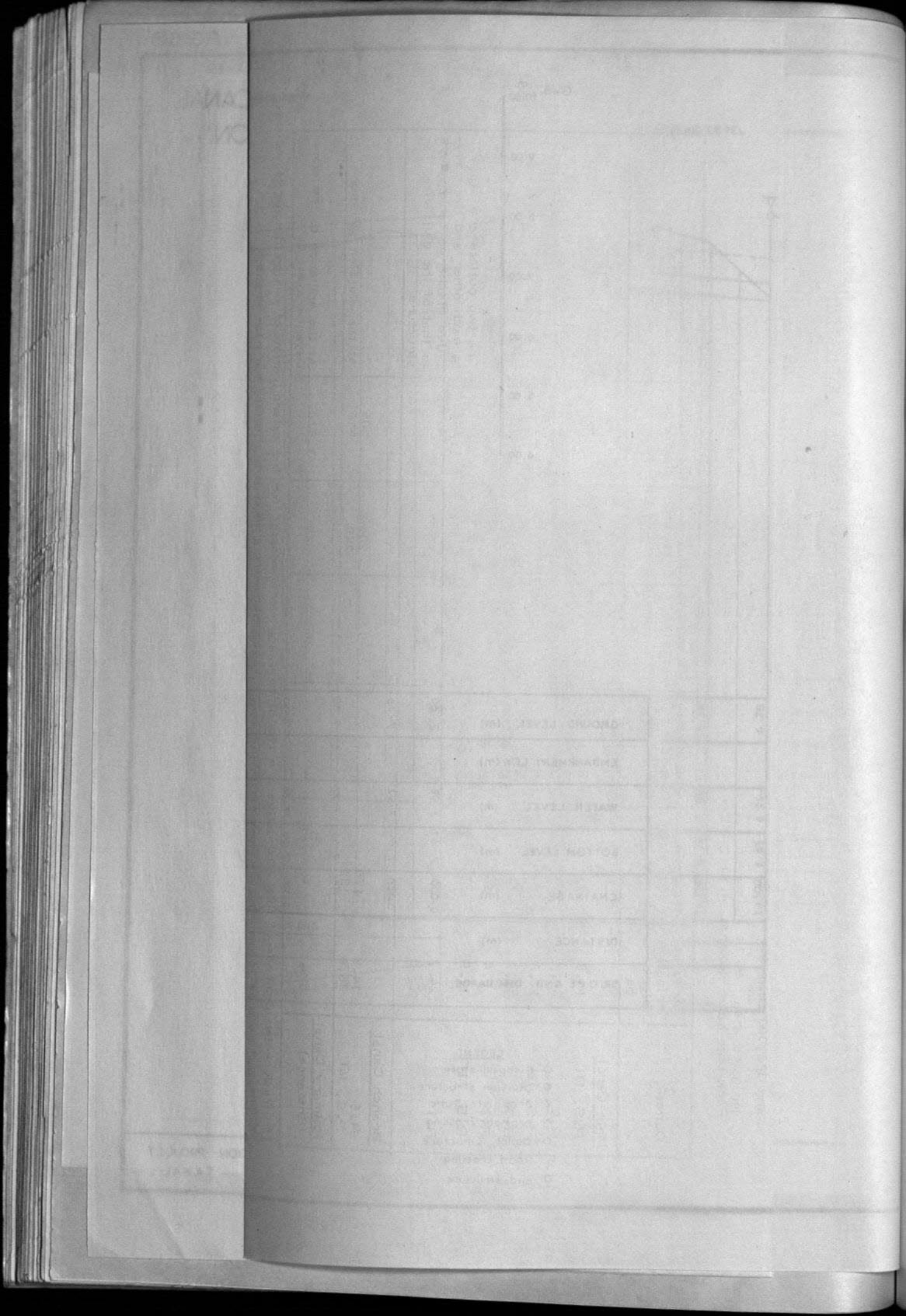


TABLE G/3: DESIGN DISCHARGES FOR AREA No.2 - WITHOUT CASSAVA ALTERNATIVE[1/]

cu.m/hr

Total water demand in the peak month, November (Table F/2): 489,100 cu.m; 147,100 cu.m for mixed farms and 342,000 cu.m for rice farms;

Irrigated area: 90 ha mixed crops and 90 ha rice;
Peak unit water demand: 4.95 cu.m/hr/ha for mixed crops and 11.5 cu.m/hr/ha for rice.

Outlet[2/]	Area of irrigation block ha	Irrigation requirement	Operational losses	Conveyance losses	Discharge	Cumulative discharge	Remarks
Main Canal							
P.S. '3'	14.8	73	12	5	90	90	
R.4	24.4	281	42	7	330	420	
P.S. '2'	20.5	101	16	18	135	555	
R.3	17.7	204	31	15	250	805	
R.2	8.4	97	15	18	130	935	
P.S. '1'	17.9	89)) 373	14)) 57	20	450	1,385	The two outlets are close to each other and the cumulative discharge corresponds to that of the division structure
R.1	24.7	284)	43)				
Branch Canal							
R.5	14.8	170	26	9	205	205	
P.S. '4'	36.8	182	28	10	220	425	At the division structure
Primary Canal (Entrance)	-	-	-	20	20	1,830	At the entrance to the conveyance system

1/ Peak water demands of this alternative are the highest and were adopted for the determination of design discharge values.

2/ "P.S." referes to pumping stations for mixed crop areas, "R" refers to gravity outlets for rice areas.

TABLE 6/3: DESIGN DISCHARGES FOR AREA NO.3 - WITHOUT CASSAVA ALTERNATIVE

Total water demand in the peak month, November (Table 6/2): 469,100 cu.m for mixed farms and 843,000 cu.m for fruits farms.

Irrigated area: 80 ha mixed crops and 80 ha fruits
Peak week demand: 9,85 cu.m/ha for mixed crops and 11,5 cu.m/ha for fruits.

Description	Area of Distribution Block (ha)	Peak Demand (cu.m/hr)	Operating Hours	Operating Days	Plan area
Main Canal					
Block 1 (Mixed Crops)	20	197	8	6	
Block 2 (Mixed Crops)	20	197	8	6	
Block 3 (Mixed Crops)	20	197	8	6	
Block 4 (Mixed Crops)	20	197	8	6	
Block 5 (Fruits)	20	230	8	6	
Block 6 (Fruits)	20	230	8	6	
Block 7 (Fruits)	20	230	8	6	
Block 8 (Fruits)	20	230	8	6	
Total Demand	160	1,676			
Block 1	20	197	8	6	
Block 2	20	197	8	6	
Block 3	20	197	8	6	
Block 4	20	197	8	6	
Block 5	20	230	8	6	
Block 6	20	230	8	6	
Block 7	20	230	8	6	
Block 8	20	230	8	6	
Total Demand	160	1,676			

TABLE G/4: AREA No.2: HYDRAULIC CHARACTERISTICS OF THE CANAL SECTIONS

Section	Discharge Q (cu.m/sec	Bottom width b (m)	Normal water depth d (m)	b/d	Flow velocity V (m/s)	Embankment depth h (m)	Energy slope J (o/oo)	Remarks
E - T2	0.51	1.20	0.52	2.31	0.39	0.95	0.60	Primary canal
T_2 - P.S. 11	0.38	1.20	0.42	2.86	0.40	0.85	0.80	Main canal
P.S. 11 - R.2	0.26	0.90	0.37	2.43	0.39	0.80	1.00	
R.2 - R.3	0.22	0.90	0.32	2.81	0.40	0.75	1.15	
R.3 - P.S. 12	0.15	0.60	0.30	2.00	0.37	0.70	1.35	
P.S. 12 - R.4	0.12	0.60	0.25	2.40	0.39	0.65	1.70	
R.4 - P.S. 13	0.03	0.30	0.14	2.14	0.33	0.50	2.50	
T_2 - P.S. 14	0.12	0.60	0.25	2.40	0.39	0.65	1.70	Branch canal
P.S. 14 - R.5	0.06	0.30	0.19	1.58	0.41	0.60	2.70	

Note: For all the sections the side slope m = $2\frac{1}{2}$ and manningis n = 0.030.

TABLE 6/A4: AREA No.2: HYDRAULIC CHARACTERISTICS OF THE CANAL SECTIONS

Section	Discharge Q (cum/sec)	Bottom width b (m)	Normal water depth d (m)	b/d	Flow velocity V (m/s)	Embankment depth h (m)	Bank slope 1/s (o/o)	Remarks
E - T2	0.51	1.20	0.42	2.86	0.39	0.85	0.60	Main canal
T2 - P.T1	0.39	1.20	0.42	2.86	0.40	0.80	0.60	
P.T1 - R.1	0.26	0.60	0.32	2.43	0.39	0.75	1.00	
R.1 - R.2	0.13	0.60	0.30	2.81	0.40	0.70	1.15	
R.2 - R.3	0.13	0.60	0.30	2.00	0.37	0.65	1.38	
R.3 - P.T2	0.13	0.60	0.30	2.40	0.39	0.60	1.70	
P.T2 - R.4	0.08	0.30	0.19	2.19	0.39	0.50	2.50	
R.4 - P.T3	0.08	0.30	0.19	1.58	0.41	0.60	2.70	Branch canal
P.T3 - R.5	0.08	0.30	0.19	1.58	0.41	0.60	2.70	

Notes: For all the sections the side slope m = 2/1 and roughness n = 0.025.

- Drainage crossing (chainage 0 + 300);
- Division structure (chainage 0 + 400);

(ii) Along the Main Canal

- Pumping station P.S. '1' and Outlet R.1. (both at chainage 0 + 900);
- Drop structure (chainage 0 + 925);
- Road Crossing (chainage 1 + 250);
- Outlet R.2 (chainage 1 + 450);
- Drainage crossing (chainage 1 + 700);
- Outlet R.3 (chainage 2 + 000);
- Drop structure (chainage 2 + 025);
- Drainage crossing (chainage 2 + 500);
- Pumping station P.S. '2' (chainage 2 + 700);
- Crossing of the Accra-Winneba Road (chainage 3 + 050);
- Outlet R.4 (chainage 3 + 100);
- Pumping station P.S. '3' (chainage 3 + 250);
- End structure and wasteway channel (chainage 3 + 270).

(iii) Along the Branch Canal

- Pumping station P.S. '4' (chainage 0 + 500);
- Drainage crossing (chainage 0 + 850);
- Outlet R.5 (chainage 1 + 300);
- End structure and wasteway channel (chainage 1 + 320).

Note that the chainage for the primary and main canals is continuous while that of the branch canal is separate. Brief description of the structures are given in Appendix G-2.

c. Pumping Stations

(1) General

In all, eleven pumping stations will be installed, seven in Area No.1 and four in Area No.2. These pumping stations will be installed alongside the main conveyance canals, to supply the head required for the sprinkler irrigated areas. As mentioned before, Area No.1 will be occupied by mixed farms irrigated by sprinklers. The sites of the pumping stations in this area were determined with the view that each pumping station would serve an area of about 200 ha, except for one, serving an irrigation block of only about 90 ha.

In Area No.2, the pumping stations will deliver water to the sprinkler irrigated mixed farms only; the rice farms will be surface irrigated.

At the pumping station site the trapezoidal cross-section of the canal will be modified to rectangular to receive the inlets of the pumps.

- Drainage crossing (chainage 0 + 300);
- Division structure (chainage 0 + 400);

(ii) Along the Main Canal

- Pumping station P.S. 1] and Outlet R.1. (both at chainage 0 + 900);
- Drop structure (chainage 0 + 925);
- Road Crossing (chainage 1 + 250);
- Outlet R.2 (chainage 1 + 450);
- Drainage crossing (chainage 1 + 700);
- Outlet R.3 (chainage 2 + 000);
- Drop structure (chainage 2 + 025);
- Drainage crossing (chainage 2 + 500);
- Pumping station P.S. 12] (chainage 2 + 700);
- Crossing of the Accra-Winneba Road (chainage 3 + 050);
- Outlet R.4 (chainage 3 + 100);
- Pumping station P.S. 13] (chainage 3 + 250);
- End structure and wasteway channel (chainage 3 + 270).

(iii) Along the Branch Canal

- Pumping station P.S. 14] (chainage 0 + 500);
- Drainage crossing (chainage 0 + 850);
- Outlet R.5 (chainage 1 + 300);
- End structure and wasteway channel (chainage 1 + 320).

Note that the chainage for the primary and main canals is continuous while of the branch canal is separate. Brief description of the structures are in Appendix G-2.

c. Pumping Stations

(i) General

In all, eleven pumping stations will be installed, seven in Area No.1 four in Area No.2. These pumping stations will be installed alongside the conveyance canals, to supply the head required for the sprinkler irrigated As mentioned before, Area No.1 will be occupied by mixed farms irrigated sprinklers. The sites of the pumping stations in this area were determined the view that each pumping station would serve an area of about 200 ha, for one, serving an irrigation block of only about 90 ha.

In Area No.2, the pumping stations will deliver water to the sprinkler irrigated farms only; the rice farms will be surface irrigated.

At the pumping station site the trapezoidal cross-section of the canal will be lled to rectangular to receive the inlets of the pumps.

The pumps themselves can be either vertical or horizontal. If the former is selected, the direct shaft couples motor type is recommended with pump assembly overhanging the canal, supported by beams and girders. In the case of horizontal pumps, the motor-pump assembly (directly coupled, on a joint frame or skid) will be located on the canal embankment with the suction pipe overhanging the canal's side. This arrangement will facilitate removal of the units for maintenance and inspection.

For horizontal pumps the pumping station will be housed in a lightly constructed structure, which will house also the electric switchboards and auxiliary equipment (except the transformer which will be located outside on a pole) as well as the pipings, valves, etc. In case of vertical pumping units, the units will be of weather-proof type and installed outside, with the delivery pipes entering the structure which houses the electric switchboards and other appurtenances.

For the design criteria of the pumping stations, see Appendix G-1. Typical layout of a pumping station with horizontal pumps is illustrated in Fig. G/10.

(2) Pumping Stations of Area No.1

As mentioned above, there are seven pumping stations in this Area, designated as stations 'A', 'B', 'C', 'D', 'E', 'F' and 'G' as shown in Fig. G/3.

The capacities of these pumping stations were determined according to the peak month water demands of the corresponding irrigation blocks, including operational losses, as discussed in section b (1) of this chapter.

Table G/5 lists the calculated required capacity of each pumping station, as well as the suggested installed capacity ratings.

TABLE G/5: DATA ON PUMPING STATIONS IN AREA No.1

Pumping station	Calculated max. demand cu.m/hr	Rated capacity installed cu.m/hr	Number of capacity of units installed 1/ cu.m/hr
A	520	550	1 x 350 + 1x200 (+1x200)
B	1,450	1,450	3 x 350 + 2x200 (+1x200)
C	1,510	1,600	4 x 350 + 1x200 (+1x200)
D	970	1,050	3 x 350 (+1x200)
E	1,210	1,250	3 x 350 + 1x200 (+1x200)
F	870	900	2 x 350 + 1x200 (+1x200)
G	1,000	1,050	3 x 350 (+1x200)
Total	7,530	7,850	19 x 350 + 6x200 (+7x200)

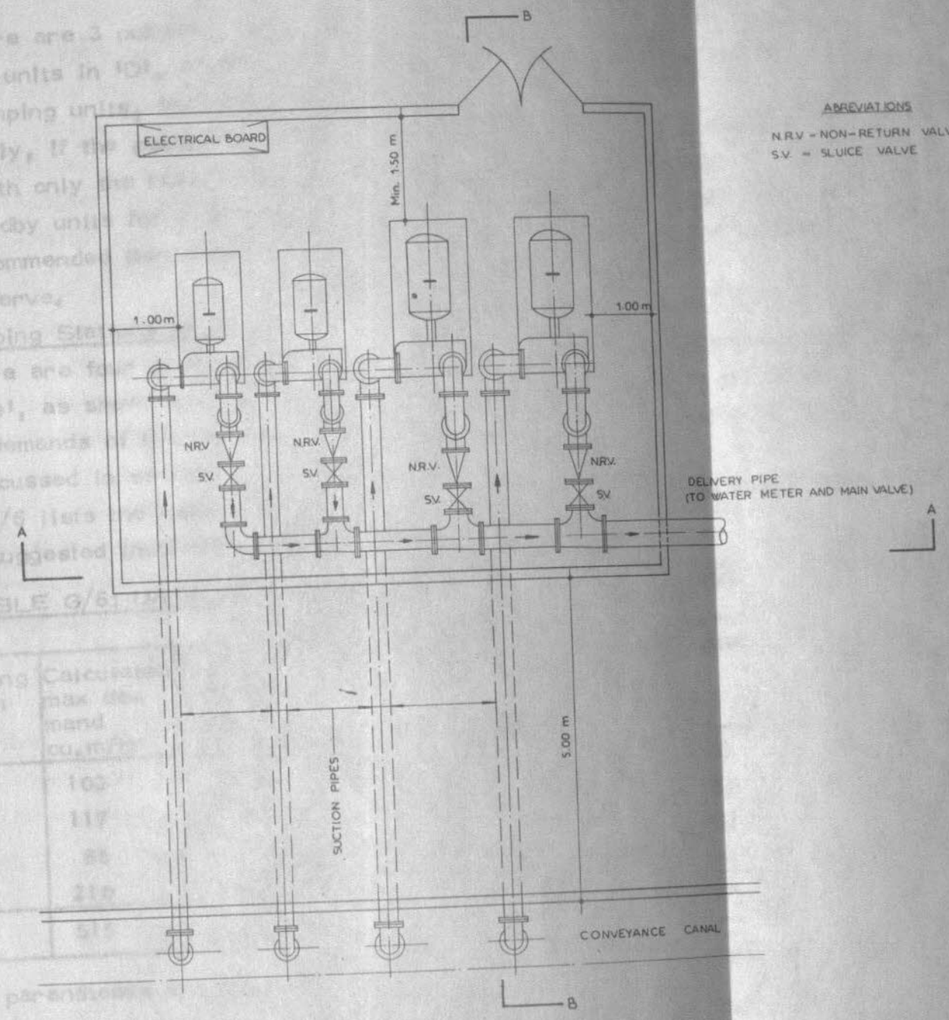
1/ In parantheses are given the numbers and rated capacity of stand-by units.

