THE ARAB REPUBLIC OF EGYPT

GENERAL AUTHORITY FOR REHABILITATION
PROJECT AND AGRICULTURAL DEVELOPMENT

MINISTRY OF DEVELOPMENT, STATE
FOR HOUSING, AND LAND RECLAMATION

FINAL REPORT
ON
FEASIBILITY STUDY
FOR
THE SOUTH HUSSINIA VALLEY
AGRICULTURAL DEVELOPMENT PROJECT PHASE II

(APPENDIXES-B&C)
VOLUME-2

MAY 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

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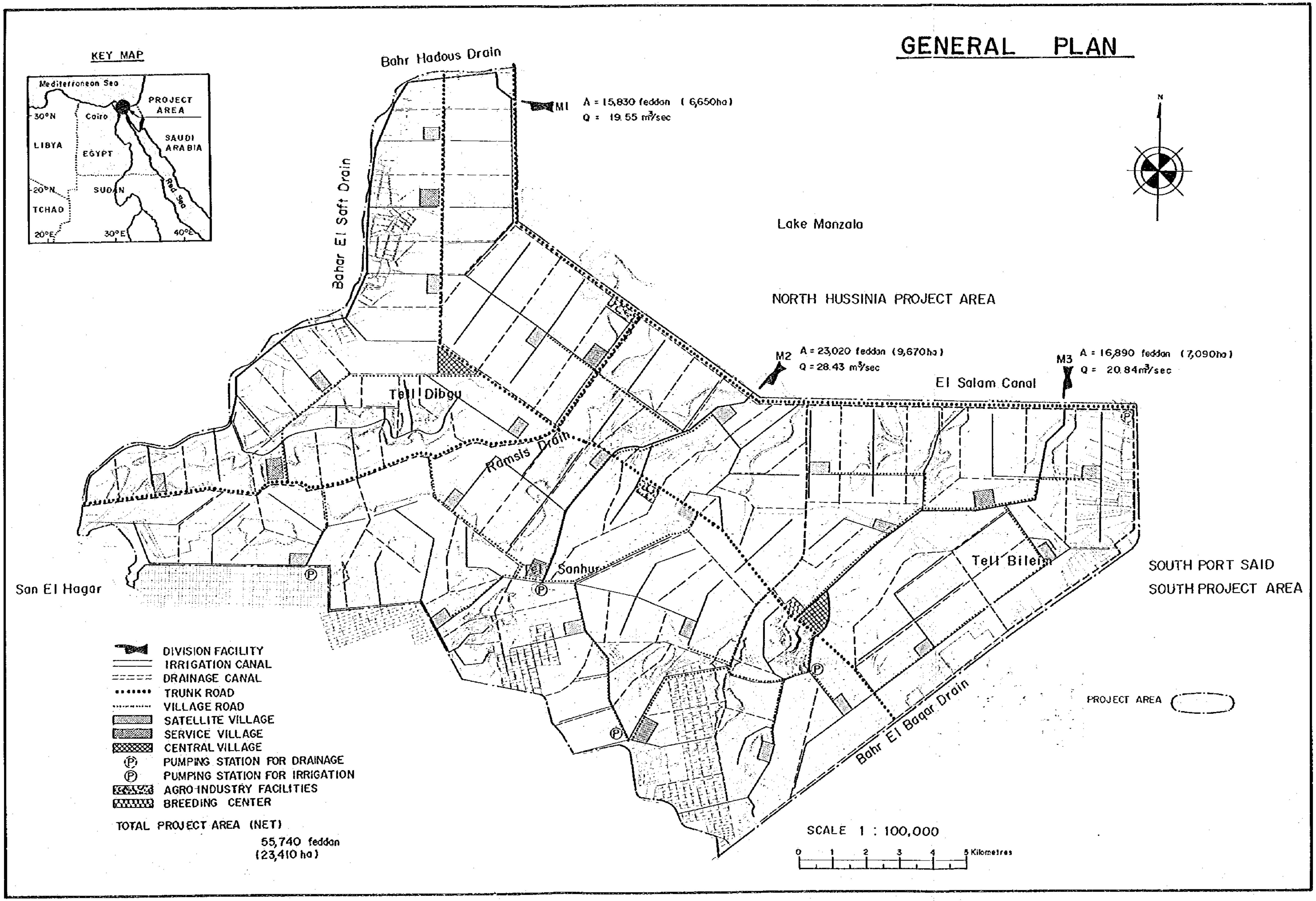
GENERAL PLAN
KEY MAP
Mediterranean Sea
PROJECT AREA
30°N
Cairo
SAUDI ARABIA
LIBYA
EGYPT
SUDAN
Red Sea
20°N
TCHAD
20°E
30°E
40°E
Bahr Hadous Drain
M1
A = 15,830 feddan (6,650ha)
Q = 19.55 m³/sec
Bahar El Saft Drain
Lake Manzala
NORTH HUSSINIA PROJECT AREA
M2
A = 23,020 feddan (9,670ha)
Q = 28.43 m³/sec
M3
A = 16,890 feddan (7,090ha)
Q = 20.84m³/sec
El Salam Canal
Tell Dibgu
Ramsis Drain
Tell Sanhur
Tell Bilein
SOUTH PORT SAID
SOUTH PROJECT AREA
San El Hagar
Bahr El Baqar Drain
DIVISION FACILITY
IRRIGATION CANAL
DRAINAGE CANAL
TRUNK ROAD
VILLAGE ROAD
SATELLITE VILLAGE
SERVICE VILLAGE
CENTRAL VILLAGE
PUMPING STATION FOR DRAINAGE
PUMPING STATION FOR IRRIGATION
AGRO-INDUSTRY FACILITIES
BREEDING CENTER
TOTAL PROJECT AREA (NET)
55,740 feddan
(23,410 ha)
PROJECT AREA
SCALE 1 : 100,000
0 1 2 3 4 5 Kilometres
N