TYPICAL LAYOUT OF PUMPING STATION

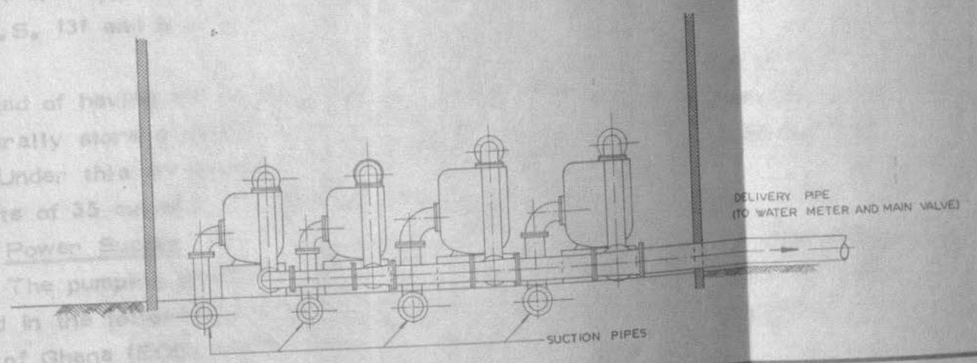
(HORIZONTAL PUMP ALTERNATIVE)

NOT TO SCALE

PLAN



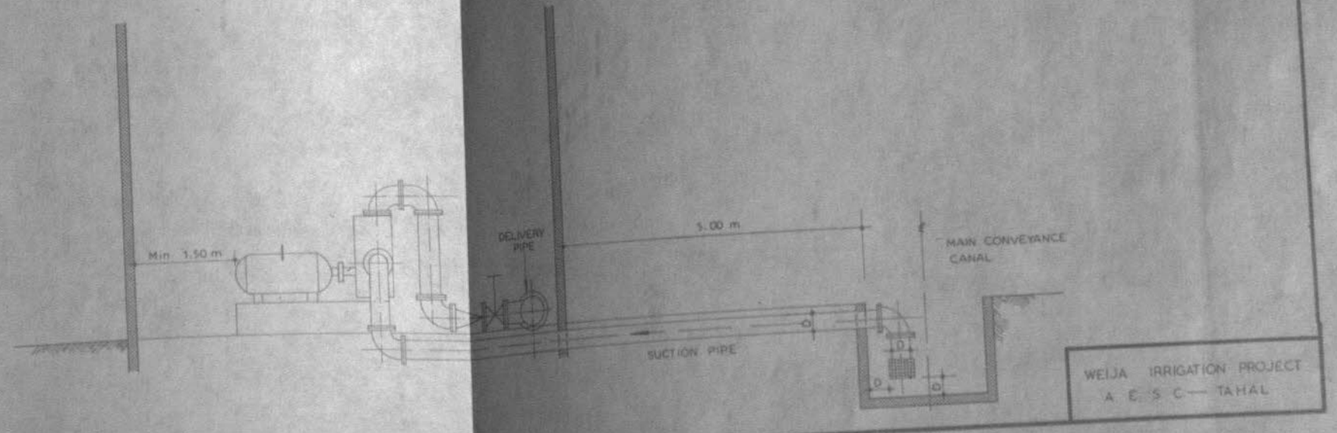
ELEVATION A–A



ABBREVIATIONS

N.R.V. – NON–RETURN VALVE
S.V. – SLUICE VALVE

CROSS–SECTION B–B



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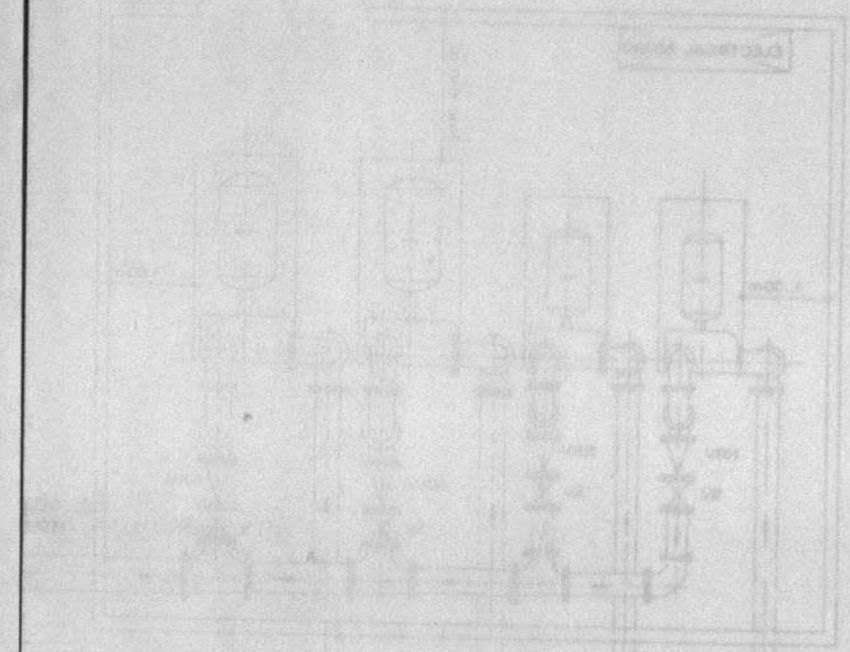


In all there are 3 pumping units in pumping station 'A', 6 units in 'B', 6 units in 'C', 4 units in 'D', 5 units in 'E', 4 units in 'F' and 4 units in 'G' - totalling 32 pumping units, including standbys.

Alternatively, if the pumping units are standardized, the pumping stations can be installed with only the rated capacity while the project will centrally store a number of standby units for replacement wherever required. Under this arrangement it is recommended that 3 units of 350 cu.m/hr. and 2 units of 200 cu.m/r be held in reserve.

(3) Pumping Stations of Area No.2

There are four pumping stations in this Area designated as stations '1', '2', '3' and '4', as shown in Fig. G/7. Their capacities conform to the peak month water demands of the corresponding irrigation blocks, including operational losses as discussed in section b(2) of this chapter.

Table G/6 lists the calculated required capacity of each pumping station, as well as the suggested installed capacity ratings.

TABLE G/6: DATA ON PUMPING STATIONS IN AREA NO.2

Pumping station	Calculated max demand cu.m/hr	Rated capacity installed cu.m/hr	Number and capacity of units installed 1/ cu.m/hr.
1	103	105	3 x 35 (+ 1 x 35)
2	117	120	1 x 50 + 2 x 35 (+ 1 x 35)
3	85	85	1 x 50 +1 x 35 (+ 1 x 35)
4	210	220	3 x 50 +2 x 35 (+ 1 x 35)
Total	515	520	5 x 50 +8 x 35 (+ 4 x 35)

1/ In parantheses are given the number and rated capacity of standby units.

In all there are 4 pumping units in pumping station '1', 4 units in P.S. '2', 3 units in P.S. '3' and 6 units in P.S. '4' - totalling 17 pumping units, including standbys.

Instead of having the standby units at the pumping stations, the project could centrally store a number of standby units for replacement wherever required. Under this arrangement it is recommended that 2 units of 50 cu.m/hr and 3 units of 35 cu.m/hr be held as standby.

(d) Power Supply

The pumping stations will be powered by electricity. The information presented in the following was obtained by the courtesy of the Electricity Corporation of Ghana (ECG) which submitted also the relevant cost estimates.

TABLE G/6: DATA ON PUMPING STATIONS IN AREA NO.2

Pumping station	Calculated max demand cu.m/hr	Rated capacity installed cu.m/hr	Number and capacity of units installed 1/ cu.m/hr.
1	103	105	3 x 35 (+ 1 x 35)
2	117	120	1 x 50 + 2 x 35 (+ 1 x 35)
3	85	85	1 x 50 + 1 x 35 (+ 1 x 35)
4	210	220	3 x 50 + 2 x 35 (+ 1 x 35)
Total	515	530	5 x 50 + 8 x 35 (+ 4 x 35)

1/ In parentheses are given the number and rated capacity of standby units.

there are 4 pumping units in pumping station 1I1, 4 units in P.S. 1I1, 3
in P.S. 131 and 6 units in P.S. 141 - totalling 17 pumping units, including
dbys.

Instead of having the standby units at the pumping stations, the project
d centrally store a number of standby units for replacement wherever re-
ed. Under this arrangement it is recommended that 2 units of 50 cu.m/hr
3 units of 35 cu.m/hr be held as standby.

(d) Power Supply

The pumping stations will be powered by electricity. The information
ented in the following was obtained by the courtesy of the Electricity Cor-
ation of Ghana (ECG) which submitted also the relevant cost estimates.

(1) Power Supply for Area NO. 1

At the KV outlet side of the 33/11 KV Torkuse transformer station a four point connection box will be installed. From it a double 11 KV underground cable will lead to the intake pumping station, which will be equipped with 11 KV switchgear and 11/0.415/0.240 KV transformer. A connection between this transformer and the motor's switchgear will complete the power supply works at this end.

One of the other connections in the 11 KV outlet box in the Torkuse station will serve the irrigation pumping stations in Area No. 1. An 11 KV buried line will cross the Accra-Winneba road, continuing as an overhead 11 KV line throughout the Area. The alignment of this line will roughly conform with that of the main water conveyance scheme, i.e. westward along the Winneba road and the southward along the Kokrobite road to pumping station 'C'; another 11 KV line will branch off from this line westward across the Area to the Oduponkpehe-Nyanyanu road and then southward along this road to pumping station 'G'. Short connecting branches will lead from the main line to those pumping stations not directly alongside the main line. In all, there will be some 11.5 km of high tension (11 KV) lines in Area 1.

The power lines will terminate at each pumping station in step-down 11/0.415/0.240 KV transformer sub-stations. The rated capacities of these transformers are given in Table G/7.

TABLE G/7: TRANSFORMER SUB-STATIONS IN AREA NO. 1

At pumping station	Installed capacity (KVA)
A	100
B	300
C	300
D	200
E	300
F	200
G	200

(2) Power Supply for Area No. 2

Power for this Area will be supplied from a main 11 KV line that the ECG plans to construct in the near future along the Accra-Winneba road for serving other consumers (the G.B.C. station at mile 13). As the rated power demands of the pumping stations of this Area are small a different supply scheme was adopted here.

(i) Power Supply for Area No.1

At the 11 KV outlet side of the 33/11 KV Tarkwa transformer station, a suitable connection box will be installed. From it a double 11 KV underground cable will lead to the intake pumping station, which will be equipped with 11 KV switchgear and 11/0.415/0.240 KV transformer. A connection between the transformer and the motor's switchgear will complete the power supply works at this end.

Some of the other connections in the 11 KV outlet box in the Tarkwa station will serve the irrigation pumping stations in Area No. 1. An 11 KV underground line will cross the Accra-Winneba road, continuing as an overhead line throughout the Area. The alignment of this line will roughly coincide with that of the main water conveyance scheme, i.e. westward along the Winneba road and the southward along the Kokrobite road to pumping station 1G1. Another 11 KV line will branch off from this line westward across country to the Oduponkpehe-Nyanyanu road and then southward along this road to pumping station 1G1. Short connecting branches will lead from the line to those pumping stations not directly alongside the main line. In all there will be some 11.5 km of high tension (11 KV) lines in Area 1.

The power lines will terminate at each pumping station in step-down 11/0.240 KV transformer sub-stations. The rated capacities of these transformers are given in Table G/7.

TABLE G/7: TRANSFORMERS SUB-STATIONS IN AREA NO.1

At pumping station	Installed capacity (KVA)
A	100
B	300
C	300
D	200
E	300
F	200
G	200

(ii) Power Supply for Area No.2

Power for this Area will be supplied from a main 11 KV line from the ECG plans to construct in the near future along the Accra-Winneba road serving other townships (the G1,G2,C1 station at mile 13). As the required power demands of the pumping stations of this Area are small a direct supply scheme was adopted here.

The two main pumping stations, Nos. 12 and 13, will receive their power from the main line through a single shared step-down transformer sub-station of 11/0.415/0.240 KV, rated at 50 KVA, to be located near the 11 KV main line (alongside the main road). From this sub-station lower voltage lines (415 V) will lead to the two pumping stations, along the canal embankment. The total length of these lines is about 0.6 km.

The other two pumping stations Nos. 11 and 14, will also share one transformer sub-station (11/0.415/0.240 KV) with a rated capacity of 75 KVA, to be installed approximately midway between them. This transformer will be supplied by a 1.1 km high-tension (11 KV) line from the main line on the Accra-Winneba road. Two lower tension (415 V) lines of total length of about 1 km will lead from the transformer sub-station to the pumping stations.

2. Main Drainage System

a. General

Irrigation and drainage are complementary, for irrigated farming cannot be practised on land that is not properly drained. Implementation of the drainage system will proceed concurently with that of the irrigation works.

The sources of excess water that make drainage necessary are both outside and within the Project Area.

- Surface runoff into the Project Area from adjacent foothills inundates low-lying areas.
- Runoff from rainfall in the area itself, which may accumulate in local depressions causing damage to crops.
- In parts of the area damage may also be caused by the temporary water table perching on the underlying heavy-textured subsoil.
- Once the irrigation system becomes operational, additional problems may arise due partly to seepage of water from the conveyance canals and partly to the percolation of surplus irrigation water raising the water table.

One should also bear in mind the proximity of the project areas to the ocean on one side and to the Weija Impounding Resevoir on the other side.

In order to create proper drainage conditions, two measures have been taken:

(i) Elevations were taken into account in the delineation of the development areas, so that even the lowest plots will be at least 4 m (12 ft) above M.S.L. and 2 m (6 ft) above the maximum water level in the Weija Reservoir.

(ii) An extensive drainage system, described in the following, is to be constructed throughout the project areas.

For the purpose of cost allocation, the drainage system of the project was divided in three parts, namely: the main system, the secondary network (on-farm and irrigation block), and subsurface drainage. This chapter deals with the first and last of the three components, these being of a more general character. The secondary drainage works have been described in Chapter F.

Design criteria for the drainage system are presented in Appendix G-1.

(b) Drainage Works in Area No.1

The functions of the main surface drainage system in this Area are to convey runoff from the surrounding areas, to remove surplus waters originating within the Area itself and to serve as outlets for the sub-surface drainage system.

The Okurudu river which intersects Area No.1 will serve as the primary collector for most of the drainage channels. The northeastern part of the Area, which is beyond the water divide of the Okurudu river, will drain directly into the Weija Impounding Reservoir.

The Okurudu river can fulfil the function of main collector over most of its course, except for a relatively short stretch of about 1.3 km (0.8 mile) which will have to be regulated and enlarged to accommodate the free passage of floods and excess waters.

The main drainage channels will run in a herringbone pattern into and through the irrigation blocks, extending to beyond the Area proper through a series of existing culverts to intercept income runoff. In all there will be about 16.7 km (10.4 miles) of main drainage channels.

Typical cross-sections of the drainage channels are shown in Fig. G/11.

(c) Drainage Works in Area No.2

The surface scheme of Area No.2 is infact comprised of two systems, as follows:

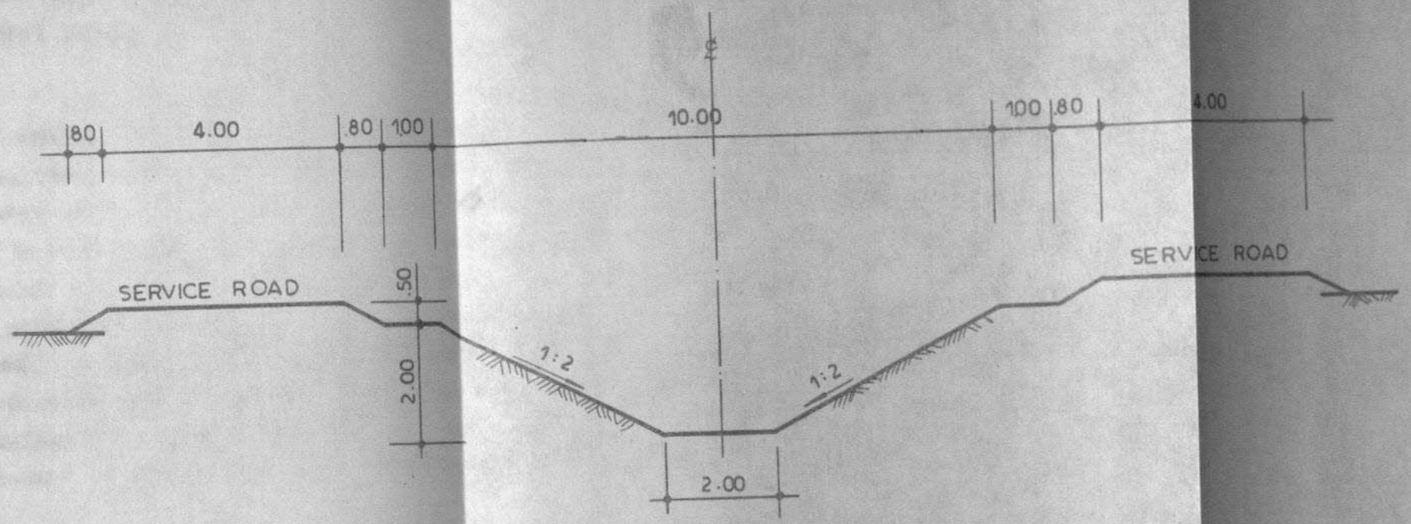
(i) The areas north and east of the main conveyance (irrigation) canal will be drained directly into the Densu river through a series of fanning out drainage channels: :

(ii) The areas south and west of the main conveyance canal will be drained by enlarging and regulating existing depressions, mainly to the western side of the hill. The runoff will be led along the existing waterways (which will have to be regulated), crossing the Accra-Winneba road through the existing culvert and reaching ultimately the Densu river.

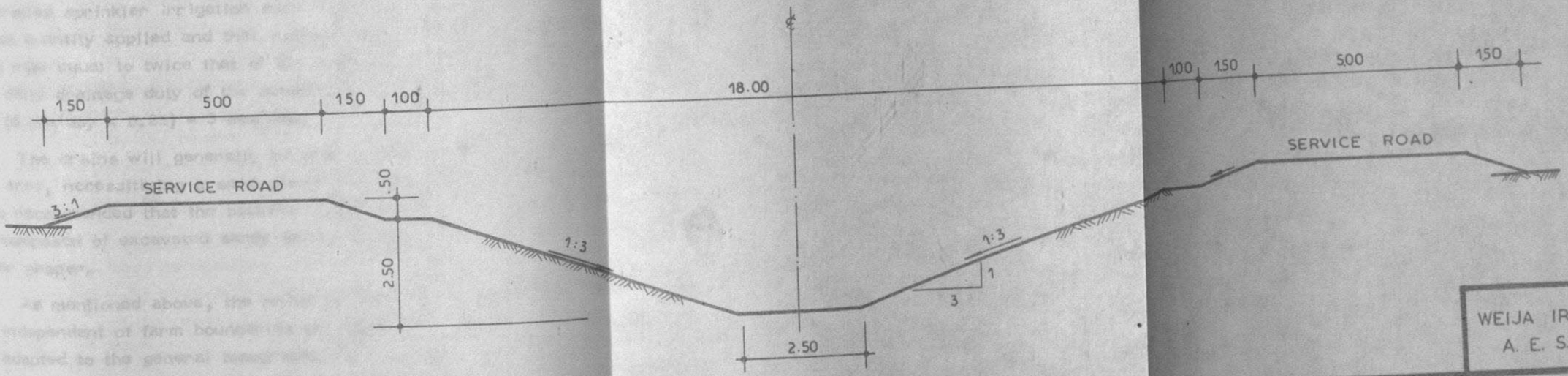
FIG. G/11

TYPICAL CROSS-SECTIONS OF THE MAIN DRAINAGE CANALS

MAIN DRAINAGE CANAL

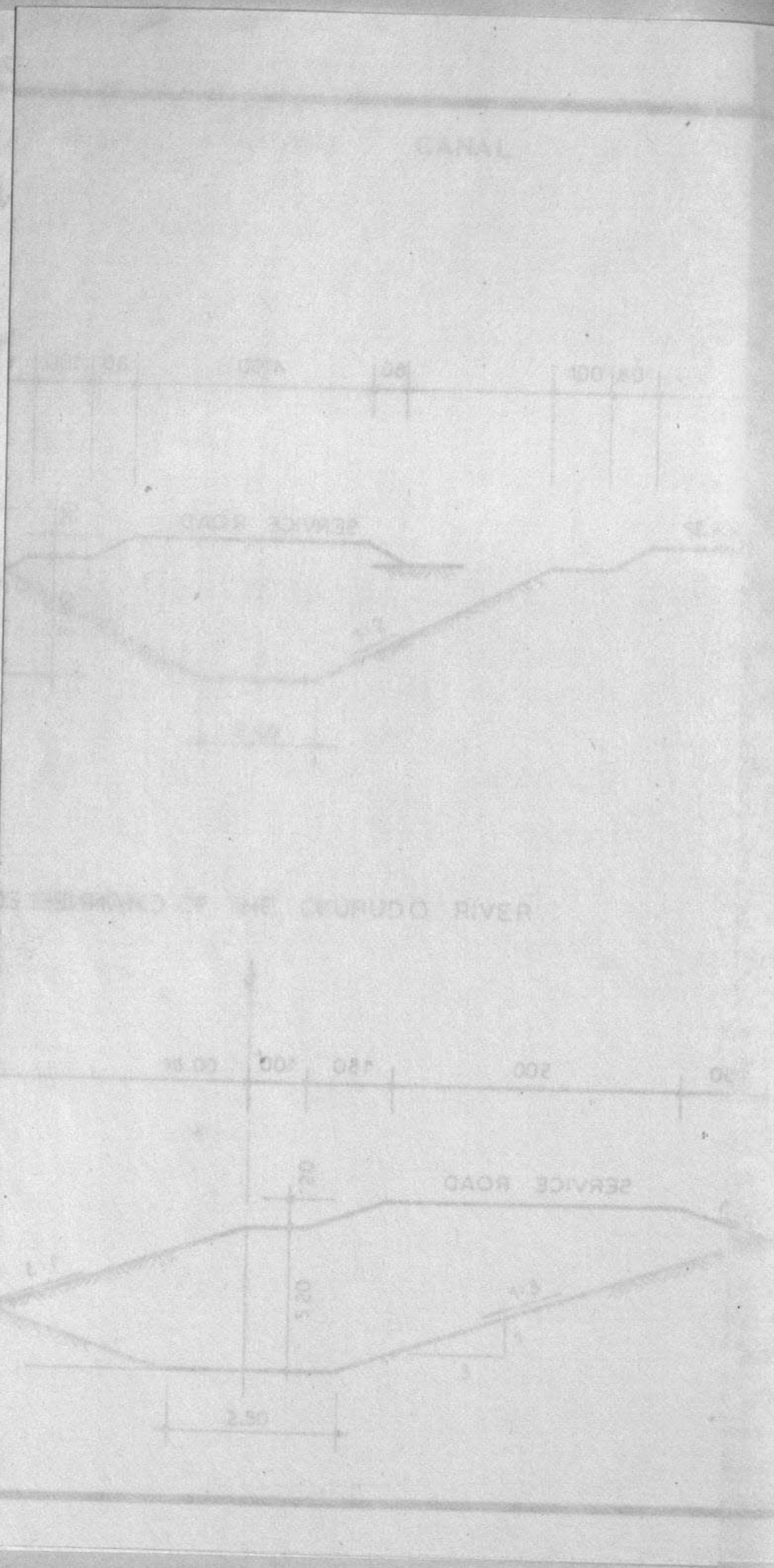


CHANNELLED SECTION OF THE OKURUDO RIVER



WEIJA IRRIGATION PROJECT
A. E. S. C.—TAHAL

drains. Outlets from the collectors to the main [illegible] located at intervals of 200 m (650 ft) or more.