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ANNEXES B IRRIGATION, DRAINAGE AND ON-FARM DEVELOPMENT

C AGRICULTURAL DEVELOPMENT

Appendix B Irrigation, Drainage and On-farm Development

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B.1. Irrigation

B.1.1. Crop Water Requirements (ETcrop)

a. Reference Crop Evapotranspiration (ETo)

Balaney-Criddle Method

The Blaney-Criddle method utilizes mean monthly percent of daytime hours, temperature and a predetermined consumptive use coefficient for individual crops. This method has been used by Federal and State agencies in the United States of America and by various countries in arid and semi-arid areas throughout the world.

$$ETo = C\ [\ P(0.46T + 8)\ ]$$

Where;

ETo = reference crop evapotranspiration for month considered (mm/day)

T = mean daily temperature for the month considered (°C)

P = mean daily percentage of total annual daytime hours obtained for a given month and latitude

C = adjustment factor which depends on minimum relative humidity, sunshine hours and daytime wind estimates

This equation was used for estimating the water requirement of the irrigable areas and determining the discharge in the El Salam canal in its planning stage.

The estimation by this method revealed that peak evapotranspiration takes place in June by 8.7 mm/day, the annual value by 2,008.6 mm and the daily mean value by 5.5 mm/day.

Radiation Method

The radiation method is applicable only when those records on atmospheric temperature, sunshine hours, cloudiness and radiation are available. The basic equation is as follows:

$$ETo = C(W.Rs)$$

Where;

ETo = Reference crop evapotranspiration for the periods considered (mm/day)

Rs = solar radiation in equivalent evaporation (mm/day)

W = weighting factor which depends on temperature and altitude

C = adjustment factor which depends on mean humidity and daytime wind conditions

The estimation by this equation has resulted in that peak evapotranspiration in June by 8.1 mm/day, and the annual total and daily mean evapotranspiration are 1,916.5 mm/year and 5.3 mm/day, respectively.

Modified Penman Method

The Modified Penman method has recently gained more popularity among scientists and engineers in the world. This method requires to provide such meteorological records as atmospheric temperature, humidity, wind velocity, sunshine hours. The basic equation for computation is as follows:

$$ETo = C [W.Rn + (1 - W) f(u) (ea - ed)]$$

Where;

ETo = reference crop evapotranspiration (mm/day)

W = temperature-related weighting factor

Rn = net radiation in equivalent evaporation (mm/day)

f(u) = wind-related function

(ea - ed) = difference between the saturation vapour pressure at mean air temperature and the mean actual vapour pressure of the air(mbar)

C = adjustment factor to compensate for the effect of day and night weather conditions

The computation found that the month when peak evapotranspiration takes place is June by 8.9 mm/day, and the annual total and daily mean evapotranspiration are 2,083.4 mm/year and 5.7 mm/day, respectively.

Comparison of Result

As a result, the estimated values by above three methods have not made large differences from each other, although the Radiation method resulting in lower values than the others and the Modified Penman method resulting in comparatively high values in peak by 8.9 mm/day and in annual total. Under the situation, either method is applicable to this study without causing any large difference. Hence, the ETo values estimated by Blaney-Criddle method have been adopted for the Project Area as the moderate values (refer to Table B-1).

b. Crop Factor (Kc)

A proposed cropping pattern is determined through the study on farming techniques, climate, labor balance, etc. The proposed cropping pattern plans to introduce rice, soybean, sorghum and tomato as summer crops, while berseem (Egyptian clover), sugarbeet, etc. as winter crops. Based on this plan, the crop factors (Kc) for the respective crops are calculated in accordance with the procedures described in FAO irrigation and drainage paper No.24.

These crop factors vary from one growing stage of plants to another. The proposed cropping pattern defines the seeding or planting period of the respective crops in due consideration of a variety of conditions such as labor requirement, etc. Thereby, the growing stages stagger among those crops planted early and late. This means that the irrigation water requirements, when estimated by one crop factor for the whole, turns into a considerably large amount. Furthermore, the facilities to be constructed in design to meet such large water requirements will result in excessive investment.

Averaged crop factors (kc), due to different planting date, are given in Table B-2.

c. Crop Water Requirements (ETcrop)

Crop water requirements for selected crops are calculated by multiplying ETo by Kc(Table B-2).

B.1.2. Land Preparation and Puddling

The water for land preparation and puddling, which is not required for cropping any other crops than paddy rice, is needed for soaking the soils to facilitate transplanting works. Water requirements for land preparation and puddling are estimated by the following equation;

W = puddling water requirements
Ws = standing water on the field (50 mm)
Wt = pore space of top-soil layer (15 cm),
150 mm x 0.2 = 30 mm
We = Evaporation from water surface (mm),
7mm/day x 5 days = 35 mm
Wp = percolation rate, 2mm/day x 5 days = 10 mm

Therefore;

W = 50 + 30 + 35 + 10 = 125 mm

In the fields where the soils are moistened, one application of such puddling water can soak the soils to saturate, whereas, for dry season paddy cropping even in the moistened fields or cropping in the arid area, the field surface is too hard to be soaked adequately only by one application of the water. Therefore, for the hardened fields, it is recommended to apply to puddling water two times by half amount of necessary water in each application for turning top soils soft enough to transplant paddy rice by effective soaking as well as saving water losses. In this case, the first irrigation should be carried out aiming at softening and moistening the top soils for ploughing and harrowing while the second aims at preparing planting bed for paddy transplanting.