The eastern slope of the hill will be drained by means of an interceptor, running parallel to the conveyance (irrigation) canal. The runoff will be conveyed southward throughtthe existing culvert under the Accra-Winneba road - back to the Densu river.

In all, some 6.3 km (3.9 miles) of main drainage channels will be excavated in this area.

d. Subsurface Drainage

Although a number of conductivity and infiltration tests have been carried out in the project areas, they do not amount to an intensive survey of the subsoil. A number of holes were augered down to a depth of 3.5 m ((11.5 ft), but no sharp changes in the soil properties could be visually observed, though there was a gradual increase of the quarzite content with depth. Thus, it is difficult to predict at this stage whether, or when subsurface drainage may be required. In view of the importance of this matter, it is highly recommended to conduct an intensive investigation regarding this subject. Pending such an investigation this study envisages the need for subsurface drainage over about one-half of Areas No.1 and No.2 (all sprinkler irrigated mixed farms).

It has been assumed that the on-farm surface drainage works will be effective enough in draining off all the water accumulating in local depressions, so that the subsurface system will have to remove only the excess irrigation water. It has also been estimated that under conditions of well-controlled sprinkler irrigation such waters will not exceed 25 percent of the gross quantity applied and that surplus water will have to be drained off at a rate equal to twice that of the peak infiltration of excess water. Thus, the daily drainage duty of the subsurface irrigation system was calculated as $2 \times (6 \text{ mm/day} \times 0.25) = 3 \text{ mm/day}$.

The drains will generally be laid in the clayey substratum underlying the area, necessitating a sand-gravel envelope around the drains. It is also recommended that the backfill of the trench (after the drains are laid) be composed of excavated sandy soils, at least up to the depth of the sandy layer proper.

As mentioned above, the layout of the subsurface drainage system will be independent of farm boundaries and plot parcellation. However, it will be adapted to the general topography and to the locations of possible outlets in the main drainage channels. A possible scheme for the network design is the gridiron system whereby the drains are aligned in parallel lines in the direction of the prevailing slope and discharge into perpendicular collector drains. Outlets from the collectors to the main drains will be located at intervals of 200 m (650 ft) or more.

Manholes will be constructed at junctions and every 400 m (about 450 yards) along the line. Automatic flap gates will be fitted to the outlets to prevent backflows and to prevent the ingress of small animals into the drains.

The cost of the subsurface drainage system was evaluated on a per ha basis, shown in Appendix Table G-3/12. Considering the present depth of the unsaturated zone in Area No.1 it can be safely predicted that the relief subsurface drainage system will not be needed during the first five years of irrigation. However, in Area No.2, where the soils are somewhat heavier in texture the need for subsurface drainage may arise earlier, possibly in the third year of irrigation. The cost estimates of project works reflect these assumptions.

3. Roads

a. General

The road network serving the project may be divided into three categories:

- Main roads, connecting the project areas with markets and supply centres;
- Access roads, connecting the villages within the project areas and leading to project facilities;
- Service roads, for the supervision, operation and maintenance of the irrigation and drainage facilities.

The Project Area lies along the main Accra-Winneba road, which together with other existing roads (some tarred, others unpaved but in good condition) may well serve as the main arteries in the sense mentioned above. These roads connect the project areas with the main anticipated markets in Accra, as well as with the supply sources, such as the Tema industrial estates and the commercial centres of Accra. The construction and maintenance of these roads is administered by the central authorities regardless of project development, consequently, they are not included in this study.

b. Access Roads

(1) Access Roads in Area No.1

This area is practically surrounded by three good roads: the main Accra-Winneba road in the north, the paved Kokrobite (mile 13) road in the east and the unpaved but very good Nyanyanu road in the west.

There is also a fourth road, passable by vehicles but in poor condition, bounding the Area in the south. This road crosses the Okrudu river, just upstream to its entry to the lagoon, over an existing bridge (partly Irish bridge but with openings to allow dry passage in low-flow conditions).

Though the existing roads bound the entire Area No.1 on its four sides, the plans call for an additional access road to be constructed between the villages of Tubakrom and Bantama. This road will be surfaced with compacted and levelled laterite to permit year-round traffic. The road will cross the Okrudu river by means of a bridge similar in design and construction to that of the south road. The alignment of this road will be determined in co-ordination with the parcellation of the irrigation blocks and with the main drainage channels along its route. Its total length will be about 3.6 km (2.2 miles).

(2) Access Roads in Area No.2

This Area is rather small and is accessible up to the foot of the central hill by an existing unpaved road, which is in rather poor condition.

The plan provides for improvement of the existing road as well as for its extension around the western side of the hill towards pumping station '1'. The road will cross the main conveyance canal, with the crossing being incorporated into the canal's related structures. The length of the extension road is about 0.8 km (0.5 mile)

Being devoid of villages, no additional access roads are contemplated for this Area.

c. Service Roads

The design of both conveyance (irrigation) canals and drainage channels provides for service roads along their embankments. The primary purpose of these service roads is to facilitate the operation and maintenance of the canals and their related structures, however, they will also serve the farmers in the transportation of products, supplies and farm machinery.

Similar service roads will also provide access to the pumping stations (located mostly along the existing roads and canal embankments) and to other on-farm facilities described elsewhere in this study.

In all cases, the design of the relevant on-farm works includes service roads, so that in this respect no separate provisions are called for.

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In all cases, the design of the relevant on-farm works includes service roads, so that in this respect no separate provisions are called for.

4. Future Development Possibilities

Although the capacity of the Weija Impounding Reservoir considerably exceeds the irrigation requirements of this project, this study has been confined to the boundaries prescribed by the soil survey and the subsequent development plans. Observations indicate that there are in the vicinity of the project additional areas which might lend themselves to irrigated agricultural development and the following considerations are presented to this end.

The most likely areas for possible future development lie to the north and northwest of Area No. 1 and to the south and southwest of Area No. 2.

a. Area No. 1

Whilst the design criteria for the engineering works have been selected with a view to maximum efficiency within the frame of the terms of reference, the generous safety factors incorporated in the design, along with modifications in some of the parameters, would permit the extension of the irrigated areas, along the following lines.

(i) The intake pumping station:

The present design calls for the installation of five operating pumping units plus one fully equipped and installed (i.e. pump, motor and rising main) standby unit. The required standby capacities could be ensured by alternative means - e.g., by allocating additional but not installed pump and motor units - permitting an increase of the supply rate by some 15 to 20 percent. Another obvious possibility is to replace one or more units by larger ones; such a solution would, however, influence materially the design parameters.

(ii) The conveyance system:

The recommendations presented in this study are based on rather conservative design standards. A more detailed study may well conclude that the recommended structure dimensions can accommodate additional capacities. But even if the present design does not allow for added supplies, one of the advantages of a gravity conveyance system is that its capacity can be easily enlarged at a relatively small additional cost.

(iii) The irrigation pumping stations:-

Similarly to the intake pumping station, these have also been provided with installed standby units. These may serve to increase the supply capability, provided that alternative arrangements are made with regard to the standby capacity. Moreover, the flexible design of the pumping stations facilitates the addition or replacement of units.

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The incorporation of additional irrigated lands to the northwest of the Area may necessitate the redesign of pumping station 'D'. However, this would still leave large segments of the system unaffected, among them all of the branch canals and the sections of the main canal down-stream of pumping station 'D', including the inverted syphon. Thus, the overall additional outlay would not be excessive.

b. Area No.2

Since the irrigation outlet is incorporated in the spillway of the Welja New Dam, its diameter cannot be altered. Nevertheless, the amount of water to be delivered can be increased, for the original design took into consideration higher water demands than the quantities quoted in this study. The conveyance system consists of canals, which are rather flexible and may be easily enlarged. Thus any reasonable increase in conveyance flows that may be called for by additional development areas, should not encounter major difficulties.

5. Cost Estimates

a. Definitions

For the purpose of estimating the costs, the engineering works have been divided into eight constituents, which are defined in the following:

(i) Feeder works.

These include the main intake pumping station of Area No.1 with its array of rising mains, and in Area No.2 - the feeder pipe from the end of the delivery pipe incorporated in the Welja New Dam works to the head of the conveyance (irrigation) canal.

(ii) Main canals.

These are the conveyance canals in both Areas regardless of their designation as primary, main, or branch sections. This item covers the cost of the canals proper without their related structures.

(iii) Structures in main canals.

These are the structures related to the main canals, including the gravity irrigation outlets in Area No.2.

(iv) Pumping stations.

These are the irrigation pumping stations installed alongside the main conveyance system in both Areas, to supply the required head for the sprinklers.

(v) Electricity supply.

This item covers the electricity supply network to be allocated to the Project, excluding the 33 KV lines and the 33/11 KV substation near Torkuse village.

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(vi) Main surface drainage.

This includes the regulation of the Ckrudu river in Area No.1 and the main drains in both Areas. It does not cover the irrigation block and on-farm drainage works, whose costs are given in Chapter F.

(vii) Roads.

These are the access roads, as defined in Section 3-b of this Chapter.

(viii) Subsurface drainage.

All the works involved in subsurface drainage in both Areas.

b. Cost Estimates

The estimated costs of construction and equipment of project engineering works are presented in a series of tables in the following pages.

Table G/8 lists the principal project data and quantities that form the basis of the cost calculation. The quantities have been estimated in accordance with the works proposed in this chapter under the appropriate headings. The unit costs of earth and concrete works and of other items are given in Table G/9. These unit costs represent the prices prevailing in February 1976, derived from contractors' bids and supported by the Consultants' familiarity with prices through their experience in similar projects. The cost of pumping units is based on quotations submitted by several manufacturers and electricity costs have been made available by the E. C. G.

Table G/10, G/11 and G/12 summarize the costs of the main engineering works - in the Project as a whole, in Area No.1 and in Area No.2, respectively. It will be noted that 15 percent of the basic costs have been allowed for physical contingencies and that a further 10 percent has been added for engineering services.

A breakdown of the engineering investments for each of the items listed in the summary tables is presented in Appendix G-3.

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A breakdown of the engineering investments for each of the items listed in the summary tables is presented in Appendix C-3.

TABLE G/8: BASIC PROJECT DATA FOR COST ESTIMATES

Item	Unit	Total	Area No.1	Area No.2
Net irrigated area	ha	1,500	1,320	180
Water requirement at farm gate				
- Mixed farm type	cu.m/hr/ha (ha)	4.95 (1,410)	(1,320)	(90)
- Rice farm type	cu.m/hr/ha (ha)	11.5 (90)	-	(90)
Water requirement at the head of the system:				
- Annual	MCM	16.8	13.7	3.1
- In the peak month (Nov)	MCM	3.31	2.71	0.60
- Max. discharge	cu.m/sec	2.79	2.28	0.51
Rising mains	km	3.1	2.1	1.0
Main canals	km	17.1	12.5	4.6
Pipes in inverted syphons	km	1.5	1.5	-
Pumping station	No.	11	7	4
Total installed power	kw	1,280	1,200	80
Power demand:				
- Annual	1,000 kwh	3,722	3,586	136
- In the peak month	1,000 kwh	737	710	27
Electricity lines	km	14.2	11.5	2.7
Main drainage system	km	24.3	18.0	6.3
Subsurface drainage	ha	750	660	90

TABLE G/8: BASIC PROJECT DATA FOR COST ESTIMATES

Item	Unit	Total	Area (Sec.)	Area No.2
Net irrigated area	ha	1,500	1,320	180
Water requirement at farm gate				
- Mixed farm type	cu.m/hr/ha (ha)	4.95 (1,410)	(1,320)	(90)
- Rice farm type	cu.m/hr/ha (ha)	11.5 (90)		(90)
Water requirement at the head of the system:				
- Annual	MCM	16.8	13.2	3.1
- In the peak month (Nov)	MCM	3.31	2.71	0.60
- Max. discharge	cu.m/sec	2.79	2.28	0.51
Rising mains	km	5.1	3.1	1.0
Main canals	km	17.1	12.5	4.6
Pipes in inverted syphons	km	1.5	1.5	-
Pumping station	No.	11	7	4
Total installed power	kw	1,290	1,200	90
Power demand:				
- Annual	1,000 kwh	3,722	3,586	136
- In the peak month	1,000 kwh	737	710	27
Electricity lines	km	14.2	11.5	2.7
Main drainage system	km	24.3	18.0	6.3
Subsurface drainage	ha	750	660	90

TABLE G/9: UNIT COSTS OF PROJECT WORKS

Item	Unit	Unit cost ¢
A. Earthworks		
Clearing	sq.m	0.75
Stripping	sq.m	0.50
Excavation of canals, in all soil types	cu.m	3.50
Excavation for structures, in all soil types	cu.m	4.00
Excavation of trenches for pipe laying	cu.m	4.00
Filling and compacting excavated materials in embankments	cu.m	1.10
Supply, spreading, compacting and trimming of clayey material in canal linings	cu.m	7.50
Supply and placing of envelope material around subsurface drains	cu.m	10.00
Supply and dumping of rip-rap and rockfill	cu.m	36.00
Supply and spreading of laterite for road surfacing	sq.m	1.25
Transportation of excavated material in trucks	ton/km	0.20
B. Concrete Works		
Concrete in walls and floors, 15 cm thick:		
Class "A" (1:1:2)	cu.m	250.00
Class "B" (1:1½:3)	cu.m	200.00
Class "C" (1:2:4)	cu.m	165.00
Reinforcement steel, cut and bent	ton	1,800.00
C. Miscellaneous Works		
Metal works (trash racks, hand rails, gates)	ton	2,500.00
Pipes:		
900 mm (36") dia, steel, incl. laying	m	350.00
900 mm (36") dia, concrete, supply only	m	130.00
700 mm (28") dia, A.C., incl. laying	m	250.00
600 mm (24") dia, concrete, supply only	m	65.00
500 mm (20") dia, A.C., incl. laying	m	120.00
150 mm (6") dia, concrete, supply only	m	4.00
100 mm (4") dia, concrete, supply only	m	2.50
Electricity lines, including poles:		
11 KV (aluminium)	km	20,700.00
0.415 KV (copper)	km	23,200.00
Buildings:		
Standard construction (offices, workshops, etc.)	sq.m	150.00
Light construction (sheds, etc.)	sq.m	100.00

TABLE G/3: UNIT COSTS OF PROJECT WORKS

Item	Unit	Unit cost
Earthworks		
Clearing	sq.m	0.75
Stripping	sq.m	0.50
Excavation of canals, in all soil types	cu.m	3.50
Excavation for structures, in all soil types	cu.m	4.00
Excavation of trenches for pipe laying	cu.m	4.00
Filling and compacting excavated materials in embankments	cu.m	1.10
Supply, spreading, compacting and trimming of clayey material in canal linings	cu.m	7.50
Supply and placing of envelope material around subsurface drains	cu.m	10.00
Supply and dumping of rip-rap and rockfill	cu.m	36.00
Supply and spreading of laterite for road surfacing	sq.m	1.25
Transportation of excavated material in trucks	ton/km	0.20
Concrete Works		
Concrete in walls and floors, 15 cm thick:		
Class "A" (1:1:2)	cu.m	250.00
Class "B" (1:1½:3)	cu.m	200.00
Class "C" (1:2:4)	cu.m	165.00
Reinforcement steel, cut and bent	ton	1,800.00
Miscellaneous Works		
Metal works (trash racks, hand rails, gates)	ton	2,500.00
Pipes:		
900 mm (36") dia, steel, incl. laying	m	350.00
900 mm (36") dia, concrete, supply only	m	130.00
700 mm (28") dia, A.C., incl. laying	m	250.00
600 mm (24") dia, concrete, supply only	m	85.00
500 mm (20") dia, A.C., incl. laying	m	120.00
150 mm (6") dia, concrete, supply only	m	4.00
100 mm (4") dia, concrete, supply only	m	2.50
Electricity lines, including poles:		
11 KV (aluminium)	km	20,700.00
0.415 KV (copper)	km	23,200.00
Buildings:		
Standard construction (offices, workshops, etc.)	sq.m	150.00
Light construction (sheds, etc.)	sq.m	100.00

TABLE G/10: SUMMARY OF COST ESTIMATE FOR MAIN ENGINEERING WORKS - ENTIRE PROJECT

¢1,000

Item	Basic estimate	Contin-gencies 15%	Field cost	Engin. services 10%	Total
Feeder Works	1,030.2	154.5	1,184.7	118.4	1,303.1
Main Canals	1,777.6	266.6	2,044.2	306.9 1/	2,351.1
Structures in main canals	791.4	118.7	910.1	91.0	1,001.1
Pumping stations	1,090.8	163.6	1,254.6	125.4	1,379.8
Electricity supply	325.6	48.8	374.4	37.5	411.9
Main surface drainage	1,042.4	156.3	1,198.7	119.9	1,318.6
Roads	126.4	19.0	145.4	14.5	159.9
Subsurface drainage	1,200.0	180.0	1,380.0	138.0	1,518.0

1/ 10% for engineering services plus ¢102,500 for complementary surveys.