In this way, the Project will adopt a plan to practice the first irrigation by 75 mm/day in depth six days before transplanting.

B.1.3. Leaching Water Requirements

The leaching requirements are calculated by the FAO equation for the yield potentials of 100% as tabulated in Table B-3. In the calculation, the leaching efficiency is assumed to be 0.5. The leaching efficiency (Le) varied with the soil type, and particularly with the internal drainage properties of the soil and the field. Useful information on Le will be obtained through the proposed field leaching tests to be carried out by GARPAD.

Since soluble salts are transported in soils in the water phase, distribution and removal are controllable by water management. The only economical means of controlling soil salinity and its deleterious effects is to produce a flow of low-salt water through the root zone and to maintain a net downward flux. To prevent the advent of harmful accumulation of salts in soils, an additional increment of water (over and above that required to meet evapotranspiration needs of the crop being grown) must be passed through the root zone when irrigating to leach out the accumulating salts. This is referred to as the leaching requirements (LR) (U.S. Salinity Laboratory Staff, 1954).

Under steady-state conditions, assuming no appreciable contribution of salts from the dissolution of soil minerals or salts, or loss of soluble salts by precipitation processes and crop removal and uniform areal application of water in the field, and where the water-table depth is sufficient to prevent the introduction of salts into the root zone from capillary rise processes, Eq.(1) may be obtained.

$$\frac{Ddw}{Diw} = \frac{ECiw}{ECdw} \tag{1}$$

where Ddw, Diw and ECdw, ECiw are volume and electrical conductivity of drainage and irrigation water, respectively.

The estimate of the extra depth of irrigation water that should be applied to maintain the average soil-water salt concentration over a period of time is obtained from Eq.(2).

$$LRec = \frac{ECiw}{EC'dw} = \frac{Ddw(min)}{Diw} \tag{2}$$

When values for ECiw and EC'dw (the maximum permissible salinity level of water draining from the bottom of the root zone) are inserted into Eq.(2), a values (fraction) is obtained which can be used to estimate the extra increment of irrigation water that should be applied with the irrigation in order to maintain soil-water salinity within acceptable limit.

The evaluation of LRec requires the selection of appropriate EC'dw values. Such data are given in FAO irrigation and drainage paper No.24 for major crop species. Bernstein and Francois (1973) have concluded that crop growth is relatively insensitive to high salinities in lower root zone regions and that leaching requirements can be reduced to one-fourth the levels previously recommended. An alternative procedure to select appropriate EC'dw values may be derived from observation that the average ECe in the root zone is related to the ECe values found at the top and bottom of the profile. R.S. Ayers et al. recommend that the following equation can be used to calculate appropriate EC'dw values,

$$EC'dw = 5EC'se - ECiw \quad (3)$$

where EC'se is the average EC of the saturation extract for a given crop appropriate to the tolerable degree of yeild depression.

Since the LRec values obtained with the historical approach seem to be too conservative, J.V. Schilfgaarde et al. (U.S. Salinity Laboratory) recommended that either the Bernstein recommendation be used or EC'dw values be obtained with the use of Eq.(3) and used in Eq.(2) to calculate LRec. The recommendations result in considerably lower LRec values than have been recommended in the past.

In this study the LRec has been calculated with the use of Eq.(2) and (3) as tabulated in Table B-3.

The LRec value is then used to estimate the depth of irrigation water to apply and the minimum drainage requirement as follows:
The depth of irrigation water is the sum of the consumptive use and the estimated minimum required drainage water, or

$$Diw = Dcw + Ddw(min) \quad (4)$$

Using this relation and Eq.(2), the depth of irrigation water may be expressed in terms of consumptive use ahd leaching requirement as

$$Diw = Dcw/(1-LRec) \quad (5)$$

The report "Irrigation and Salinity, A world-Wide Survey, (ED.) K.K. Framji, ICID" presents 10 of practical leaching equations based on long-term increments, of which three equations of U.S. Salinity Laboratory, Bernstein (USA) and R.S. Ayers et al. (FAO) are similar to those discussed above. Two equations of Republic China and Volobuev are not applicable to this study. The equation by the studies of Reeve at al. (USA) is developed to calculate the quantity of water needed to reclaim salt-affected soils. Data and information on the project area are lacking for the use of three equations of Durand (North Africa), Darab (Hungary) and Bresler (Israel). The equation by Deleman et al. (Iraq) is examined, for reference, to calculate LR. Deleman et al. present the following equation;

$$LR = \frac{Dd}{Di} = \frac{Ci}{Cd} \cdot \frac{Mfc}{Mex} \times \frac{1}{f} \qquad (6)$$

where, Mfc, Mex = Soil moisture content at field capacity and saturated paste.

f = Coefficient, ratio between the salt concentration of the water draining from a soil layer and the salt concentration of the soil solution in that layer. This coefficient becomes smaller the heavier the soil is.

Ci = salinity of irrigation water

Cd = salinity of drainage water

Mfc and Mex range from 27 ∿ 39 % and 65 ∿ 87 %, respectively. For the simplification of calculation, averaged Mfc of 33% and Mex of 75% are used. f is assumed to be 0.50 due to heavy soil in the field. Accordingly, Eq.(6) is rewritten as

$$LR = 0.78 \frac{Ci}{Cd} \qquad (7)$$

The LR by Deleman et al. is given in Table B-4.

B.1.4. Project Water Requirements

Following the proposed cropping pattern and calendar, monthly net field requirements including leaching water are calculated as given in Table B-5. Gross field requirements including field application losses and distribution losses are estimated with the irrigation efficiencies of 0.64 (Table B-6). Table B-7 and B-8 present the project water requirements.

B.1.5. Irrigation Method

Water for the maintenance of plant growth may be applied in one of three ways: subirrigation; surface irrigation; overhead (or sprinkler) irrigation.

a. Subsurface Irrigation

With subsurface irrigation, water is applied below the ground surface rather than on it. As moisture reaches the plant roots through capillary movement, an adequate supply of good-quality water must be available throughout the growing season. The upward movement of high-saline water tends to accumulate salts in surface soil; these salts hinder crop production.

The use of subirrigation as described above will always be limited because there are few places where all of these conditions exist jointly. The Project Area has a severe problem of salt accumulation. This subirrigation is not permitted.

b. Surface Irrigation

(1) Basin Irrigation

Most crops can be irrigated with basin irrigation. It is widely used for irce, and for row crops that can withstand some inundation, such as sugarbeet, corn, sorghum, and cotton. This irrigation method is best suited to soils of moderated to low intake rate. Basin irrigation is best suited to smooth, gently, uniform land slopes.

High application efficiency can be obtained easily with little labor. Basin irrigation can be used efficiently by inexperienced workers. Many different kinds of crops can be grown in sequence without major changes in design, layout, or operating procedures. There is no irrigation runoff, there is little deep percolation if no excess is applied. Leaching is easy and can be done without changing either the layout or operation method.

Accurate initial land leveling is essential and level surface must be maintained. In some areas special provisions must be made for surface irrigation.

(2) Border Strip Irrigation

The border method of irrigation, also called the strip check method, consists of dividing the land into strips by constructing parallel dikes or levees which guide the water as it moves down the slope as a sheet. The land between two levees is called a border, strip or check.

Border irrigation is suitable for all close-growing, non-cultivated, sown or drilled crops, and other crops grown in ponded water. Border irrigation can be used on most soils. It is however, best suited to soils with a moderately low to a moderately high intake rate.

Field application efficiency is good to excellent if the border strips are designed and installed properly and good water management practices are followed. Labor requirements are low.

The topography and soil profile characteristics must not restrict land leveling necessary to eliminate cross slope within feasible border widths, and the achievement of a uniform border strip slope.

(3) Furrow and Corrugation Irrigation

Small, evenly spaced, shallow channels are installed down or across the slope of the field to be irrigated. Water is turned in at the high end and conveyed in the small channels to the vicinity of palnts growing in, or on beds between the channels.

The method is separated into types according to the kinds of crops and size of channel. Furrow irrigation is primarily used with clean filled crops planted in rows, while corrugation irrigation is associated with non-cultivated close-growing crops using small closely-spaced channels. Water application principles are the same for both furrow and corrugation irrigation.

Most crops can be irrigated by the furrow or corrugation method except those grown in ponded water, such as rice. This method is suited to fine textures very slowly permeable soils.

Moderate to high application efficiency can be obtained if water management practices are followed and land is proerly prepared. The initial capital investment is relatively low on lands not requiring extensive land forming. Labor requirement may be high as irrigation streams must be carefully regulated to achieve uniform water distribution. It should not be used on saline soils or where irrigation water has a high salt content.

c. Sprinkler Irrigation

Sprinkler irrigation systems have many advantages. Erosion can be controlled, and efficient irrigation is possible on land too steep for other methods. Uniform application is possible on all kinds of soil. On sandy soils that have high intake rates, or nonuniform soils with variable-intake rates, sprinkler irrigation distributes water more uniformly than any other method. Water can be saved, more land can be irrigated with a designated amount of water, and drainage problems can be reduced.

The amount of water applied can be controlled to meet the needs of the crop. Light applications can be made to seedlings or young plants, or for fertilizer and herbicide applications. Land preparation is not required. Soils too shallow to be leveled properly for other methods can be irrigated safely with sprinklers. On deeper soils, the cost of land leveling can be eliminated or greatly reduced.

More land is available for cropping. Field ditches, levees, and borders are not needed. Sprinkler irrigation also decreases the weed problem, reduces wear of farm machinery, and simplifies tillage. Surface runoff of irrigation water is eliminated. Labor costs are reduced notably on soil having a high water-intake rate and on land that is steep or rolling. Irrigation can be fitted into other farm operations as incidental work that is done once or twice a day. With solid or permanent systems, labor is negligible, and they lend themselves to automation for all water-application purposes.

According to the cost estimate of irrigation methods, the project cost of the sprinkler irrigation system is the highest among other irrigation system. The operation and maintenance cost is not a limitation factor to choose an irrigation system to the Area because the laborer charge is cheaper in and around the Area at present. Other factors such as topographic conditions, climate and etc. have not limited to introduce the sprinkler irrigation system to the Area.

When the labor charge becomes higher in future, the sprinkler irrigation system will be proposed for the Area. Therefore, the sprinkler irrigation system with effective water management of on-farm level is recommendable to the Area. Amont surface irrigation methods, basin and border strip irrigation methods are practical and recommended.

B.1.6. Rotational Irrigation

Methods of applying water to the farm fields are classified into two; continuous irrigation and intermittent irrigation. For the project, the main irrigation system shall be operated on the basis of intermittent water supply in accordance with the MOI's operation rule. Accordingly, intermittent water supply shall be applied to field irrigation. Advantages of intermittent irrigation are to promote aeration of the soil, produce savings in irrigation water and minimize drainage problems, while disadvantages to require closer supervision and make weed control more expensive.

Rotational irrigation is practiced by rotating the supply of water to different area. With ratational irrigation, water can be reasonably regulated and evenly distributed over the reaches of the canal systems, there will be savings in water due to lower conveyance losses, and farmers are assured of the timely delivery of sufficient irrigation water.