TABLE G/11: SUMMARY OF COST ESTIMATE FOR MAIN ENGINEERING WORKS - AREA No.1

¢1,000

Item	Basic estimate	Contin-gencies 15%	Field cost	Engin. services 10%	Total
Feeder works	704.7	105.7	810.4	81.0	891.4
Main canals	1,506.9	226.0	1,732.9	248.3 1/	1,981.2
Structures in main canals	670.5	100.6	771.1	77.1	848.2
Pumping stations	1,006.1	150.9	1,157.0	115.7	1,272.7
Electricity supply	261.5	39.2	300.7	30.1	330.8
Main surface drainage	782.2	117.3	899.5	90.0	989.5
Roads	102.0	15.3	117.3	11.7	129.0
Subsurface drainage	1,056.0	158.4	1,214.4	121.4	1,335.8

1/ 10% for engineering services plus ¢75,000 for complementary surveys.

TABLE G/12: SUMMARY OF COST ESTIMATE FOR MAIN ENGINEERING WORKS - AREA No.2

¢1,000

Item	Basic estimate	Contin-gencies 15%	Field cost	Engin. services 10%	Total
...der works	325.5	48.8	374.3	37.4	411.7
...in canals	270.7	40.6	311.3	28.6	339.9
...ctures in main canals	120.9	18.1	139.0	13.9	152.9
...ping stations	84.7	12.7	97.4	9.7	107.1
...ricity supply	66.1	9.8	73.7	7.4	81.1
...in surface drainage	260.2	39.0	299.2	29.9	329.1
...ads	24.4	3.7	28.1	2.8	30.9
...subsurface drainage	144.0	21.6	165.6	16.6	182.2
...tal	1,296.5	194.1	1,488.6	176.3	1,664.9

10% for engineering services plus ¢27,500 for complementary surveys.

H. PROJECT ORGANIZATION AND MANAGEMENT

1. Targets of the Organization System

The construction of the irrigation and drainage systems and that of the agricultural infrastructure provides farmers only with part of the physical means required for stepping up production. However, these installations and other physical facilities are not sufficient in themselves. The smooth and successful functioning of modern agriculture, in addition to requiring efficient operation and maintenance of the various installations depends largely on the services at the disposal of the farmer, such as training, supply of inputs, marketing, credit etc. In order to derive maximum economic and social benefits from the agricultural potential of the Project Area, the installations and services of the project must be operated and managed in such a way as to ensure the efficiency of all farm activities.

The aims of the proposed organization are:

- to establish an organizational framework which will enable efficient operation of the facilities and services needed by the farmer;
- to co-ordinate and integrate all agricultural and related activities in order to achieve the objectives of the project.

2. Guidelines for the Planning of the Organizational Systems

To realize the aims of the project and for the organizational systems to be fully effective, the Project will be granted operational independence in so far as its day-to-day functioning is concerned.

The Project will come under the responsibility of the Irrigation Department of the Ministry of Agriculture. Other bodies involved, such as the various units of the Agriculture Department and the Agricultural Mechanization and Transport Department and outside organizations such as the Agricultural Development Bank (A.D.B.) will be given a share in the running of the Project through their representatives on a Co-ordination Committee which will guide the Project Management in specific fields of activity.

Members of the Co-ordination Committee will serve as the link between the project and the respective bodies they represent. During the development and initial operations stages the Project will be run centrally by the Project Management, comprised of the Project Manager and the heads of sections. All services required by the project will be supplied by the Project Management through the relevant sections or from outside sources under the directions of the respective units.

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The Project Management will, as far as possible, make use of the services already existing in the area, such as the farm machinery station at Oduponkpehe (Kasua-Gariba), existing supply and marketing channels, etc., thereby taking advantage of experience acquired and avoid overlapping of activities and mushrooming of the project staff. The proximity of the project to Accra will facilitate the finding of existing services, such as marketing outlets, workshops, contractors for maintenance, etc.

The Project Management will mediate between farmers and the various outside bodies that provide credit, marketing and other services thus leaving the farmer free to concentrate his efforts in agricultural production. The organizational structure must be as simple as possible and comprehensible to the project staff and farmers alike.

The division of duties and authority must be clear-cut and unambiguous. Lines of communication and work procedures and methods must be simple and straightforward. Vague or complicated processes lead to inefficiency and a lack of confidence in the Project. Authority for operative decisions within the framework of the policy laid down, will, as far as possible, be delegated to the operation level personnel in the various fields of activity. The delegation of authority and responsibility to levels directly involved and familiar with the Project and its day-to-day problems leads to smoother and faster decision taking process and is conductive of closer identification of the managerial set-up with the project.

In order to reduce to a minimum the cost of establishment and operation of the management organization, by using existing facilities and services, it is proposed to locate the Project Management headquarters in Accra. The proximity of the Project Area to the city will facilitate contact between the farmer and the management, which in turn will boost the farmers' confidence and, in the course of time, make it easier for the farmers themselves to take an active part in the management of the project.

Project development is a step-by-step process from construction to operation in its initial phase and thence to operation in its ultimate phase. Since one of the purposes of a development project is to bring about certain changes in environmental conditions, the organizational structure must be suited to local conditions; it should be able to change with time and adapt itself to new situations at each stage of development. The organizational set-up will be analysed throughout the phases of project development, since each of stages makes its own demands on the organizational set-up.

In planning the organization special emphasis will be laid on the encouragement and training of farmers towards resourcefulness and mutual help. The NNCBCA groups[1/] could be utilized as a suitable framework for encouraging farmers to colloborate in self-contained projects. It should be borned in mind that the farmers themselves will eventually have to run their own organization and provide whatever services are required.

3. Supporting Services

a. General

As has been stated above, a successful farming enterprise depends largely on the efficient operation to the farmer. The Project Management must set up an organization capable of providing the services and conducting the activities as follows:

- Operation and maintenance of the irrigation and drainage system and service roads in the Project Area.
- Provision of agricultural extension service to the farmers, including agricultural planning, training and instruction, and field experimentation.
- Supply of agricultural inputs such as seeds, fertilizers and pesticides.
- Marketing services and appurtenant facilities such as storage and transportation.
- Co-ordination of the provision of agricultural cultivation service.
- Co-ordination of Credit for investments and working capital.

b. Irrigation and Drainage

The main physical components of the Project are the irrigation and drainage systems, as described in Chapters F and C.

The Project Management will operate and maintain the irrigation and drainage system through the Water Supply and Drainage Section which will be responsible for the system from the headworks up to the connection to the pipe network on the individual farm. Farmers in each of the irrigation blocks (between 60 and 90 farmers in each block) will form an Irrigation Group. Members of the Group, with the help of the Agricultural Instructor will co-ordinate among themselves irrigation times and applications, in conjunction with the Water Supply and Drainage Section, which will control pumping operations accordingly. The Irrigation Group will be responsible for the maintenance of on-farm pipelines and for irrigation operations.

1/ Groups set up for the common cultivation of group members' farms moving inrotation between group members plots.

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The Group will elect from among its members an Irrigation Coordinator, a task which will rotate at fixed time intervals. The Coordinator, assisted by two other members of the group, will be responsible for the execution and coordination of irrigation activities. Together, the Irrigation Coordinators of the Groups will form an Irrigation Committee which will assist the Director of the Water Supply and Drainage Section and represent the farmers using the system vis-a-vis the section.

The arrangement will afford the farmers the opportunity of understanding the system, enabling them eventually to participate in its management.

This division of functions between the Water Supply and Drainage Section and the farmers themselves will enable the Section to concentrate on the technical and operative aspects of water supply leaving to the farmers the initiative for developing their farms and using the water at their disposal to the best advantage; it will also encourage collaboration among the farmers. During the initial stages of operation the Agricultural Instructor will act also as the Irrigation Coordinator of the block. At the design stage it will be necessary to draw up detailed guidelines for the activities of the Irrigation Groups.

The Water Supply and Drainage Section will act through two units:

(i) The Operation Unit will be responsible for the operation of pumping stations, sluices and valves; it will also keep records of the quantities of water supplied to the various blocks. The quantities of water supplied to the block will be charged in equal measure to the members of the group. It is recommended that water used for rice irrigation be charged as a fixed sum according to the size of the plot. The price of the water will be determined by the Project Management on the basis of cost calculations and in accordance with the policy of the Ministry of Agriculture. Although the farmer would be hardput to pay real cost of the water, the price should be sufficiently high to discourage waste, yet not as high as to deter him from using the water.

As the system is planned for 15-hour a day irrigation, the unit must be set up so as to operate in two shifts.

(ii) The Maintenance Unit will be responsible for the maintenance and repair of the various irrigation installations and the drainage. Minor repairs only will be carried out by the Unit itself; for bigger repair jobs and road and canal improvements the unit could be assisted by competent contractors or by the maintenance unit of the Irrigation Department of

the Ministry of Agriculture. The Maintenance Unit will also have the task of training the farmers in the use and maintenance of irrigation equipment.

The Office of this Unit, as well as its workshop and spare parts store will be located to the intake pumping station of Area No.1. The staff will have at their disposal a pick-up, a small wheeled tractor and bicycles for operators and ditchriders.

Since the personnel required for this Unit is largely comprised of technicians, every effort should be made to recruit and train the necessary staff already at the inception of project implementation. Insufficiently skilled operation and maintenance teams may cause severe damage to the system and irrepairable losses in agricultural production.

c. Extension and Agricultural Planning

Improved installations and services are only part of the agricultural development programme. The most important contribution of the development process is to raise the standards of the farmers themselves. The Extension and Agricultural Planning Service will provide the farmers with an agricultural programme, and supply all the training and know-how they need in order to cope successfully with the implementation of the programme. Except for the ultimate phase of development the Extension Service will be an integral part of the Project Management. Agricultural training will mainly consits of on-the-job training by Farm Instructors. A Farm Instructor will be assigned to every few irrigation blocks and he will be assisted by specialists in the various disciplines, placed at his disposal by the Ministry of Agriculture.

A number of farmers will be selected from each irrigation block, who will be in close touch with the Farm Instructor, receiving from him regular guidance, and they in turn will pass on to the other farmers the know-how necessary for the efficient management of their farms. It is proposed to make use of the NNOBCA groups for the dissemination of agricultural know-how and in this way each Farm Instructor will be able to reach a large number of farmers.

In addition to the field extension and on-the-job training, the Extension Service will hold courses and seminars both for farmers and project workers, including supplementary courses for the Farm Instructors themselves to keep them up to date with the latest developments in their fields.

The agricultural Planning Unit will draw up an agricultural programme including cropping and cultivations. This programme will also serve as the basis for supervised credit schemes.

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d. Supply and Marketing Service

The functions of supply of input items and marketing of produce are linked by logic and by tradition. The farmer's expenditures are spread over a relatively long period, while his income generally comes in a lump sum once or twice a year, or at any rate, in a stream which does not coincide with his stream of expenditures. By linking supply and marketing, credit arrangements can also be worked out more easily. Furthermore, both supply and marketing are tied to the agricultural cycle, so that the manpower and facilities of one or the other are underemployed during parts of the year. Linking supply and marketing results in more efficient utilization of manpower and of facilities.

(i) Supply Service

The principal items of production inputs supplied under this heading are seeds, fertilizers and pesticides. The supply service acts as the farmer's purchasing agent. Centralized purchasing and delivery to the farm relieves the farmer of the need to travel to distant centres; furthermore, centralized purchasing for a large number of farms permits the setting of quality standards and offers the farmer the benefits of price reductions, credit, etc., as a result of bulk purchases.

The farm supply service is coordinated with the agricultural plan which determines the approximate quantities of supplies. On this basis, the service enters into agreements with producers and suppliers for providing the required quantities at specified delivery dates. The supply service arranges for the delivery of the supplies to the farm, either by project vehicles, or through agreements with private transport companies or with the original supplier. Accordingly, the tasks of the supply service are:

- Purchasing - translating the agricultural plan into a procurement plan, drawing up agreements with suppliers, specifying standards, preparing supply schedules, purchasing, and obtaining credits.
- Sale to Farmers - transferring the materials from the local supply depots to the farms, determining the sale price to the farmer, debiting farmers' accounts and collecting payments.

(ii) Marketing Service

The marketing service collects the agricultural produce from the farm gate, performs all handling and processing, delivers the produce to the market, sells it, and distributes the proceeds among the farmers. The marketing service frees the individual farmer from the necessity of finding outlets for his produce and its standing on the market is strong enough to assure the farmer a fair price.

This service obtains seasonal and long-range forecasts of crop yields and, on this basis, enters into agreements for marketing the produce. Such agreements define the handling and processing to be done before the produce reaches the market, including grading, sorting, packing, etc. To some extent, the marketing service may influence the agricultural programme, since it is sensitive to price changes, to demand and market requirements. Regular information on market fluctuations and demand will serve to revise the agricultural plan and adapt it to changing conditions.

The marketing service is of great importance, since it is the main channel through which the farmer obtains his income. High yields, improved quality, efficient cultivations and seasonal advantages may all be nullified by defects in the marketing service.

The Marketing Unit should take advantage of the vicinity of the Project Area to Accra and the existing market at Oduponkpehe by entrusting the collection of the produce, its transportation and other post-harvest operations to the purchasers with whom the sales agreement has been made. The Project Management should refrain from setting up facilities and from making unnecessary investments in this field. The tasks of the marketing service are:

- Sale: - negotiating seasonal and long-term marketing agreements, determining prices and standards, fixing terms of payment, and collection of payments.
- Book-keeping - keeping the accounts of individual farmers' and transferring monies earned through sales of produce to the clearing account.

It should also be borne in mind that at least part of the produce will be marketed directly by the farmers.

e. Agricultural Cultivation Service

The land cultivation service carries out the necessary agro-technical operations by mechanical equipment, in keeping with the agricultural development plan, starting with the preparation of the seedbed and ending with the harvest of the crops. Since the timing of field operations is determined to a certain extent by other services, such as the water supply service, close co-ordination is necessary among the services. Co-ordination is also needed to ensure effective utilization and maintenance of agricultural equipment.

Several alternative possibilities have been considered for properly organized and co-ordinated cultivation to the farmers:

(i) Through a cultivation unit belonging to the Project Authority;

(ii) Through the provision of agricultural machinery to the farmers;

(iii) Through cultivation co-operatives of the farmers themselves;

(iv) Through governmental agencies or other contracting bodies.

Although the farmers of the region may some day purchase their own tractors, it is strongly recommended to rely in the initial stages on the Oduponkpehe farm machinery station of the Ministry of Agriculture, Mechanization Section.

The station will have to be recognized, enabling it to undertake the required services in the operation stages.

The setting up of cultivation co-operatives should be considered. It is proposed that people in the area who will not be receiving lands but possess technical skills be organized into such co-operatives, acting as contractors vis-a-vis the farmers.

The planning, co-ordination and supervision of cultivation should be one of the project Management's tasks and should include the following:

(i) The annual and seasonal planning of agricultural cultivation;

(ii) The setting of standards for cultivations;

(iii) Overall supervision of cultivation with respect to quality of work and timely execution;

(iv) The collection of data and information as a basis for the improvement of the service and of planning for the coming years.

It is proposed that co-ordination with the machinery station be done by a member of the office team. Planning activities should be the responsibility of the Planning and Extension staff.

Each irrigation block will also be designated as a cultivation block and one of the farmers from the block will be elected as Cultivation Co-ordinator and Supervisor.

The farm instructors will assist farmers in the co-ordination of cultivation activities and in supervising and checking the standard of the work performed.

f. Credit, Accounting and Clearing Service

Modern agriculture, with its attendant use of water, fertilizers, pesticides and mechanization, brings the farmer a far better income than traditional farming. However, because the streams of income and expenditure do not coincide, the farmer is often heavily dependent on credit. Without a system which can make available credit in sufficiently large quantities with a minimum of bureaucracy, the project's goals will not be realized.

The farmer needs credit for the following purposes:

- Working capital for the financing of production operations (short-term credit)
- Additional investments in farm development and/or acquisition of implements and equipment for the farmer or a group of farmers (medium-term credit)
- Family allowance to be granted to the farmer during the initial period until he has an income from the sale of his produce.
- Loans for financing the purchase of co-operative shares.
- Farmers' Association will also have the right to apply for credits for the financing of their activities and acquisition in accordance with the policy of the Ministry of Agriculture and of the A.D.B.

The main source of credit will be the Agricultural Development Bank, which will make available three types of loans.

- Short-term: 0 - 1½ years,
- Medium-term: 1½ - 5 years
- Long-term: Over 5 years.

Short-term loans are granted to meet production costs. Medium-term loans are granted for the purchase of farm equipment, livestock and other means of production. Long-term loans are made available for extensive new projects or for the improvement of existing ones. The Bank will appoint a Credit Supervisor who will be in charge of matters connected with project credit. Consideration should be given the possibility of making the Credit Supervisor a member of the Co-ordination Committee working in association with the Project Management.

Co-ordination of all the project credit activities will be carried out by a Credit Co-ordinator, a member of the Project Administration Section.

Credit will be granted within the framework of long-term or annual agreements according to the credit forecast based on the production and investment programmes. These programmes will be drawn up by the agricultural planners in conjuction with the Farm Instructors and will be ratified by the Project Management for submittal to the Bank.

In addition to its credit co-ordinating task the Project Administration Section will have an Accounting Unit which will conduct all debiting, crediting and cash operations required for keeping the accounts of users of the irrigation system.

At the ultimate stage of development farmers' co-operatives are likely to serve as the natural channel through which credit will be extended and loans repaid. The co-operative will have the necessary organization and facilities; furthermore, it will have its own funds and, therefore, will have less need to borrow on its own.

4. The Objectives and Organizational Structure at Various Stages of Development

a. General

A development project is by its nature an instrument for planned change, and consequently its organizational structure must allow for changing circumstances. In the course of project development from planning and construction up to its ultimate operation, a number of stages will be discerned. The transition from one stage to the next is gradual and there is generally considerable overlapping between stages. Nevertheless, for the present purpose, the project may be divided into two main stages:

(i) Construction and implementation stage.

(ii) Operation stage.

Each of these stages makes its own special demands on those involved and on the organizational structure.

b. The Construction Stage

This stage, during which the physical structures and installations of the irrigation and drainage system, the road and power networks are constructed differs from the operation stage both in the activities involved and also with regard to the technical qualifications of the participants.

Construction will be carried out by competent contracting agencies, under the supervision of the Project Management and the Irrigation Department of the Ministry of Agriculture. The installations will be handed over to the Project when completed and run in. The construction and implementation stage will last four years, an area of about 400 ha being developed each year. In order to permit commencement of agricultural production without having to complete the infrastructure in the whole area, it is proposed to develop the area block by block, so that every year a number of blocks will enter into production. Every block that is ready for cultivation and every installation that has been completed will be put under the management of the Project.

Development will start in Area No. 1 and after this has been completed, development of Area No. 2 will follow. Obviously, the headworks in each area must be completed, in the first year of its development.

Handing over of the installation to the project will take place only after they ave been run-in to the satisfaction of the Project Team and after it has been ascer- ained that the Project Team is sufficiently trained for taking over their operation nd maintenance. This applies mainly to the irrigation system.

The first year of the construction stage will be utilized by the Project Mana- ement for setting-up the organization for the tasks awaiting it at the subsequent tages. As stated, after the first year, the construction and operation stages will verlap for a number of years, requiring co-ordination between the various bodies perating in the field.

Since the main installations belong to the irrigation and drainage system, it is roposed that the head of this section, being a technically qualified man, should erve as laison between the Project and the agency concerned with construction and evelopment.

During the detailed design stage, it will be necessary to draw up a detailed lan of operations encompassing all of construction and development and their co- rdination and integration with the plan for the commencement of farm production.

Assignments to be carried out by the Project Management at the construction tage, until taking over the first blocks, are as follows:

- Recruitment of manpower for running the project in its initial stages;
- Initial training of personnel appointed to the various tasks;
- Organization of project units, work procedures and regulations;
- Drawing up budgets and credit arrangements for initial operations;
- Selection of candidates from among the farmers for participation in the Project;
- Integration of the selected farmers into the construction activities and preparation of the area;
- Drawing up the detailed agricultural plan for the first season;
- Completing logistic preparations and finalizing avenues of credit.

Project staff in the first year of this stage will include the Project Manager, heads of secretarial and personnel sections and the extension service. Whilst this stage is in progress personnel will be appointed to fill the posts required during the initial stage of operation, as discussed in the follo- wing.

c. Operation Stage

The operation stage may be broken down into sub-stages, or phases, corresponding to the progress of project development.

(i) Initial Operation, and

(ii) Ultimate Operation.

At first the main effort will be directed to establishing and activating the necesry services, putting into operation the facilities and irrigation blocks that have completed, improving yields and steering the project towards economic self-ficiency. During the transition to the ultimate phase emphasis will be placed on eamlining the services, stepping up agricultural production, and especially on ing the farmers and others involved in the project to act on their own, so that the ultimate operation phase the Project Management can transfer its tasks onto farmers themselves, who will with the aid of their organizations (Co-operative, ordination, and Irrigation Committee) gradually take over responsibility for run- the project.

The duration of each one of the above phases will depend on the rate of elopment of the project. The transition from one phase to the next need not take ce at the same time for each project component.

The Organizational Set-up in the Initial Operation Phase

The organizational chart for the set-up of the Project Management in the ini- operation phase is shown in Fig. H/1 with details of the manpower requirements en in Table H/1. A summary of responsibilities and activities in various levels the organization are described in the following.

a. Project Management

At this stage the project will be run by the Project Manager under the guidance of the Irrigation Department of the Ministry of Agriculture. The project will be given operational independence in all fields of activity.

To co-ordinate the operational policy of the Project, a Co-ordination Commi- e will be established, consisting of representatives of ministerial and other encies whose participation may be of assistance to the project. These repre- ntatives will provide link between the project and the respective agencies. For ample, the representative of the ADB may serve as the Bank's Credit Supervisor the project.

The Co-ordination Committee, chaired by the representative of the Irrigation epartment, will include representatives of the following:

- Agriculture Department
- Mechanization and Transport Department
- Agricultural Development Bank

The Ministry of Agriculture will also appoint an auditor and controller who ill follow up the activities of the Project with regard to the Ministry's policy nd will also audit the project accounts.

TABLE H/1: MANPOWER REQUIREMENTS IN THE INITIAL OPERATION PHASE

ORGANIZATION CHART
INITIAL OPERATION PHASE

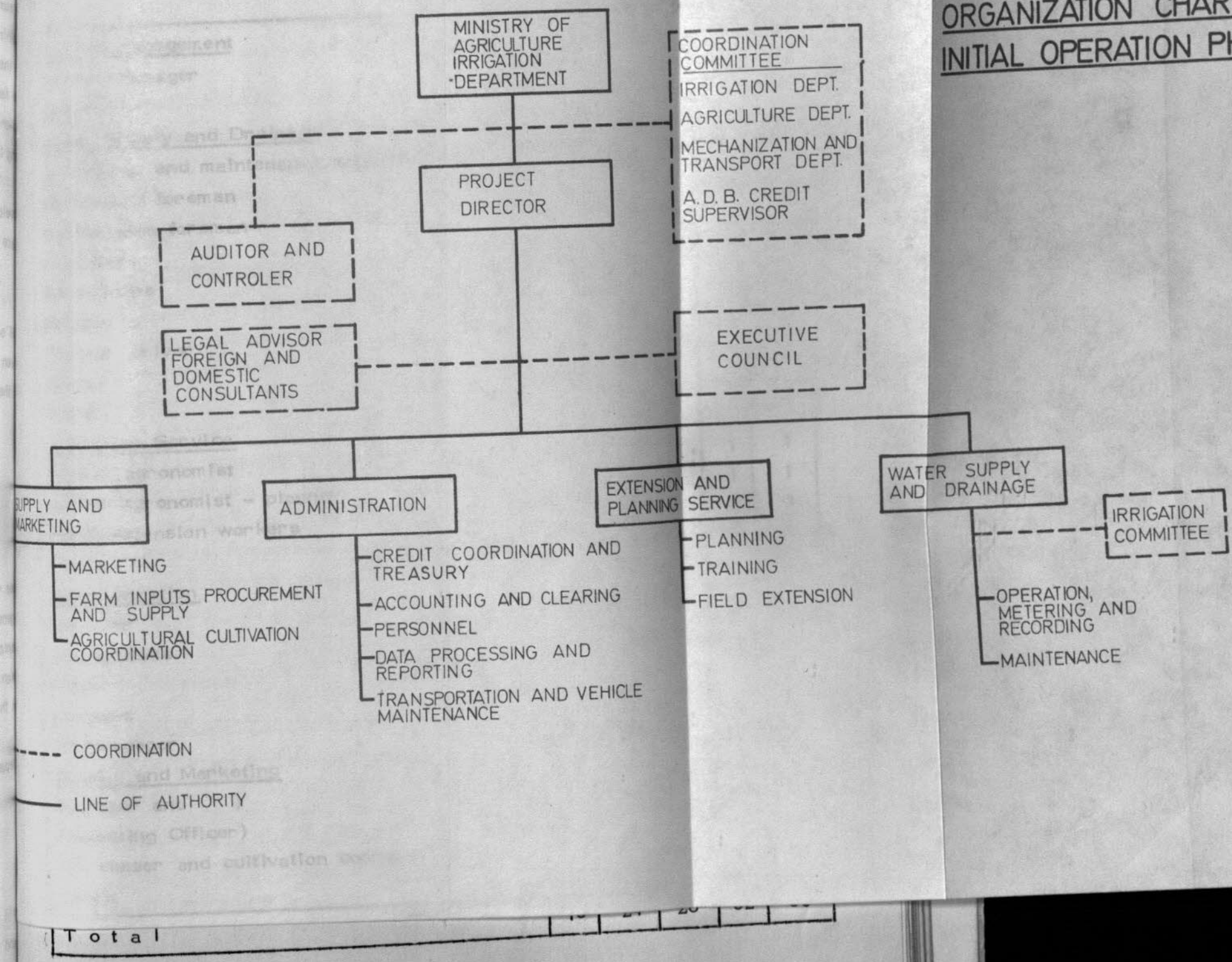

FIG. H/1

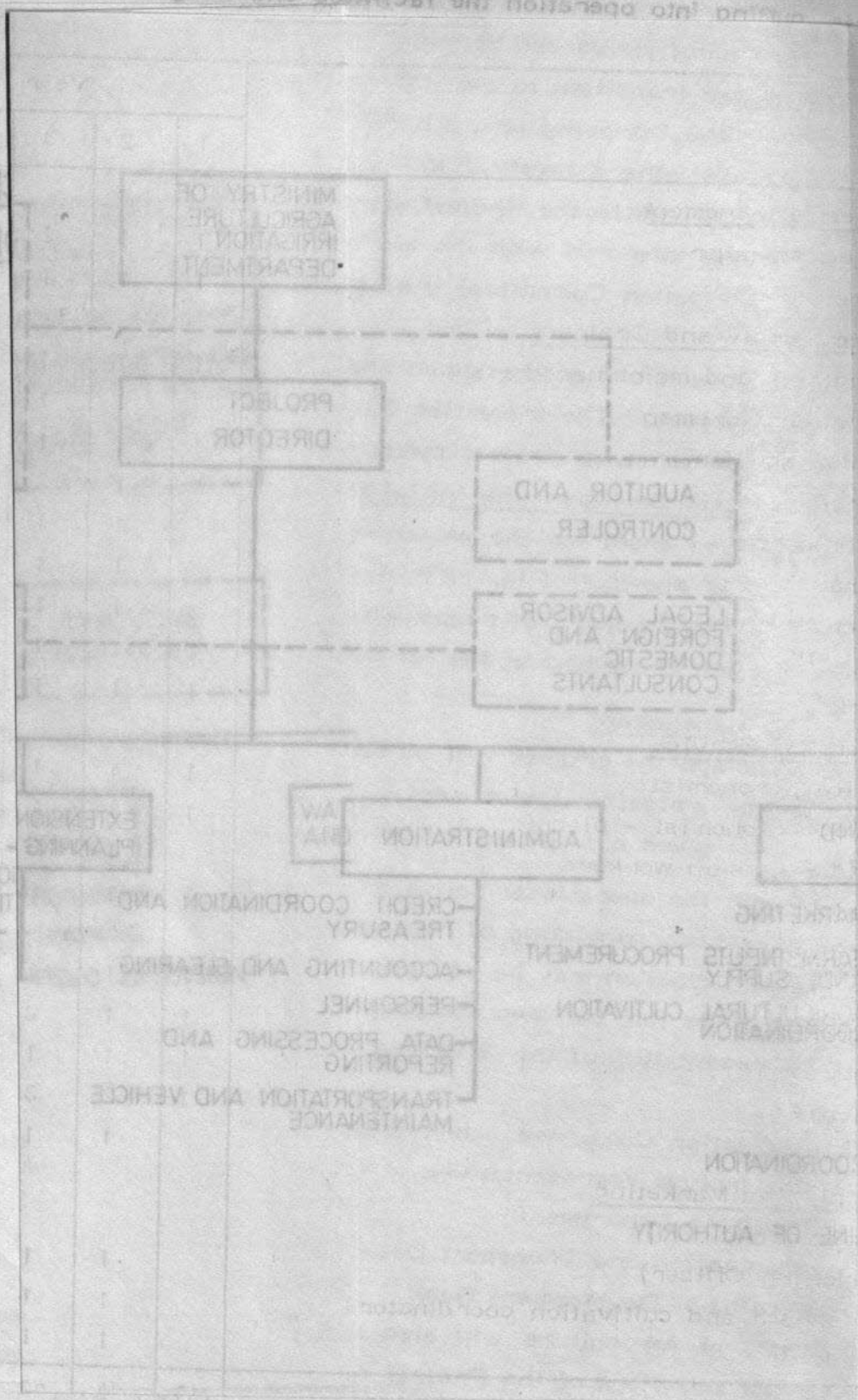

TABLE H/1: MANPOWER REQUIREMENTS IN THE INITIAL OPERATION PHASE

Function	Year				
	1	2	3	4	5
Project Management					
Project Manager	1	1	1	1	1
Secretary	1	1	1	1	1
Water Supply and Drainage					
Operations and maintenance engineer	1	1	1	1	1
Operations foreman		1	1	1	1
Maintenance foreman	1	1	1	1	1
Operators		1	2	4	6
Ditchriders		1	1	2	3
Mechanics		1	1	1	1
Tractor driver		1	1	1	1
Driver	1	1	1	1	1
Clerk	1	1	1	1	1
Extension Service					
Senior agronomist	1	1	1	1	1
Junior agronomist - planner	1	1	1	1	1
Field extension workers		1	2	2	3
Clerk	1	1	1	1	1
Administration					
Manager	1	1	1	1	1
Accountants	1	1	2	2	2
Clerk	1	1	1	1	1
Drivers	1	2	3	4	4
Storekeeper		1	1	1	1
Supply and Marketing					
Manager and)					
Marketing Officer)		1	1	1	1
Purchaser and cultivation coordinator		1	1	1	1
Clerk		1	1	1	1
T o t a l	13	24	28	32	36

The Project Manager, who is charged with carrying out the policy of the Ministry will administer the project through the heads of four sections, as shown in the organization chart, Fig. H/1.

b. Water Supply and Drainage Section

The Water Supply and Drainage Section, headed by an Engineer who will be assisted by a team of technicians, as detailed in Table H/1 will undertake the tasks as described in paragraph 3-b of this Chapter.

c. Planning and Extension Service

The planning and Extension Service, headed by a senior agronomist with the assistance of a junior agronomist in the field of agricultural planning, training services, and agricultural experimentation, and assisted also by a team of field instructors who will guide farmers as described in paragraph 3-c of this Chapter.

d. Administration Section

This section will run all administrative services required for the proper operation of the project, including a secretariat, personnel unit and accounting both for the transportation pool at the disposal of the project and will be responsible for its proper operation and maintenance. One of the main tasks of this section will be the handling of credits. The section will draw up credit programmes based on the findings of agricultural planning and marketing and supply forecasts, it will be responsible, after approval by the Project Manager for submitting the credit to the Bank and for dealing with all aspects of credit procurement for the farmers. Because of the vital importance of this subject it is proposed that all credit matters be handled directly by the section head.

In addition, the administration section will be engaged in gathering information on the various project activities and presenting it in the form of periodical reports to the various levels.

e. Supply and Marketing Section

The Supply and Marketing Section which will deal with all commercial and contractual aspects of the relations with suppliers, purchasers and tractor stations.

f. Legal Advisor and Administrative Committee

Apart from the heads of sections, the Project Manager will also be assisted by a legal adviser and from time to time by experts on specific subjects.

The Project Manager, who is charged with carrying out the policy of the Project Committee, will administer the project through the heads of four sections, as shown on the organization chart, Fig. IV.1.

b. Water Supply and Drainage Section

The Water Supply and Drainage Section, headed by an Engineer who will be assisted by a team of technicians, as detailed in Table IV.1 will undertake the activities described in paragraph 3-b of this Chapter.

c. Planning and Extension Service

The planning and Extension Service, headed by a senior agronomist with the assistance of a junior agronomist in the field of agricultural planning, training services, and agricultural experimentation, and assisted also by a team of field supervisors who will guide farmers as described in paragraph 3-c of this Chapter.

d. Administration Section

This section will run all administrative services required for the proper operation of the project, including a secretariat, personnel unit and accounting unit. The transportation pool at the disposal of the project and will be responsible for the proper operation and maintenance. One of the main tasks of this section will be handling of credits. The section will draw up credit programmes based on the agricultural planning and marketing and supply forecasts. It will be responsible, after approval by the Project Manager for submitting the credit to the bank and for dealing with all aspects of credit procurement for the farmers.

In view of the vital importance of this subject it is proposed that all credit matters be handled directly by the section head.

In addition, the administration section will be engaged in gathering information on the various project activities and presenting it in the form of periodical reports to the various levels.

e. Supply and Marketing Section

The Supply and Marketing Section which will deal with all commercial and contractual aspects of the relations with suppliers, purchasers and tractor stations.

f. Legal Advisor and Administrative Committee

Apart from the heads of sections, the Project Manager will also be assisted by a legal adviser and from time to time by experts on specific subjects.

An administrative committee, headed by the Project Manager and consisting of the heads of sections and two representatives of the farmers, will serve as a forum for the co-ordination of project management.

g. The Farmers

As stated, the irrigation and cultivation blocks will constitute the units for the purposes of field extension, irrigation and mechanized cultivations. To this end, a number of functionaries will be elected by the farmers from among themselves for the following posts:

- Farmers' activities organizer (leader);
- Irrigation co-ordinator;
- Cultivation activities co-ordinator;
- A number of training group heads (preferably these groups should coincide with the NNCBOA groups)

This body, to be elected for a fixed period, will, in addition to the aforesaid tasks, also act as a Block Council, with the co-ordinator representing it in matters concerning the block as a whole. The agricultural instructor will guide the group in the performance of its tasks. Naturally, his intervention will be at its peak during the initial stages and will gradually decrease until his tasks will be confined to agricultural advice.

6. The Organizational Set-up at the Ultimate Operation Phase

The transition to the ultimate phase must take place gradually and should be managed with utmost care. Excessive speeding-up of the process endanger the achievements of the preceding stage. Although the aim of the ultimate phase is the transfer of the responsibility for agricultural production and management of the supporting services to the farmers themselves, the Ministry of Agriculture, through its various agencies, will continue to supply the planning and extension services and operate the water supply and drainage systems. The management of the supporting services will be in the hands of a farmers' co-operative, to which every farmer in the area will belong. The general meeting of the members will elect three or four farmers to form an Administrative Council, to which the co-ordinators of the agricultural block will be co-opted. The Council will appoint a Co-operative Manager who will receive a salary from the co-operative and will manage the supply and marketing services and the administration. These services, as well as the extension service and the water supply will operate in the same organizational framework as in the preceding phase, except that the organizational subordination will be different.

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As already pointed out, the transition to this phase will be gradual. At the beginning of the process, the various functionaries of the co-operative will be elected, but the central administration by the project management will continue to function and the elected representatives will act as observers attached to the management. This stage will enable the co-operative members to learn about their future tasks, and the management will be able to test their readiness to take over responsibility. Gradually, the Project Management will start transferring the administration of the services to the co-operative, until the latter can ultimately take over.

The organization set-up at the ultimate phase is shown in Fig. H/2.

The activities of the co-operative will be financed out of the monies paid up for their shares by the members who will be granted a special loan for this purpose. This loan will be repaid in the course of a number of years. During the first years of its activities the co-operative may still need financial support by the Ministry of Agriculture, but within a set period it will have to become self-sufficient and finance its activities out of its profits or from members' contributions.

In spite of the autonomous status of the co-operative it is recommended that an auditor and controller be appointed by the Ministry of Agriculture and that during the initial period of its independent activities a representative of the Ministry be a member of the Administrative Committee, at least as an observer.

The organization of agricultural activities within the blocks shall retain the form worked out for the preceding phase.