As the main irrigation system shall be operated by the MOI on the basis of four-day-on and four-day-off during the peak water demand period, the capacity of the system shall be twice the water demand of 12.7 mm/day, namely 24.5 mm/day. Table B-9 shows the monthly water demand and numbers of irrigation days required with the designed system capacities. Numbers of irrigation days in winter are three to eitht days a month, less than half of the irrigation days in summer, and the water supply intervals in winter can be made longer than four days. Accurate intervals shall depend on available soil moisture and crop water requirements, however.

With the intermittent water supply of four-day-on and four-day-off, a given farm plot shall be irrigated at an interval of eight days when rotational irrigation is practiced. Excluding conveyance losses (15 %) in the main and secondary irrigation canals, the design capacity of tertiary canal is given as follow;

Peak irrigation requirement: 12.7 x (1.00 - 0.15) = 10.8 mm/day
(or, 1.25 l/s/ha)

Design capacity; 10.8 x 8 = 86.4 mm/day
(or, 10.0 l/s/ha)

There are two options in establishing rotational irrigation blocks; one is evenly to divide the project area into four irrigation blocks which shall be arranged along the main irrigation systems from upstream to downstream, and the other is extensively to disperse over the project area the farm plots to be irrigated at the same day. The former has disadvantage that concentrated irrigation may be a burden to the drainage systems. The project has proposed to employ the latter method. The minimum rotation unit consists of 10 farm plots, having an area of 50 feddan (or, 21 ha), and is to be irrigated within one day. The layout of ratational irrigation system for M1 irrigation area (6,650 ha), as a sample, is presented in Figure B-1.

Main and secondary canal

Irrigation area;	6,650	ha
Irrigation requirement; 6,650 x 1.47 =	9.775	cu.m/s
Water supply; 9,775 x 2 =	19.55	cu.m/s

Rotation block

Daily irrigation area; 6,650 /4 =	1,665.2	ha
Field water requirement; 1,662.5 x 10 =	16.62	cu.m/s
(or, 19.55 x 0.85)		

B.1.7. Gravity Irrigation and Lifting by Farmers

The project area is divided into three irrigation systems of M1(6,650 ha), M2(9,670 ha) and M3(7,090 ha), among which the M1 irrigation area can be irrigated with gravity with the designed water level of the El Salam canal, while the M2 and M3 areas need to construct pumping station(s). For the latter case two alternatives may be set up; (1) to construct pumping station(s) in the main irrigation system so as to enable gravity irrigation at the farm, and (2) to lift the water by farmers at the farm.

Comparison of two alternatives has been made, as a sample, for the M2 irrigation area where the ground elevations vary from 0.0 m to 2.5 m, while the design water level of the El Salam canal at the M2 off-take is 1.95m.

a. Gravity Irrigation

The proposed slope of main irrigation canals is 1/20,000 (refer to B.4.1.), and the water levels in the main canals shall be kept at lowest 50 cm above the ground surface to make gravity irrigation effective. Studies on topography and canal hydraulics revealed that there was necessity of constructing three pumping stations; one station on the main canal, and two relift stations on the secondary canals (refer to Figure B-2). Major dimensions of the proposed irrigation facilities are presented in Table B-10 and B-11.

<u>Summary of Gravity Irrigation</u>

Irrigation area	9,670 ha
Irrigation requirements; 9,670 x 1.47 ℓ/s	14.21 cu.m/s
Main irrigation canal (1/20,000)	
-Total length	9,250 m
-Max. canal capacity; 14.21 x 2	28.43 cu.m/s
-Intake water level	1.95 El. m

Secondary Irrigation canal (1/10,000)	122,520 m
M2 pumping station	
-Irrigation area	5,680 ha
-Total capacity	16.70 cu.m/s
M2-1 relift pumping station	
-Irrigation area	1,165 ha
-Total capacity	3.43 cu.m/s
M-2-2 relift pumping station	
-Irrigation area	860 ha
-Total capacity	2.53 cu.m/s

b. Lifting by Farmers

Two cases were compared in regard to intake water levels; EL.1.45 m (case 1) and EL. 1.20 m (case 2). Even though lifting irrigation is introduced, M2 pumping station on the main canal will have to be constructed in order to maintain the water level to a some extent as the topographic slope of the area is in reverse, otherwise farmers shall need to increase capacities of pumping equipment more than common ones. This study plans to maintain the water levels at lowest equal to the ground surface for case 1, and 0.25 m below the ground surface for case 2. One small scaled pumping station will be constructed by farmers for each irrigation unit of 50 feddan (or, 21 ha). The number of such stations amount to 460 to cover the M2 irrigation area. Table B-10 and B-11 give the major dimensions of the proposed irrigation facilities.