J. ECONOMIC EVALUATION

1. Introduction

The purpose of the economic evaluation of this project is to appraise the

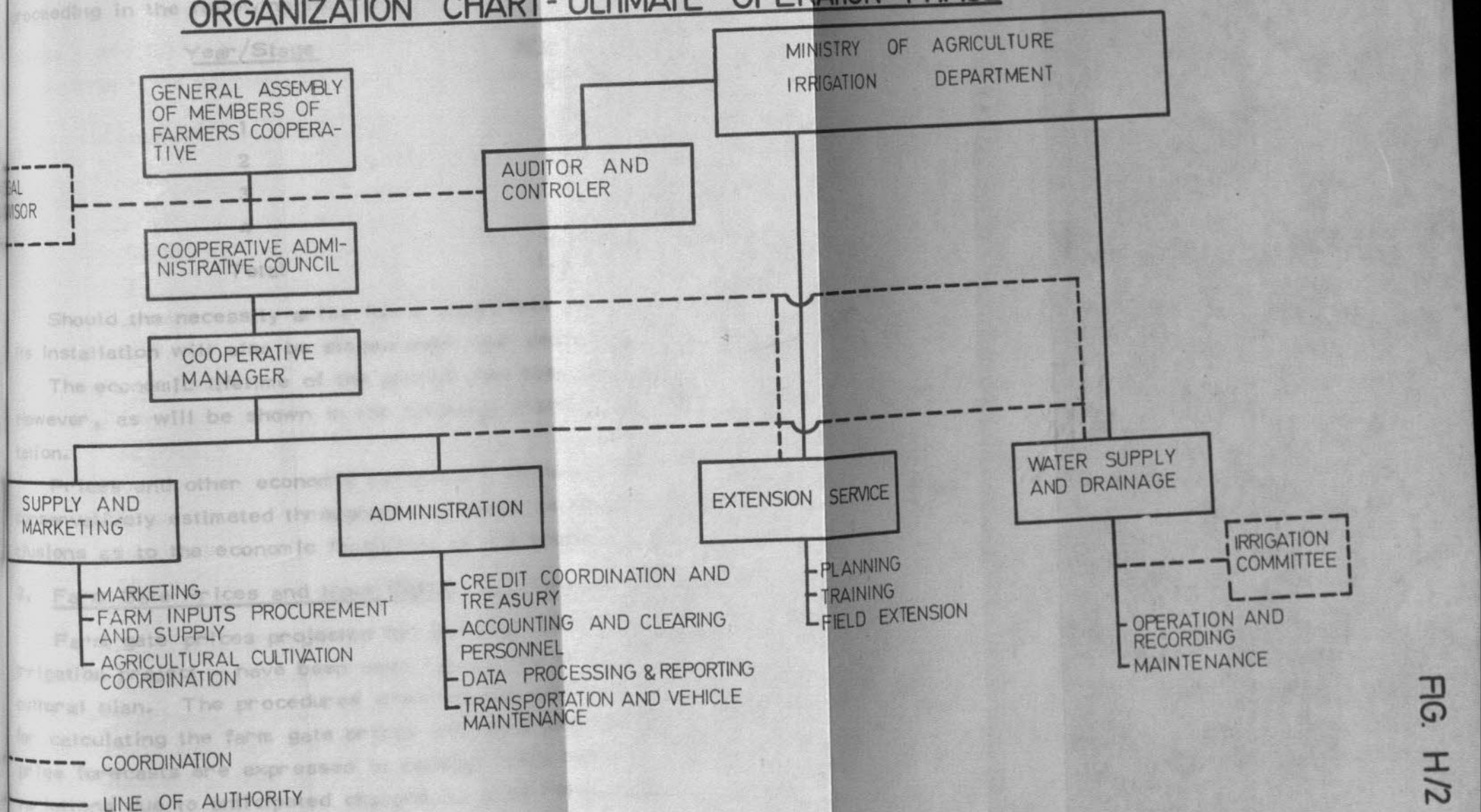
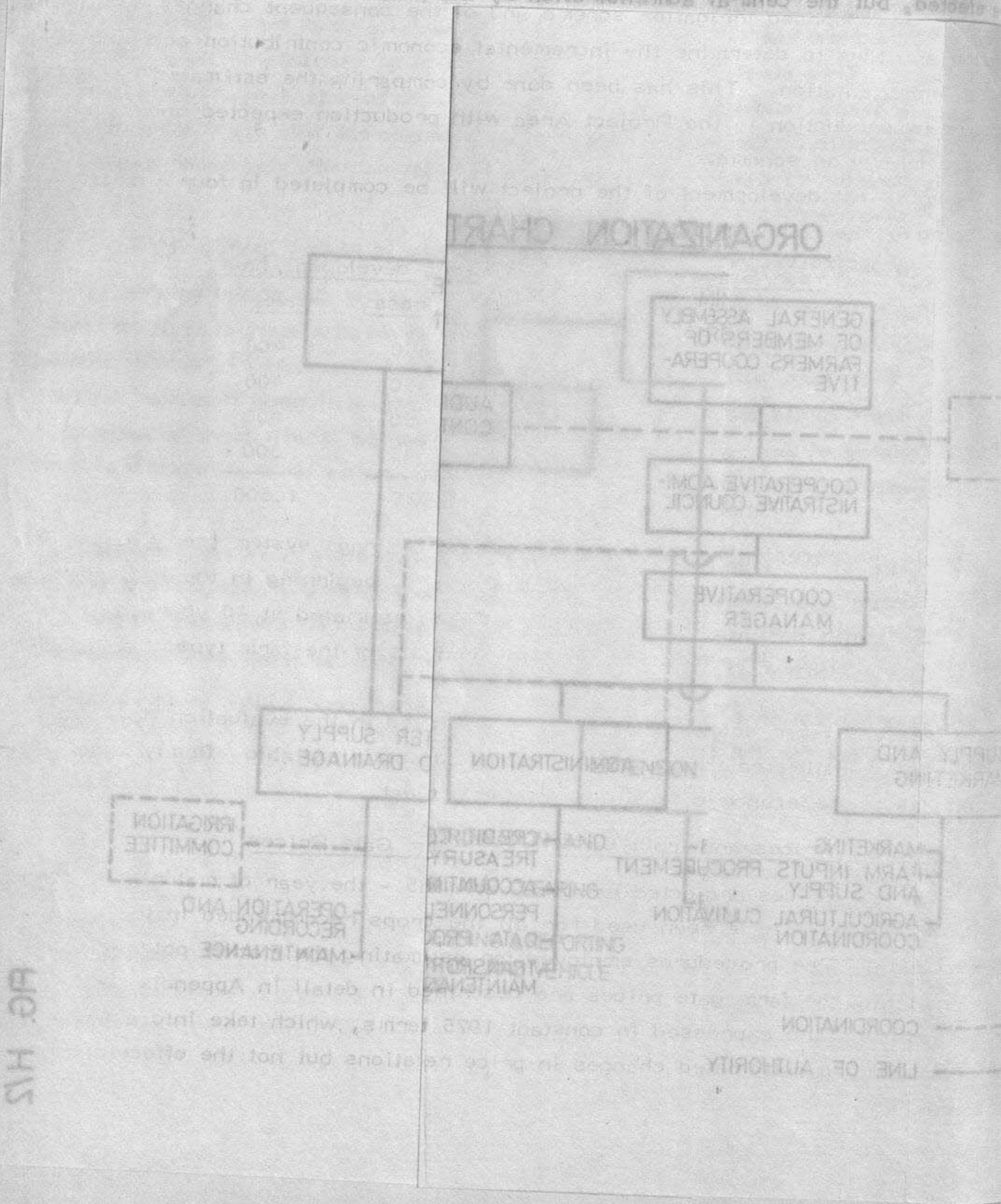


FIG. H/2



J. ECONOMIC EVALUATION

1. Introduction

The purpose of the economic evaluation of this project is to appraise the effects of the proposed irrigation scheme and of the consequent changes in farming practice and thus to determine the incremental economic contribution accruing from project implementation. This has been done by comparing the estimated "natural" increase in production in the Project Area with production expected under the proposed irrigation scheme.

The physical development of the project will be completed in four years, proceeding in the following four stages:

Year/Stage	Area developed, ha	
	Gross	Net
1	460	400
2	460	400
3	460	400
4	345	300
Total	1,725	1,500

Should the necessity arise for a subsurface drainage system (see Chapter G), its installation will also be staged over four years, beginning in the fifth year

The economic lifetime of the project has been estimated at 40 years. However, as will be shown in the financial analysis of the farm types, implementation.

Prices and other economic parameters employed in the evaluation have been conservatively estimated throughout, in order to obtain reliable, firmly based conclusions as to the economic feasibility of the project.

2. Farm Gate Prices and Input Costs (a) Farm Gate Prices

Farm gate prices projected for the year 1985 - the year of maturity of the irrigation project - have been used for all the crops recommended in the agricultural plan. The procedures employed for estimating the market potential and for calculating the farm gate prices are described in detail in Appendix J-1. The price forecasts are expressed in constant 1975 terms, which take into account variations due to anticipated changes in price relations but not the effect of inflation.

6. ECONOMIC EVALUATION

Introduction

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Since the anticipated demand for the crops that will be grown in the project will exceed domestic supplies in Ghana, especially in the Eastern Region, prices in 1985 are likely to be higher than in 1975. Nevertheless, the 1975 price levels have been adopted, in keeping with the conservative conception applied throughout this evaluation, aimed at presenting a realistic assessment of project feasibility.

The prices prevailing in 1975 have been used as the projected farm gate prices for all crops with the exception of rice, which is considered to be an important substitute (see Table J/1). The farm gate price of rice is based on the projected 1985 C.I.F. price calculated from the forecast world market price.

Two of the field crops, maize and groundnuts, are potentially exportable. However, since their forecast export prices - estimated at the official rate of exchange - are lower than the 1975 domestic market prices, the latter were adopted for these crops too as the 1985 farm gate price.

TABLE J/1: FARM GATE PRICES OF PROJECT CROPS

¢/ton

Crop	Farm gate price 1975	Projected farm gate price 1985
Cassava	82	82
Maize	196	196
Groundnuts	476	476
Rice	177	204
Tobacco	1,800	1,800
Tomatoes	264	264
Pepper	1,200	1,200
Eggplants	200	200
Okro	138	138

b. Agricultural Input Costs

The forecast prices of fertilizers have been based on projections of world market prices, because current prices are still distorted by the effects of the oil crisis and they are not expected to remain at their present level. For pesticides the 1975 prices have been used as the projected cost for 1985. Seeds and machinery-hire are subsidized to farmers and for these inputs the 1975 prices have been adopted, but without the subsidies.

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A list of the unit costs of inputs and the cost estimate for fertilizers are presented in Appendix J-2.

3. Project Costs

The investments and O & M costs involved in the implementation of the Weija irrigation Project have been discussed in Chapter F, G and H. This section presents an itemized distribution of these costs over the assumed lifetime of 40 years of the project in local and foreign currencies.

Table J/2 shows that total investments over an 8-year construction period will amount to about ₵17.3 million, including the foreign currency component, totalling US $6.9 million.

Notes to Table J/2:

(1) It is assumed that construction work will take eight years, starting in 1978.

(2) All investment items include contingencies at the rate of 15% and an additional 10% for engineering services and supervision of construction.

(3) The conveyance, irrigation and surface drainage systems will be completed within the first four years of development.

(4) Construction of the subsurface drainage network will begin in the fifth year of development. Costs cover one-half of the Project Area, as explained in Chapter G. Rice lands will have no subsurface drainage.

(5) Investments in on-farm development follow the irrigation development schedule. For rice farms, on-farm investments are included in the cost of the irrigation system.

(6) Investments in infrastructure and supporting facilities are scheduled as follows: 35% in the first year of implementation, 30% in the second year, 25% in the third year and 10% in the fourth year.

(7) The lifetime of the various project components are standards normally adopted in projects of this nature.

(8) The foreign currency components of the investments represent the following proportions of the total:

	%
- Weija Dam	60
- Civil engineering equipment	40
- Electro-mechanical equipment	90
- Irrigation system	35
- Drainage system	40
- On-farm development (sprinkler-irrigated farms)	85
- Infrastructure and supporting facilities	40.

A list of the unit costs of inputs and the cost estimate for fertilizers are presented in Appendix J-2.

Project Costs

The investments and O & M costs involved in the implementation of the Wella Irrigation Project have been discussed in Chapter F, G and H. This section presents an itemized distribution of these costs over the assumed life-time of 40 years of the project in local and foreign currencies.

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- Civil engineering equipment	40
- Electro-mechanical equipment	90
- Irrigation system	35
- Drainage system	40
- On-farm development (sprinkler-irrigated farms)	85
- Infrastructure and supporting facilities	40

TABLE J/2: PROJECT INVESTMENTS

In thousands and U.S. $ thousands

Year	1		2		3		4		5		6		7		8		Total		Life-time of component years
Item	Total 1/	F.C 2/	Total	F.C	Total	F.C	Total	F.C	Total	F.C	Total	F.C	Total	F.C	Total	F.C	Total	F.C	
1. Participation in the cost of Weija Dam	1,040	543															1,040	543	50
2. Feeder works																			
2.1 Intake for Area 1: civil engineering works	637	222															637	222	50
electromechanical equipment	254	199															254	199	20
2.2 Area 2: civil engineering works							412	143									412	143	50
3. Main conveyance systems																			
3.1 Area 1: civil engineering works	1,104	384	947	329	789	274	315	110									3,155	1,097	50
electromechanical equipment	447	350	383	300	320	250	128	100									1,278	1,000	20
3.2 Area 2: civil engineering works							607	211									607	211	50
electromechanical equipment							104	81									104	81	20
4. Irrigation systems																			
4.1 Area 1	1,027	313	1,027	313	1,027	313	343	104									3,424	1,043	40
4.2 Area 2							405	123									405	123	40

1/ Total investment in thousand cedis.

2/ Foreign currency component, in thousand U.S. dollars.

TABLE 4/2: PROJECT INVESTMENTS

In thousands and U.S. $ thousands

Year	1		2		3		4		5		6		7		8		Total		Life of Investment
Item	Total LC	Total FC	Total LC	Total FC	Total LC	Total FC	Total LC	Total FC	Total LC	Total FC	Total LC	Total FC	Total LC	Total FC	Total LC	Total FC	Total LC	Total FC	Years
1. Construction in the case of wells for water supply	1,040	343															1,040	343	50
2. Transmission line for water supply	621	203															621	203	30
3. Main conveyance system	889	289					412	140									1,301	429	30
3.1 Pipeline 12 km	847	279			1,104	364	315	110									2,266	753	30
3.2 Pipeline 15 km	847	279			1,104	364	315	110									2,266	753	30
4. Treatment plant	847	279			1,104	364	315	110									2,266	753	30
4.1 Pipeline 12 km	847	279			1,104	364	315	110									2,266	753	30
4.2 Pipeline 15 km	847	279			1,104	364	315	110									2,266	753	30
5. Distribution system	847	279			1,104	364	315	110									2,266	753	30
5.1 Area 1	847	279			1,104	364	315	110									2,266	753	30
5.2 Area 2	847	279			1,104	364	315	110									2,266	753	30
6. Main conveyance system	847	279			1,104	364	315	110									2,266	753	30
6.1 Area 1	847	279			1,104	364	315	110									2,266	753	30
6.2 Area 2	847	279			1,104	364	315	110									2,266	753	30
7. Total Investment in thousand units*	12,000	3,960			15,456	5,096	4,410	1,540									31,866	10,596	

* Total investment in thousand units.

** Foreign currency component, in thousand U.S.$ units.

TABLE J/2: (CONT'D): PROJECT INVESTMENTS

Year	1		2		3		4		5		6		7		8		Total		Life-time of component years
Item	Total 1/	F.C 2/	Total	F.C	Total	F.C	Total	F.C	Total	F.C	Total	F.C	Total	F.C	Total	F.C	Total	F.C	
5. On-farm development																			
5.1 Area 1	167	124	167	124	167	124	56	40									557	412	12
5.2 Area 2							38	28									38	28	12
6. Drainage works																			
6.1 Area 1: main system	495	172	347	120	148	52											990	344	50
secondary system	623	217	623	217	623	217	209	72									2,078	723	50
subsurface drains									400	122	400	122	400	122	135	41	1,336	407	25
6.2 Area 2: main system							329	114									329	114	50
secondary system							271	95									273	95	50
subsurface drains													182	55			182	55	25
7. Infrastructure and supporting facilities	88	31	75	26	63	22	24	8									250	87	50
Total	5,882	2,555	3,569	1,409	3,137	1,252	3,243	1229	400	122	400	122	582	177	136	41	17,349	6,927	

1/ Total investment, in thousand cedis.

2/ Foreign currency component, in thousand U.S. dollars.

TABLE VII: PROJECT INVESTMENTS (CONTD)

Year	1		2		3		4		5		6		7		8		Total		Life-time of comple-tion years
Item	Total	F.C	Total	F.C	Total	F.C	Total	F.C	Total	F.C	Total	F.C	Total	F.C	Total	F.C	Total	F.C	
5. Construction development	187	154	187	154	187		85	40									459	194	12
5.1 Area 1	852	212	342	120	148		328	28									1,670	388	30
5.2 Area 2			652	212	652		208	72	400	122	400	122	400	122	128	41	2,730	723	50
6. Ordinance workshop																	1,330	407	25
6.1 Area 1: main system							325	114									273	80	50
accountrics drains							2341	82									1e2	55	24
6.2 Area 2: main system																			
accountancy systems																	230	81	50
subcontracts drains and																			
7. Infrastructure & facilities																			
subcontracts																			
Total	5,985	2,565	3,250	1,260	3,148	1,260	3,249	1,260	400	122	400	122	400	122	128	41	17,750	6,902	

1/ Total investment, in thousand US$ dollars.

2/ Foreign currency component, in thousand US$ dollars.

Table J/3 lists the annual operation and maintenance costs of the main project components, including the annual foreign currency outlay, starting in the second year of implementation.

Notes to Table J/3:

(1) Energy costs were estimated as a function of the electricity requirement and the unit cost of electricity. Their increase over the first four years matches the scheduled development of irrigated areas.

(2) O & M costs of the dam were taken at 0.75% of the investments in the Weija Dam.

(3) O & M of the civil engineering works was estimated at 1 % of the corresponding investments.

(4) O & M of the electro-mechanical equipment was estimated at 1.8% of the corresponding investments.

(5) O & M of the irrigation and surface drainage system was estimated at 1 % of the corresponding investments, and that of the subsurface drainage - at 2.5% of the investment.

(6) O & M of the infrastructural and supporting facilities was estimated at 1 % of the investments.

(7) Operators and vehicles, project management and extension services were assessed according to the manpower and vehicle requirements, as described in Chapter H. Co-operative management costs are not included herewith as they are reflected already in the marketing and inputs costs.

(8) The foreign currency components of O & M costs were estimated as the following proportions of the total:

- Energy costs 80%
- All the rest 33%

Table J/4 is a summary of the cost streams - investments in the project, including renewal costs, and O & M - which have been used in the economic evaluation.

4. Project Benefits

The value of project products and input costs are listed in Tables J/5 and J/6, respectively, under the two alternatives: with and without the inclusion of cassava in the cropping plan. The difference between the output values and input costs gives the gross returns and these are shown in Table J/7. This table also gives the corresponding estimated returns that would be attained without implementation of the irrigation scheme. The last two columns of Table J/7 represent the benefit stream, i.e. the incremental income accruing each year as a direct contribution of project implementation (with and without cassava alternative).

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Notes to Table 4/3:

(1) Energy costs were estimated as a function of the electricity requirement and the unit cost of electricity. Their increase over the first four years matches the scheduled development of irrigated areas.

(2) O & M costs of the dam were taken at 0.75% of the investments in the Walla Dam.

(3) O & M of the civil engineering works was estimated at 1% of the corresponding investments.

(4) O & M of the electro-mechanical equipment was estimated at 1.5% of the corresponding investments.

(5) O & M of the irrigation and surface drainage system was estimated at 1% of the corresponding investments, and that of the subsurface drainage at 2.5% of the investment.

(6) O & M of the infrastructural and supporting facilities was estimated at 1% of the investments.

(7) Operators and vehicles, project management and extension services were assessed according to the manpower and vehicle requirements, as described in Chapter H. Co-operative management costs are not included herewith as they are reflected already in the marketing and inputs costs.

(8) The foreign currency components of O & M costs were estimated as the following proportions of the total:

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TABLE J/3: OPERATION AND MAINTENANCE COSTS

in ¢ thousands and U.S. $ thousands

Item	Year								
	1	2	3	4	5	6	7	8	9 onward
1. Participation in Weija Dam		8	8	8	8	8	8	8	8
2. Civil engineering works		17	27	35	44	44	44	44	44
3. Electromechanical equipment		13	20	25	29	29	29	29	29
4. Irrigation system		10	21	31	38	38	38	38	38
5. On-farm development		3	6	9	11	11	11	11	11
6. Surface drainage works		11	21	29	37	37	37	37	37
7. Subsurface drainage works						10	20	35	38
8. Infrastructure and supporting fac.			1	2	2	3	3	3	3
9. Project management and admin.		25	32	49	49	49	49	49	49
10. Operations and vehicles		20	37	51	65	65	65	65	65
11. Extension services		11	22	33	41	41	41	41	41
Sub total 1/	-	119	196	272	325	335	345	360	363
Foreign currency component 2/	-	34	56	78	93	96	99	103	104
12. Energy		11	22	33	38	38	38	38	38
Foreign currency component		8	15	23	26	26	26	26	26
13. Total 1/	-	130	218	305	363	373	383	398	401
Foreign currency component 2/	-	42	71	101	119	122	125	129	130

1/ Total operation and maintenance costs, in thousand Cedis.