Summary of Lifting Irrigation

Irrigation area	9,670 ha
Irrigation requirements; 9,670 x 1.47 ℓ/s	14.21 cu.m/s
Main irrigation canal (1/20,000)	
-Total length	9,250 m
-Max. canal capacity; 14.21 x 2	28.43 cu.m/s
-Intake water level; case 1	1.45 EL. m
case 2	1.20 EL. m

Secondary irrigation canal (1/10,000)	122,520 m
M2 pumping station	
-Irrigation area	5,680 ha
-Total capacity	16.70 cu.m/s

c. Construction Cost and Economic Comparison

The construction costs are presented in Table B-12. In summary, as for the construction of irrigation canals, the costs for lifting irrigation is cheaper than the costs for gravity irrigation that keeps high water levels. However, the total costs for lifting irrigation exceed the costs for gravity irrigation due to a large amount of construction costs for small scaled pumping stations as summarized below;

Summary of Construction Costs

('000 LE)

Item	Gravity WL.1.95m	Lifting WL.1.45m	Lifting WL.1.20m
1. Canal - 132 km	7,089	6,026	6,141
2. Pumping station			
-Main station	4,211	2,665	2,665
-Small scaled station - 460	-	8,255	8,619
Total	11,300	16,946	17,425

Annual costs were estimated on the conditions of an annual interest rate of 10% and a project life span of 50 years. In the estimation, pumping equipment were replaced every 10 years and seven years for main station and small scaled stations, respectively. Details are given in Table B-13. As a result, gravity irrigation method has been recommended because of lowest annual costs ($1,617 \times 10^3$ LE) when compared with annual costs of $2,967 \times 10^3$ LE for case 1 and $3,060 \times 10^3$ LE for case 2.

B.1.8. A Guide for Preliminary Planning on the Use of Herbicides

The following is a guide for preliminary planning on the use of herbicides for weed control in moving water (irrigation and drainage canals).

Product

1. Amitrol-T camitrole + ammonium thiocyanate
   - Rate per treated acre; 1-1.5 ℓb. ai (0.5 - 0.75 gal.)
   - Condition of application; Spray in 100 - 300 gal./A from ground or 5 - 10 gal./A air.
   - Weed controlled; Waterhyacinth
   - Remarks; Use the higher rate where growth is very dense. Wet the plants throughly, indluding small shoots under the main plant.
2. Cutrine-Plus (copper-alkanolamine complex)
   - Rate per treated acre; 1 gt./cfs of water flow per hour for 3 hours.
   - Calculated concentration in water; 1 ppm.
   - Condition of application; When algae begins to interfere with normal delivery of water (clogging at later headgates, suction screens, and siphon tubes).
   - Remarks; Follow all label directions. Treat when there is sufficient water flow to allow dispersion of chemical. Start treatment early in the morning. Chemical should be introduced at points of turbulence-creating structures such as weirs. Cleared for use in potable water upto 1 ppm copper.
   - Weed controlled; Chara. Nitella and filamentous algae

3. Emulsifiable aromatic solvents (methylated benzens, such as xylene)

-Rate per treated acrea; 6 - 10 gal./cfs of water flow. Apply during a period of 30 - 60 min.

-Calculated concentration in water; 450 - 740 ppm

-Condition of application; Before weeds become matted on surface

-Weeds controlled; Algae and most submersed rooted weeds.

-Remarks; Treated water may be used for sprinkler and furrow irrigation.

4. Magnacide "H" (acrolein)

-Rated per treated acre; 0.5 gal. product/A ft.

-Calculated concentration in water; 1.3 ppm.

-Condition of application; Apply to flowing water as necessary to control aguatic weeds.

-Weed controlled; Algae: Chara spp., Hydrodictyon reticulatum. Spirogyra spp. Flowering plants: Waterstarwort, coontail, elodea, waterstargrass, pondweeds, naiad, horned pondweed.

-Remarks; Do not permit livestock to drink treated water. Must be stored and applied under nitrogen gas pressure cylinders. Follow all label directions.

5. Weedar 64 (2.4-D amine)

-Rate per treated acre; 1-4 ℓb.ai (1-4 gt.)

-Condition of application; Treat when annuals and perennials are young and growing vigorously.

-Weed controlled; Annual and perennial bradleaf weeds and woody brush

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Notes; ai.-active ingredient

Table B-1 Comparison of Estimated ETo

(Unit: mm/day)

Month	Blaney-Criddle	Radiation	Modified Penman
Jan.	2.7	2.4	2.8
Feb.	3.2	3.3	3.8
Mar.	4.2	4.4	5.2
Apr.	5.7	5.8	6.8
May	8.2	7.4	8.2
Jun.	8.7	8.1	8.9
Jul.	7.5	7.6	7.9
Aug.	7.2	7.3	7.3
Sep.	6.6	6.3	6.4
Oct.	5.4	4.6	4.9
Nov.	3.7	3.3	3.5
Dec.	2.8	2.4	2.7

Notes: Station : El Mansura
Location : Lat. 31°00'N, Long. 31°27'E, Alt. 3.8 m
Data : 10 years from 1970 to 1979

Table B-2 Estimates of Averaged ETcrop in mm

Month	ETo(mm)	Paddy Kc	Paddy ETcrop	Berseem Kc	Berseem ETcrop	Soybean Kc	Soybean ETcrop
Jan.	84			0.83	70		
Feb.	90			0.75	68		
Mar.	130			0.40	52		
Apr.	171			0.05	9	0.15	26
May	254					0.52	132
Jun.	261	0.37	97			0.92	240
Jul.	233	0.95	221			1.01	235
Aug.	223	1.18	263			0.51	114
Sep.	198	0.99	196	0.10	20	0.05	10
Oct.	167	0.39	65	0.50	84		
Nov.	111			0.81	90		
Dec.	87			0.82	71		
Total			842		464		757

Month	ETo(mm)	Sugarbeet Kc	Sugarbeet ETcrop	Tomato Kc	Tomato ETcrop	Sorghum Kc	Sorghum ETcrop
Jan.	84	1.11	93				
Feb.	90	1.06	95				
Mar.	130	0.55	72	0.04	5		
Apr.	171	0.06	10	0.21	36		
May	254			0.46	117	0.14	36
Jun.	261			0.55	144	0.46	120
Jul.	233			0.53	123	0.83	193
Aug.	223			0.37	83	1.06	236
Sep.	198	0.13	26	0.09	18	0.96	190
Oct.	167	0.36	60			0.45	75
Nov.	111	0.62	69			0.04	4
Dec.	87	0.93	81				
Total			506		526		854

- Continued -

Month	ETo(mm)	Onion		Cauliflower		Cabbage	
		Kc	ETcrop	Kc	ETcrop	Kc	ETcrop
Jan.	84	1.05	88	0.82	69	0.39	33
Feb.	90	1.04	94	0.20	18		
Mar.	130	0.87	113				
Apr.	171	0.25	43				
May	254						
Jun.	261						
Jul.	233						
Aug.	223						
Sep.	198						
Oct.	167			0.16	27	0.16	27
Nov.	111	0.28	31	0.57	63	0.57	63
Dec.	87	0.81	70	0.94	82	0.85	74
Total			439		259		197

Table B-3 Estimate of LR

Month	ECw (ppm)	ECw (mS/cm)	Paddy	Berseem	Soybean	Sugarbeet	Tomato
Jan.	802	1.3		0.42		0.08	
Feb.	730	1.1		0.34		0.06	
Mar.	780	1.2		0.38		0.07	0.21
Apr.	720	1.1		0.34	0.09	0.06	0.19
May	725	1.1			0.09		0.19
Jun.	769	1.2	0.17		0.10		0.21
Jul.	732	1.1	0.16		0.09		0.19
Aug.	697	1.1	0.16		0.09		0.19
Sep.	782	1.2	0.17	0.38	0.10	0.07	0.21
Oct.	800	1.3	0.19	0.42		0.08	
Nov.	807	1.3		0.42		0.08	
Dec.	824	1.3		0.42		0.08	

Notes:

$$LR = \frac{ECw}{5ECe - ECw} \times \frac{1}{0.5}$$

ECw: derived from Study on El Salam Canal Project, MOI, 1979
1 mS/cm = 640 ppm

ECe: from Table 36, FAO Paper No.24
100% yield potential

Crop	ECe(mS/cm)
Paddy	3.0
Berseem	1.5
Soybean	5.0
Sugarbeet	7.0
Tomato	2.5

- Continued -

Month	ECw (ppm)	ECw (mS/cm)	Sorghum	Onion	Cauliflower	Cabbage
Jan.	802	1.3		0.55	0.20	0.34
Feb.	730	1.1		0.45	0.17	
Mar.	780	1.2		0.50		
Apr.	720	1.1		0.45		
May	725	1.1	0.12			
Jun.	769	1.2	0.13			
Jul.	732	1.1	0.12			
Aug.	697	1.1	0.12			
Sep.	782	1.2	0.13			
Oct.	800	1.3	0.14		0.20	0.34
Nov.	807	1.3	0.14	0.55	0.20	0.34
Dec.	824	1.3		0.55	0.20	0.34

Notes:

$$LR = \frac{Ecw}{5ECe - ECw} \times \frac{1}{0.5}$$

ECw: derived from Study on El Salam Canal Project, MOI, 1979
1 mS/cm = 640 ppm

ECe: from Table 36, FAO Paper No.24
100% yield potential

Crop	ECe(mS/cm)
Sorghum	4.0
Onion	1.2
Cauliflower	2.8
Cabbage	1.8

Table B-4 LR by Deleman Equation

Month	Ci (mS/cm)	Paddy	Berseem	Soybean	Sugarbeet	Tomato
Jan.	1.3		0.68		0.14	
Feb.	1.1		0.57		0.12	
Mar.	1.2		0.62		0.13	0.37
Apr.	1.1		0.57	0.17	0.12	0.34
May	1.1			0.17		0.34
Jun.	1.2	0.31		0.19		0.37
Jul.	1.1	0.29		0.17		0.34
Aug.	1.1	0.29		0.17		0.34
Sep.	1.2	0.31	0.62	0.19	0.13	0.37
Oct.	1.3	0.34	0.68		0.14	
Nov.	1.3		0.68		0.14	
Dec.	1.3		0.68		0.14	

Notes: $LR = 0.78 \frac{Ci}{Cd}$

Ci; derived from study on El Salam Canal Project, MOI

Cd; from Table 36, FAO paper No.24, 100 % yield potential

Crop	Cd(mS/cm)
Paddy	3.0
Berseem	1.5
Soybean	5.0
Sugarbeat	7.0
Tomato	2.5

Table B-5 Net Field Requirement (NFR) by Crops

(Unit: mm)

Month	Paddy: Land Preparation	ETcrop	Leaching	Total
May	12			12
Jun.	63	97	15	175
Jul.	50	221	47	318
Aug.		263	62	325
Sep.		196	60	256
Oct.		65	47	112
Total	125	842	231	1,198

Month	Berseem			Soybean		
	ETcrop	Leaching	Total	ETcrop	Leaching	Total
Jan.	70	51	121			
Feb.	68	35	103			
Mar.	52	32	84			
Apr.	9	5	14	26	3	29
May				132	13	145
Jun.				240	27	267
Jul.				235	23	258
Aug.				114	11	125
Sep.	20	12	32	10	1	11
Oct.	84	61	145			
Nov.	90	65	155			
Dec.	71	51	122			
Total	464	312	776	757	78	835

- Continued -

Month	Sugarbeet ETcrop	Sugarbeet Leaching	Sugarbeet Total	Tomato ETcrop	Tomato Leaching	Tomato Total
Jan.	93	8	101			
Feb.	95	6	101			
Mar.	72	5	77	5	1	6
Apr.	10	1	11	36	8	44
May				117	27	144
Jun.				144	38	182
Jul.				123	29	152
Aug.				83	19	102
Sep.	26	2	28	18	5	23
Oct.	60	5	65			
Nov.	69	6	75			
Dec.	81	7	88			
Total	506	40	546	526	127	653