2/ Foreign currency component, in thousand U.S. dollars.

TABLE J/3: OPERATION AND MAINTENANCE COSTS

In ¢ thousands and U.S. $ thousands

Item	Year 1	2	3	4	5	6	7	8	9 onward
1. Participation in Wella Dam		8	8	8	8	8	8	8	8
2. Civil engineering works		17	27	35	44	44	44	44	44
3. Electromechanical equipment		13	20	25	29	29	29	29	29
4. Irrigation system		10	21	31	38	38	38	38	38
5. On-farm development		3	6	9	11	11	11	11	11
6. Surface drainage works		11	21	29	37	37	37	37	37
7. Subsurface drainage works						10	20	35	38
8. Infrastructure and supporting fac.			1	2	2	3	3	3	3
9. Project management and adm'n.		25	32	49	49	49	49	49	49
10. Operations and vehicles		20	37	51	65	65	65	65	65
11. Extension services		11	22	33	41	41	41	41	41
Sub total 1/	-	119	196	272	325	335	345	360	363
Foreign currency component 2/	-	34	56	78	93	96	99	103	104
12. Energy		11	22	33	38	38	38	38	38
Foreign currency component		8	15	23	26	26	26	26	26
13. Total 1/	-	130	218	305	363	373	383	398	401
Foreign currency component 2/	-	42	71	101	119	122	125	129	130

1/ Total operation and maintenance costs, in thousand Cedis.

2/ Foreign currency component, in thousand U.S. dollars.

TABLE J/4: SUMMARY OF COST STREAMS

Year	Investments		O & M	
	Total ¢ thousands	F.C U.S thousands	Total ¢ thousands	F.C. U.S. thousands
1	5,882	2,555	-	-
2	3,569	1,429	130	42
3	3,137	1,252	218	71
4	3,243	1,229	305	101
5	400	122	363	119
6	400	122	373	122
7	582	177	383	125
8	136	41	398	129
9	-	-	401	130
10	-	-	401	130
11	-	-	401	130
12	-	-	401	130
13	167	124	401	130
14	167	124	401	130
15	167	124	401	130
16	94	68	401	130
17	-	-	401	130
18	-	-	401	130
19	-	-	401	130
20	-	-	401	130
21	701	549	401	130
22	383	300	401	130
23	320	250	401	130
24	232	181	401	130
25	167	124	401	130
26	167	124	401	130
27	167	124	401	130
28	94	68	401	130
29	-	-	401	130
30	400	122	401	130
31	400	122	401	130
32	582	177	401	130
33	136	41	401	130
34	-	-	401	130
35	-	-	401	130
36	-	-	401	130
37	167	124	401	130
38	167	124	401	130
39	167	124	401	130
40	94	68		

TABLE 4A: SUMMARY OF COST ESTIMATES

Year	Investments		O & M	
	Total ₡ thousands	F.C. U.S. thousands	Total ₡ thousands	F.C. U.S. thousands
1	5,882	2,555	-	-
2	3,569	1,429	130	42
3	3,137	1,252	218	71
4	3,243	1,229	305	101
5	400	122	383	119
6	400	122	373	122
7	582	177	383	125
8	136	41	398	129
9	-	-	401	130
10	-	-	401	130
11	-	-	401	130
12	-	-	401	130
13	167	124	401	130
14	167	124	401	130
15	167	124	401	130
16	94	68	401	130
17	-	-	401	130
18	-	-	401	130
19	-	-	401	130
20	-	-	401	130
21	701	549	401	130
22	383	300	401	130
23	320	250	401	130
24	232	181	401	130
25	167	124	401	130
26	167	124	401	130
27	167	124	401	130
28	94	68	401	130
29	-	-	401	130
30	400	122	401	130
31	400	122	401	130
32	582	177	401	130
33	136	41	401	130
34	-	-	401	130
35	-	-	401	130
36	-	-	401	130
37	167	124	401	130
38	167	124	401	130
39	167	124	401	130
40	94	68	401	130

TABLE J/5: VALUE OF PROJECT OUTPUT BY YEARS AND STAGES OF DEVELOPMENT

¢ thousands

Year	Stage 1	Stage 2	Stage 3	Stage 4	Total
A. With Cassava Alternative					
1	1,132.81	-	-	-	1,132.81
2	1,497.97	1,132.81	-	-	2,630.78
3	1,887.31	1,497.97	1,132.81	-	4,518.09
4	2,297.81	1,887.31	1,497.97	668.17	6,351.26
5	2,671.50	2,297.81	1,887.31	878.23	7,734.85
6	2,780.12	2,671.50	2,297.81	1,101.00	8,850.43
7	2,780.12	2,780.12	2,671.50	1,334.87	9,566.61
8	2,780.12	2,780.12	2,780.12	1,549.42	9,889.78
9 onward	2,780.12	2,780.12	2,780.12	1,624.80	9,965.16
B. Without Cassava Alternative					
1	1,128.90	-	-	-	1,128.90
2	1,476.29	1,128.90	-	-	2,605.19
3	1,863.67	1,476.29	1,128.90	-	4,468.86
4	2,264.56	1,863.67	1,476.29	666.11	6,270.63
5	2,624.74	2,264.56	1,863.67	866.85	7,619.82
6	2,700.66	2,624.74	2,264.56	1,088.59	8,678.55
7	2,700.66	2,700.66	2,624.74	1,317.41	9,343.47
8	2,700.66	2,700.66	2,700.66	1,524.87	9,626.85
9 onward	2,700.66	2,700.66	2,700.66	1,585.09	9,685.07

Note: The four stages, relate to successive portions of the Project Area that will be incorporated from the first to the fourth year of development. Subsequent increases in output demonstrate the maturation process of the respective portion.

TABLE 6/5: VALUE OF PROJECT OUTPUT BY YEARS AND STAGES OF DEVELOPMENT

(¢ thousands)

Year	Stage 1	Stage 2	Stage 3	Stage 4	Total
A. With Cassava Alternative					
1	1,132.81	-	-	-	1,132.81
2	1,497.97	1,132.81	-	-	2,630.78
3	1,867.31	1,497.97	1,132.81	-	4,498.09
4	2,297.81	1,867.31	1,497.97	866.17	6,529.26
5	2,671.50	2,297.81	1,867.31	858.25	7,734.87
6	2,780.12	2,671.50	2,297.81	1,101.06	8,850.49
7	2,780.12	2,780.12	2,671.50	1,338.87	9,568.61
8	2,780.12	2,780.12	2,780.12	1,549.42	9,889.78
9 onward	2,780.12	2,780.12	2,780.12	1,624.80	9,965.16
B. Without Cassava Alternative					
1	1,128.90	-	-	-	1,128.90
2	1,476.29	1,128.90	-	-	2,605.19
3	1,863.67	1,476.29	1,128.90	-	4,468.86
4	2,264.56	1,863.67	1,476.29	866.11	6,370.63
5	2,624.74	2,264.56	1,863.67	866.85	7,619.82
6	2,700.66	2,624.74	2,264.56	1,088.59	8,678.53
7	2,700.66	2,700.66	2,624.74	1,317.41	9,343.47
8	2,700.66	2,700.66	2,700.66	1,524.07	9,626.05
9 onward	2,700.66	2,700.66	2,700.66	1,585.09	9,685.07

Note: The four stages relate to successive portions of the Project Area that will be incorporated from the first to the fourth year of development. Subsequent increases in output demonstrate the maturation process of the respective portion

TABLE J/6: INPUT COSTS BY YEARS AND STAGES OF DEVELOPMENT

¢ thousands

Year	Stage 1	Stage 2	Stage 3	Stage 4	Total
A. With Cassava Alternative					
1	448.54	-	-	-	448.54
2	505.96	448.54	-	-	954.50
3	561.25	505.96	448.54	-	1,515.75
4	616.72	561.25	505.96	315.36	1,999.29
5	671.83	616.72	561.25	354.63	2,204.43
6	671.83	671.83	671.83	392.90	2,446.51
7	671.83	671.83	671.83	431.02	2,446.51
8	671.83	671.83	671.83	469.07	2,484.56
9 onward	671.83	671.83	671.83	469.07	2,484.56
B. Without Cassava Alternative					
1	449.78	-	-	-	449.78
2	505.48	449.78	-	-	955.21
3	558.76	505.43	449.78	-	1,513.97
4	612.27	558.76	505.43	316.01	1,992.47
5	665.43	612.27	558.76	354.35	2,190.81
6	665.43	665.43	612.27	391.59	2,334.72
7	665.43	665.43	665.43	428.68	2,424.97
8	665.43	665.43	665.43	465.71	2,462.00
9 onward	665.43	665.43	665.43	465.71	2,462.00

Note: The four stages relate to successive portions of the Project Area that will be incorporated from the first to the fourth year of development. Subsequent increases in input costs demonstrate the maturation process of the respective portion.

TABLE J/6: INPUT COSTS BY YEARS AND STAGES OF DEVELOPMENT

₡ thousands

Year	Stage 1	Stage 2	Stage 3	Stage 4	Total
A. With Cassava Alternative					
1	448.54	-	-	-	448.54
2	505.96	448.54	-	-	954.50
3	561.25	505.96	448.54	-	1,515.75
4	616.72	561.25	505.96	315.36	1,999.29
5	671.83	616.72	561.25	354.83	2,204.43
6	671.83	671.83	671.83	392.90	2,446.51
7	671.83	671.83	671.83	431.02	2,446.51
8	671.83	671.83	671.83	469.07	2,484.56
9 onward	671.83	671.83	671.83	469.07	2,484.56
B. Without Cassava Alternative					
1	449.78	-	-	-	449.78
2	505.48	449.78	-	-	955.27
3	558.76	505.43	449.78	-	1,513.97
4	612.27	558.76	505.43	316.01	1,992.47
5	665.43	612.27	558.76	354.35	2,190.81
6	665.43	665.43	612.27	391.59	2,334.72
7	665.43	665.43	665.43	428.60	2,424.97
8	665.43	665.43	665.43	465.71	2,462.00
9 onward	665.43	665.43	665.43	465.71	2,462.00

Note: The four stages relate to successive portions of the Project Area that will be incorporated from the first to the fourth year of development. Subsequent increases in input costs demonstrate the maturation process of the respective portion.

TABLE J/7: OUTPUT VALUES, INPUT COSTS AND GROSS RETURNS, WITH AND WITHOUT PROJECT IMPLEMENTATION AND BENEFITS OF THE PROJECT

¢ thousands

Year	WITH PROJECT IMPLEMENTATION						WITHOUT PROJECT			BENEFITS	
	Output value		Input cost		Gross returns		Output value	Input costs	Gross returns	With cassava	Without cassava
	With cassava	Without cassava	With cassava	Without cassava	With cassava	Without cassava					
1	1,132.81	1,128.90	448.54	449.78	684.27	679.12	1,629.38	307.14	330.56 1/	353.71	348.56
2	2,630.78	2,605.19	954.50	955.21	1,676.28	1,649.98	1,741.73	311.58	715.07 1/	961.21	934.91
3	4,518.09	4,468.86	1,515.75	1,513.97	3,002.34	2,954.89	1,829.89	316.02	1,513.87	1,488.47	1,441.02
4	6,351.26	6,270.63	1,999.29	1,992.47	4,351.97	4,278.16	1,895.88	318.94	1,576.94	2,775.03	2,701.22
5	7,734.85	7,619.82	2,204.43	2,190.81	5,530.42	5,429.01	1,994.05	321.85	1,672.20	3,858.22	3,756.81
6	8,850.43	8,678.55	2,353.28	2,334.72	6,497.15	6,343.83	2,039.30	326.29	1,713.01	4,784.14	4,630.82
7	9,566.61	9,343.47	2,446.51	2,424.97	7,120.10	6,918.50	2,049.71	330.72	1,718.99	5,401.11	5,199.51
8	9,889.78	9,626.85	2,484.56	2,462.00	7,405.22	7,164.85	2,055.15	333.61	1,721.54	5,683.68	5,443.31
9 onward	9,965.16	9,685.07	2,484.56	2,462.00	7,480.60	7,223.07	2,064.92	338.09	1,726.83	5,753.77	5,496.24

1/ Adjusted to one-fourth in the first year and one-half in the second year, corresponding to the "with project" development of irrigated areas.

TABLE 4/7: OUTPUT VALUES, INPUT COSTS AND GROSS RETURNS, WITH AND WITHOUT PROJECT IMPLEMENTATION AND BENEFITS OF THE PROJECT

₡ thousands

Year	WITH PROJECT IMPLEMENTATION						WITHOUT PROJECT		BENEFITS	
	Output Value		Input cost		Gross returns		Output value	Input costs	Gross returns	With cassava
	With cassava	Without cassava	With cassava	Without cassava	With cassava	Without cassava				Without cassava
1	1 122.81	1 138.89	446.54	446.78	676.27	692.11	1 029.36	307.14	722.22	353.71
2	2 630.78	2 602.19	936.30	835.21	1 694.48	1 766.98	1 941.73	311.58	1 630.15	971.21
3	4 518.09	4 468.66	1 816.75	1 813.87	2 702.34	2 654.79	1 829.80	316.02	1 513.78	1 688.87
4	6 251.28	6 270.63	1 809.29	1 888.47	4 441.99	4 381.16	1 888.88	318.04	1 570.84	1 576.94
5	7 734.83	7 818.83	2 204.43	2 190.81	5 530.42	5 628.01	1 904.05	321.88	1 582.17	1 672.20
6	8 850.43	8 978.55	2 353.26	2 334.72	6 497.15	6 643.83	2 038.30	325.20	1 712.01	1 713.09
7	9 568.61	9 743.47	2 446.51	2 434.87	7 120.10	6 918.50	2 060.71	330.72	1 718.39	1 729.81
8	9 889.78	9 828.85	2 484.56	2 483.00	7 405.22	7 164.68	2 085.13	333.61	1 751.54	1 853.08
9 onward	9 965.16	9 985.07	2 484.56	2 482.00	7 480.60	7 283.07	2 064.02	339.06	1 728.83	1 753.77

1/ Adjusted to one-fourth in the first year and one-half in the second year, corresponding to the "with project" development of irrigated areas.

5. Economic Appraisal of the Project

a. Analysis of the Basic Plan

In this analysis, three commonly employed criteria have been adopted for measuring the economic contribution of irrigation development:

- Internal rate of return
- Benefit-cost ratio
- Net present value

The application of several analytical parameters makes it possible to shed light on the economic characteristics of the project from different perspectives. Thus, the benefit-cost ratio and the internal rate of return - which gives a measure of the break-even rate of return of the investment - appraise the project as a separate entity. On the other hand, establishment of the present value of income arising in the future - through discounting it at a rate of interest equivalent to the rate of which it could be invested - enables the planner to compare project performance with the performance of similar projects.

The economic analysis evaluates direct project benefits, i.e. all returns from farm operations, and not the secondary or intangible benefit flows.

The results of the analysis, presented in Table J/8, show an internal rate of return of 20.8% and 20.1% for "with" and "without cassava" alternative, respectively. At a 13% discount rate the corresponding benefit-cost ratios for "with" and "without cassava" alternatives are 1.67 and 1.60 and the net present values: ¢11.6 million and ¢10.4 million.

TABLE J/8: INTERNAL RATE OF RETURN, BENEFIT-COST RATIO AND NET PRESENT VALUE

Crop Alternative	Internal rate of return %	Discount rate %	Benefit-cost ratio	Net present value ¢ millions
"With cassava		10	2.12	21.2
		13	1.67	11.6
		15	1.44	7.3
	20.8			
"Without cassava		10	2.03	19.6
		13	1.60	10.4
		15	1.39	6.4
	20.1			

5. Economic Appraisal of the Project

a. Analysis of the Basic Plan

In this analysis, three commonly employed criteria have been adopted for measuring the economic contribution of irrigation development:

- Internal rate of return
- Benefit-cost ratio
- Net present value

The application of several analytical parameters makes it possible to shed light on the economic characteristics of the project from different perspectives. Thus, the benefit-cost ratio and the internal rate of return - which gives a measure of the break-even rate of return of the investment - appraise the project as a separate entity. On the other hand, establishment of the present value of income arising in the future - through discounting it at a rate of interest equivalent to the rate of which it could be invested - enables the planner to compare project performance with the performance of similar projects.

The economic analysis evaluates direct project benefits; i.e. all returns from farm operations, and not the secondary or intangible benefit flows.

The results of the analysis, presented in Table 1/8, show an internal rate of return of 20.8% and 20.1% for "with" and "without cassava" alternative, respectively. At a 13% discount rate the corresponding benefit-cost ratios for "with" and "without cassava" alternatives are 1.67 and 1.60 and the net present values: ₲11.6 million and ₲10.4 million.

TABLE 1/8: INTERNAL RATE OF RETURN, BENEFIT-COST RATIO AND NET PRESENT VALUE

Crop Alternative	Internal rate of return %	Discount rate %	Benefit-cost ratio	Net present value ₲ millions
"With cassava	20.8	10	2.12	21.2
		13	1.67	11.6
		15	1.41	7.3
"Without cassava	20.1	10	2.03	19.6
		13	1.60	10.4
		15	1.39	6.4

b. Sensitivity Tests

Six sensitivity tests were carried out in order to measure the impact of possible divergences in the cost and benefit streams on the economic feasibility of the project. The results of these tests, summarized in Table J/9, show the effect of the following deviations from the basic assumptions:

1. All investment and O & M costs increased by 10%
2. All investments and O & M costs increased by 20%
3. All investments and O & M costs increased by 30%
4. Benefits declined by 10%
5. Benefits declined by 20%
6. Benefits declined by 30%

In tests 1, 2 and 3, benefits remain at the basic level and in tests 4, 5 and 6, costs remain at the basic level.

TABLE J/9: RESULTS OF SIX SENSITIVITY TESTS

Economic parameter	Discount rate %	Sensitivity test					
		1	2	3	4	5	6
A. "With Cassava" Alternative							
Internal rate of return, %		19.1	17.0	16.6	18.9	17.1	15.1
Benefit-cost ratio	10	1.92	1.76	1.63	1.90	1.69	1.48
	13	1.52	1.39	1.28	1.50	1.33	1.17
	15	1.31	1.20	1.11	1.30	1.15	1.01
Net present value, ¢ million	10	19.3	17.4	15.5	17.2	13.2	9.1
	13	9.8	8.1	6.4	8.7	5.8	2.9
	15	5.7	4.0	2.3	4.9	2.5	0.1
B. "Without Cassava" Alternative							
Internal rate of return, %		18.5	17.2	16.0	18.4	16.6	14.6
Benefit-cost ratio	10	1.85	1.69	1.56	1.83	1.62	1.42
	13	1.45	1.33	1.23	1.44	1.28	1.12
	15	1.26	1.15	1.07	1.25	1.11	0.97
Net present value, ¢ million	10	17.7	15.8	13.9	15.7	11.9	8.0
	13	8.7	7.0	5.2	7.7	4.9	2.1
	15	4.7	3.1	1.6	4.1	1.8	0.5

b. Sensitivity Tests

Six sensitivity tests were carried out in order to take account of possible divergences in the cost and benefit streams on which the profitability of the project. The results of these tests, summarized in Table 9/9, show the effect of the following deviations from the basic assumptions:

1. All investment and O & M costs increased by 10%
2. All investments and O & M costs increased by 20%
3. All investments and O & M costs increased by 30%
4. Benefits declined by 10%
5. Benefits declined by 20%
6. Benefits declined by 30%

In tests 1, 2 and 3, benefits remain at the basic level and in tests 4, 5 and 6, costs remain at the basic level.

TABLE 9/9: RESULTS OF SIX SENSITIVITY TESTS

Economic parameter	Discount rate %	Sensitivity test					
		1	2	3	4	5	6
A. "With Cassava" Alternative							
Internal rate of return, %		19.1	17.0	15.6	16.9	17.1	15.1
Benefit-cost ratio	10	1.92	1.76	1.63	1.90	1.78	1.68
	13	1.82	1.69	1.58	1.80	1.73	1.67
	15	1.71	1.60	1.51	1.70	1.65	1.61
Net present value, C million	10	19.3	17.4	15.5	17.2	15.2	13.1
	13	9.8	8.1	6.4	8.7	6.6	4.9
	15	5.7	4.0	2.3	4.9	2.5	0.1
B. "Without Cassava" Alternative							
Internal rate of return, %		18.5	17.2	15.6	16.4	16.8	14.6
Benefit-cost ratio	10	1.95	1.80	1.67	1.89	1.81	1.72
	13	1.86	1.73	1.62	1.84	1.78	1.72
	15	1.76	1.65	1.57	1.75	1.71	1.67
Net present value, C million	10	17.7	15.9	14.2	15.7	13.9	12.0
	13	9.2	7.6	6.2	7.7	6.4	5.1
	15	4.7	3.1	1.6	4.1	1.3	0.5

The sensitivity analyses show that even in the event of a 30 percent increase in project costs or a 30 percent drop in benefits the project would still be economically feasible, at the 13 percent interest rate adopted in this study (see Appendix J-2, Section 3 for calculation of the shadow rate of interest).

c. Foreign Exchange Benefits

Of the crops recommended in the agricultural plan, two - rice and tobacco - are import substitutes and another two - maize and groundnuts - are potentially exportable commodities. In estimating the foreign exchange contribution of these products, Table J/10 lists the revenues and Table J/11 the inputs in US dollars, using C.I.F. prices for import substitutes and F.O.B. prices for export products. It will be seen that the added value in foreign exchange amounts to $662,000 in the "with cassava" alternative and to 985,000 in the "without cassava" alternative.

TABLE J/10: FOREIGN EXCHANGE VALUE OF IMPORT SUBSTITUTE AND EXPORTABLE CROPS

Crop	Area ha	Yield ton/ha	Production	1985 FOB/CIF price 1/ US$/ton	Foreign exchange value, US $ thousands
With Cassava Alternative					
Rice	180	4.5	810	233	189
Tobacco	282	1.4	395	1,360	537
Maize	282	3.5	987	105	104
Groundnuts	563	2.5	1,408	345	486
Total					1,316
Without Cassava Alternative					
Rice	180	4.5	810	233	189
Tobacco	282	1.4	395	1,360	537
Maize	564	3.5	1,971	105	207
Groundnuts	845	2.5	2,113	345	729
Total					1,662

1/ In 1975 constant prices.

The sensitivity analyses show that even in the event of a 30 percent increase in project costs or a 30 percent drop in benefits the project would still be economically feasible, at the 13 percent interest rate adopted in this study (see Appendix J-2, Section 3 for calculation of the shadow rate of interest).

c. Foreign Exchange Benefits

Of the crops recommended in the agricultural plan, two - rice and tobacco - are import substitutes and another two - maize and groundnuts - are potentially exportable commodities. In estimating the foreign exchange contribution of these products, Table J/10 lists the revenues and Table J/11 the inputs in US dollars, using C.I.F. prices for import substitutes and F.O.B. prices for export products. It will be seen that the added value in foreign exchange amounts to $662,000 in the "with cassava" alternative and to 965,000 in the "without cassava" alternative.

TABLE J/10: FOREIGN EXCHANGE VALUE OF IMPORT SUBSTITUTE AND EXPORTABLE CROPS

Crop	Area ha	Yield ton/ha	Production	1985 FOB/CIF price 1/ US$/ton	Foreign exchange value, US $ thousands
With Cassava Alternative					
Rice	180	4.5	810	233	189
Tobacco	202	1.4	395	1,360	537
Maize	282	3.5	987	105	104
Groundnuts	563	2.5	1,408	345	486
Total					1,316
Without Cassava Alternative					
Rice	180	4.5	810	233	189
Tobacco	282	1.4	395	1,360	537
Maize	564	3.5	1,971	105	207
Groundnuts	845	2.5	2,113	345	729
Total					1,662

1/ In 1975 constant prices.

TABLE J/11: FOREIGN EXCHANGE COMPONENT OF INPUT COSTS

Crop	Area ha	Input costs 1/ ¢/ha	Total input costs ¢ thousands	Foreign exchange component 2/	
				¢ thousands	US $ thousands
With Cassava Alternative					
Rice	180	217	39	27	23
Groundnuts	563	168	95	67	58
Maize	282	188	53	37	32
Tobacco	282	204	58	41	36
Tomatoes	503	620	312	218	190
Pepper	345	450	155	109	95
Eggplants	63	470	30	21	18
Okro	218	254	55	39	34
Cassava	282	220	62	43	37
O & M					131
Total					654
Without Cassava Alternative					
Rice	180	217	39	27	23
Groundnuts	845	168	142	99	86
Maize	564	188	106	74	64
Tobacco	282	204	58	41	36
Tomatoes	503	620	312	218	190
Pepper	345	450	155	109	95
Eggplants	63	470	30	21	18
Okro	218	254	55	39	34
O & M					131
Total					677

1/ Costs of fertilizers, pesticides and machinery.

2/ Calculated at 70% of the input cost.

Foreign exchange contribution of the project in US $:

	With cassava	Without cassava
Value of products	1,316,000	1,662,000
Inputs in foreign currency	654,000	677,000
Added value	662,000	985,000

TABLE 3/11: FOREIGN EXCHANGE COMPONENT OF INPUT COSTS

Crop	Area	Input cost1/	Total input cost	Foreign exchange component2/	
	ha	¢/ha	¢ thousands	¢ thousands	US $ thousands
With Cassava Alternative					
Rice	180	217	39	27	23
Groundnuts	563	168	95	69	58
Maize	282	188	53	37	32
Tobacco	282	204	58	41	36
Tomatoes	503	620	312	218	190
Pepper	345	450	155	109	95
Eggplants	63	470	30	21	18
Okro	218	254	55	39	34
Cassava	282	220	62	43	37
C & M					131
Total					694
Without Cassava Alternative					
Rice	180	217	39	27	23
Groundnuts	845	168	142	99	86
Maize	564	188	106	74	64
Tobacco	282	204	58	41	36
Tomatoes	503	620	312	218	190
Pepper	345	450	155	109	95
Eggplants	63	470	30	21	18
Okro	218	254	55	39	34
C & M					131
Total					677

1/ Costs of fertilizers, pesticides and machinery.

2/ Calculated at 70% of the input cost.

Foreign exchange contribution of the project in US $:

	With cassava	Without cassava
Value of products	1,316,000	1,662,000
Inputs in foreign currency	654,000	677,000
Added value	662,000	985,000

6. Financial Analysis of the Farm Types

a. General

Whereas the economic analysis of the project deals with its overall feasibility, the financial analysis evaluates future farm-level cash flows for the various farm types described in the agricultural plan. Output prices assumed here are as forecast for the year 1985 in the project's economic analysis.

As family labour has no weight in the cash flow, no cost was assigned to this item as an input. However, funds have been allotted for family allowance, to cater for the support of the family, and this may legitimately be considered renumeration for family labour. The family allowance is considered an integral part of farm expenses, since the well-being of the family should be assured before the farm's payment ability can be determined.

The inputs include water charges in the form of operation and maintenance costs at the fully operational stage of the project.

The fixed component of project investment reimbursement was not included in the financial analysis, because the decision as to how the financial burden of the project investment is to be shared between the farmers and the State rests with the Government. However, the item "net cash flow" gives an indication of the ability of each farm to contribute to the reimbursement of project investments and can also be of help in the formulation of a taxation policy[1/].

The three representative farm types for which the projections were made were those discussed in the agricultural plan, namely:

- Two mixed farm types - one with and one without cassava, occupying 2.5 ha each (2.25 ha net) - typifying the holdings in all of Area No.1 and in part of Area No.2;
- A 5-ha rice farm, as the representative farm type proposed for part of Area No.2 only.

The planned crop areas and estimated budgets of the three farm types are represented in Tables E/5 and E/6, respectively, in Chapter E.

1/ At present, farmers pay no income tax.

8. Financial Analysis of the Farm Types

a. General

Whereas the economic analysis of the project deals with its overall feasibility, the financial analysis evaluates future farm-level cash flows for the various farm types described in the agricultural plans. Output prices assumed here are as forecast for the year 1985 in the project's economic analysis.

As family labour has no weight in the cash flow, no cost was assigned to this item as an input. However, funds have been allotted for family allowances to cater for the support of the family, and this may legitimately be considered remuneration for family labour. The family allowance is considered an integral part of farm expenses, since the well-being of the family should be assured before the farm's payment ability can be determined.

The inputs include water charges in the form of operation and maintenance costs at the fully operational stage of the project.

The fixed component of project investment reimbursement was not included in the financial analysis, because the decision as to how the financial burden of the project investment is to be shared between the farmers and the State rests with the Government. However, the item "net cash flow" gives an indication of the ability of each farm to contribute to the reimbursement of project investments and can also be of help in the formulation of a taxation policy[1].

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- A 5-ha rice farm, as the representative farm type proposed for part of Area No.2 only.

The planned crop areas and estimated budgets of the three farm types are represented in Tables E/5 and E/6, respectively, in Chapter E.

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[1] At present, farmers pay no income tax.

b. Results of the Analysis

(1) Representative Mixed Farm Types - Table J/12

The net cash flow reaches a steady state in the sixth year of development, both for the "with cassava" and "without Cassava" alternatives. These two farm types show positive cash flow balances from the very beginning. Indeed, the net cash flow figures of ¢2,768 in the first year and C ¢11,177 in the sixth year (with cassava) and ¢2,717 and ¢10,727 respectively (without cassava)- are well above the allowance of ¢1,300 for the family.

(2) Representative Rice Farm Type - Table J/13

Here too the net cash flow reaches a steady state in the sixth year, but the cash flow balance is negative during the initial two years. The net cash flow obtained ranges from ¢635 in the first year to the positive value of ¢2,200 obtained at the steady state stage and is considerably below the cash flow accruing from the mixed farm types.

TABLE J/12: FINANCIAL ANALYSIS OF THE REPRESENTATIVE MIXED FARM TYPES

¢

Item \ Year	1	2	3	4	5	6 onward
"WITH CASSAVA" ALTERNATIVE						
A. Funds						
1. Value of production	(6,372)	8,426	10,616	12,925	15,027	15,638
2. Revolving fund loan	2,178	2,377	2,560	2,746	2,990	2,990
Total funds	8,550	10,803	13,176	15,671	18,017	18,628
B. Use of Funds						
1. Inputs	(2,184)	(2,381)	(2,566)	(2,752)	(2,997)	(2,997)
- Purchased Inputs	1,610	1,789	1,957	2,126	2,294	2,294
- Contingencies, 10%	161	179	196	213	229	229
- O & M	413	413	413	413	474	474
2. Loan reimbursement	2,298	2,507	2,701	2,897	3,154	3,154
3. Family allowance	1,300	1,300	1,300	1,300	1,300	1,300
Total use of funds	5,782	6,188	6,567	6,949	7,451	7,451
Net cash flow (A-B)	2,768	4,615	6,609	8,722	10,566	11,177

b. Results of the Analysis

(1) Representative Mixed Farm Types - Table 4/12

The net cash flow reaches a steady state in the sixth year of development, both for the "with cassava" and "without Cassava" alternatives. These two farm types show positive cash flow balances from the very beginning. Indeed, the net cash flow figures of ₵2,768 in the first year and C ₵11,177 in the sixth year (with cassava) and ₵2,717 and ₵10,727 respectively (without cassava) are well above the allowance of ₵1,300 for the family.

(2) Representative Rice Farm Type - Table 4/13

Here too the net cash flow reaches a steady state in the sixth year, but the cash flow balance is negative during the initial two years. The net cash flow obtained ranges from ₵635 in the first year to the positive value of ₵2,200 obtained at the steady state stage and is considerably below the cash flow accruing from the mixed farm types.

TABLE 4/12: FINANCIAL ANALYSIS OF THE REPRESENTATIVE MIXED FARM TYPES

₵

Item \ Year	1	2	3	4	5	6 onward
"WITH CASSAVA" ALTERNATIVE						
A. Funds						
1. Value of production	(6,372)	8,426	10,616	12,925	15,027	15,638
2. Revolving fund loan	2,178	2,377	2,560	2,746	2,900	2,990
Total funds	8,550	10,803	13,176	15,671	18,017	18,628
B. Uses of Funds						
1. Inputs	(2,184)	(2,381)	(2,566)	(2,752)	(2,907)	(2,997)
- Purchased inputs	1,610	1,759	1,957	2,126	2,294	2,294
- Contingencies, 10%	161	179	196	213	229	229
- O & M	413	413	413	413	474	474
2. Loan reimbursement	2,298	2,507	2,701	2,832	3,184	3,184
3. Family allowance	1,300	1,300	1,300	1,300	1,300	1,300
Total use of funds	5,782	6,188	6,567	6,949	7,451	7,481
Net cash flow (A-B)	2,768	4,615	6,609	8,722	10,566	11,177

TABLE J/12 (CONT'D) FINANCIAL ANALYSIS OF THE REPRESENTATIVE MIXED FARM TYPES

¢

Item \ Year	1	2	3	4	5	6 onward
WITHOUT CASSAVA ALTERNATIVE						
A. Funds						
1. Value of production	6,350	8,304	10,483	12,738	14,764	15,191
2. Revolving fund loan	2,206	2,395	2,575	2,756	2,992	2,992
Total funds	8,556	10,699	13,058	15,494	17,756	18,183
B. Use of Funds						
1. Inputs	(2,212)	(2,401)	(2,581)	(2,762)	(2,999)	(2,999)
- Purchased inputs	1,635	1,807	1,971	2,135	2,295	2,295
- Contingencies, 10%	164	181	197	214	230	230
- O & M	413	413	413	413	474	474
2. Loan reimbursement	2,327	2,527	2,717	2,908	3,157	3,157
3. Family allowance	1,300	1,300	1,300	1,300	1,300	1,300
Total use of funds	5,839	6,228	6,598	6,970	7,456	7,456
Net Cash Flow (A-B)	2,717	4,471	6,460	8,524	10,300	10,727

TABLE J/13: FINANCIAL ANALYSIS OF THE REPRESENTATIVE RICE FARM TYPE

¢

Item \ Year	1	2	3	4	5	6 onward
A. Funds						
1. Value of production	3,672	4,590	5,508	6,426	7,344	8,262
2. Revolving fund loan	2,945	3,221	3,703	4,153	4,609	4,609
Total funds	6,617	7,811	9,211	10,579	11,953	12,871
B. Use of Funds						
1. Inputs	(2,845)	(3,141)	(3,603)	(4,053)	(4,509)	(4,509)
- Purchase Inputs	2,086	2,244	2,406	2,558	2,715	2,715
- Hired labour	-	112	369	626	884	884
- Contingencies, 10%	209	235	278	319	360	360
- O & M	550	550	550	550	550	550
2. Loan reimbursement	3,107	3,398	3,907	4,381	4,862	4,862
3. Family allowance	1,300	1,300	1,300	1,300	1,300	1,300
Total use of funds	7,252	7,839	8,810	9,734	10,671	10,671
Net Cash Flow (A-B)	-635	-28	401	845	1,282	2,200

TABLE 4/12 (CONT'D) FINANCIAL ANALYSIS OF THE REPRESENTATIVE FARM TYPES

Item	Year 1	2	3	4	5	6 onwards
WITHOUT CASSAVA ALTERNATIVE						
A. Funds						
1. Value of production	6,358	8,104	10,983	12,280	14,264	15,191
2. Revolving fund loan	2,306	2,384	2,575	2,759	2,992	2,992
Total funds	8,856	10,688	13,058	15,439	17,256	18,183
B. Use of Funds						
1. Inputs	(2,212)	(2,401)	(2,981)	(2,752)	(3,999)	(2,999)
- Purchased inputs	1,852	1,807	1,971	2,135	2,395	2,268
- Contingencies, 10%	184	181	197	214	230	230
- O & M	413	413	413	413	424	474
2. Loan reimbursement	2,422	2,722	2,712	2,908	3,157	3,157
3. Family allowance	1,300	1,300	1,300	1,300	1,300	1,300
Total use of funds	6,859	6,229	6,596	6,970	7,456	7,456
Net Cash Flow (A-B)	2,717	4,471	6,460	8,554	10,200	10,727

TABLE 4/13: FINANCIAL ANALYSIS OF THE REPRESENTATIVE RICE FARM TYPES

Item	Year 1	2	3	4	5	6 onwards
A. Funds						
1. Value of production	3,872	4,590	6,508	6,426	7,144	8,252
2. Revolving fund loan	2,945	3,221	3,703	4,183	4,809	4,809
Total funds	6,817	7,811	9,211	10,609	11,953	12,971
B. Use of Funds						
1. Inputs	(2,845)	(3,141)	(3,603)	(4,053)	(4,509)	(4,509)
- Purchase inputs	2,066	2,324	2,686	3,068	3,715	3,715
- Hired labour	-	112	169	228	289	884
- Contingencies, 10%	209	235	278	319	360	360
- O & M	850	850	850	850	850	550
2. Loan reimbursement	3,102	3,198	3,907	4,381	4,862	4,862
3. Family allowance	1,300	1,300	1,300	1,300	1,300	1,300
Total use of funds	7,282	7,839	8,810	9,734	10,671	10,671
Net Cash Flow (A-B)	-825	-28	401	845	1,282	2,300

(3) Explanatory Notes to Tables J/12 and J/13

- Value of production (gross return): According to the farm gate prices listed in Section 2 of the chapter, which have also been used in the economic analysis.
- Revolving fund loan: Covers the costs of the inputs, including purchased inputs, hired labour, water charges and contingencies.
- Purchased inputs: Include seeds, fertilizers, pesticides and machinery (see Appendix J-2, Section 1).
- Hired labour: The labour demand for each crop was calculated monthly. It was estimated, on the basis of an average family size of six persons, that a family can supply up to 450 workdays p.a. or 50 to 60 work-days per month and up to 70 work-days in the peak month. It was assumed that the labour demand beyond 70 work-days per month would be met by hired labour at a cost of ¢2.60 per work-day (See Appendix J-2, Section 2 for the shadow cost of labour).
- O & M: Includes the variable costs of the irrigation and drainage systems, as estimated in Appendix J-2, Section 4.
- Contingencies: Estimated at 10 percent of purchased inputs and hired labour.
- Loan reimbursement: Covers the repayment of the principal and the interest of the revolving fund loan. The interest imputed was 5.5 percent of the principal, based on information provided by the Agricultural Development Bank.[1/]
- Family allowance: Family allowance is based on the above mentioned assumption that the farmer's family can devote up to 450 work-days p.a. to working their own land. Because of the responsibility involved, the management skills required, risks, etc., the ¢2.60 per day has been increased by 10 percent, to ¢2.86. Thus, the family allowance of ¢1,300 was ontained by multiplying ¢2.86 by 450.

1/ The ADB normally grants loans to farmers at a rate of 11 percent p.a., which includes interest and various other charges. The agricultural plan envisages an average borrowing period of six months (one crop season).