Month	Sorghum ETcrop	Sorghum Leaching	Sorghum Total	Onion ETcrop	Onion Leaching	Onion Total
Jan.				88	108	196
Feb.				94	77	171
Mar.				113	113	226
Apr.				43	35	78
May	36	5	41			
Jun.	120	18	138			
Jul.	193	26	219			
Aug.	236	32	268			
Sep.	190	28	218			
Oct.	75	12	87			
Nov.	4	1	5	31	38	69
Dec.				70	86	156
Total	854	122	976	439	457	896

- Continued -

Month	Cauliflower			Cabbage		
	ETcrop	Leaching	Total	ETcrop	Leaching	Total
Jan.	69	17	86	33	17	50
Feb.	18	4	22			
Mar.						
Apr.						
May						
Jun.						
Jul.						
Aug.						
Sep.						
Oct.	27	7	34	27	14	41
Nov.	63	16	79	63	32	95
Dec.	82	21	103	74	38	112
Total	259	65	324	197	101	298

Table B-6 Gross Field Requirement (FWR) by Crops

(Unit: mm)

Month	Paddy	Berseem	Soybean	Sugarbeet	Tomato
Jan.		189		158	
Feb.		161		158	
Mar.		131		120	9
Apr.		22	45	17	69
May	19		226		225
Jun.	273		417		284
Jul.	496		402		237
Aug.	507		195		159
Sep.	399	50	17	44	36
Oct.	175	226		101	
Nov.		242		117	
Dec.		190		137	
Total	1,869	1,211	1,302	852	1,019

Month	Sorghum	Onion	Cauliflower	Cabbage
Jan.		306	134	78
Feb.		267	34	
Mar.		353		
Apr.		122		
May	64			
Jun.	215			
Jul.	342			
Aug.	418			
Sep.	340			
Oct.	136		53	64
Nov.	8	108	123	148
Dec.		243	161	175
Total	1,523	1,399	505	465

Note: FWR = NFR/0.64

Table B-7 Estimate of Project Water Requirement (PWR)

Month	Paddy (18,580 fed) GFR (mm)	Paddy PWR (1,000 m^3)	Sorghum (10,580 fed) GFR (mm)	Sorghum PWR (1,000 m^3)	Tomato (7,840 fed) GFR (mm)	Tomato PWR (1,000 m^3)
Jan.						
Feb.						
Mar.					9	296
Apr.					69	2,272
May	19	1,483	64	2,844	225	7,409
Jun.	273	21,304	215	9,554	284	9,352
Jul.	496	38,706	342	15,197	237	7,804
Aug.	507	39,564	418	18,574	159	5,236
Sep.	399	31,136	340	15,108	36	1,185
Oct.	175	13,656	136	6,043		
Nov.			8	355		
Dec.						
Total		145,849		67,675		33,554

Month	Soybean (18,020 fed) GFR (mm)	Soybean PWR (1,000 m^3)	Berseem (18,580 fed) GFR (mm)	Berseem PWR (1,000 m^3)	Sugarbeet (18,210 fed) GFR (mm)	Sugarbeet PWR (1,000 m^3)
Jan.			189	14,749	158	12,084
Feb.			161	12,564	158	12,084
Mar.			131	10,223	120	9,178
Apr.	45	3,406	22	1,717	17	1,300
May	226	17,105				
Jun.	417	31,560				
Jul.	402	30,425				
Aug.	195	14,758				
Sep.	17	1,287	50	3,902	44	3,365
Oct.			226	17,636	101	7,725
Nov.			242	18,885	117	8,948
Dec.			190	14,827	137	10,478
Total		98,541		94,503		65,162

- Continued -

Month	Onion (12,740 fed)		Cauliflower (2,740 fed)		Cabbage (2,720 fed)	
	GFR (mm)	PWR (1,000 m^3)	GFR (mm)	PWR (1,000 m^3)	GFR (mm)	PWR (1,000 m^3)
Jan.	306	16,373	134	1,542	78	891
Feb.	267	14,287	34	391		
Mar.	353	18,888				
Apr.	122	6,528				
May						
Jun.						
Jul.						
Aug.						
Sep.						
Oct.			53	610	64	731
Nov.	108	5,779	123	1,415	148	1,691
Dec.	243	13,002	161	1,853	175	1,999
Total		74,857		5,811		5,312

$$PWR = (Area)\ fed \times 4.2 \times 10^3 m^3 \times GFR\ (mm) \times 10^{-3}$$
$$= (Area)\ fed \times 4.2 \times GFR\ (mm) \ldots\ldots\ldots\ldots\ m^3$$

Table B-8 Monthly Project Water Requirement

(Unit: 10^3 cu.m)

Month	Paddy	Sorghum	Tomato	Soybean	Berseem
Jan.					14,749
Feb.					12,564
Mar.			296		10,223
Apr.			2,272	3,406	1,717
May	1,483	2,844	7,409	17,105	
Jun.	21,304	9,554	9,352	31,560	
Jul.	38,706	15,197	7,804	30,425	
Aug.	39,564	18,574	5,236	14,758	
Sep.	31,136	15,108	1,185	1,287	3,902
Oct.	13,656	6,043			17,636
Nov.		355			18,885
Dec.					14,827
Total	145,849	67,675	33,554	98,541	94,503

Month	Sugarbeet	Onion	Cauliflower	Cabbage	Total
Jan.	12,084	16,373	1,542	891	45,639
Feb.	12,084	14,287	391		39,326
Mar.	9,178	18,888			38,585
Apr.	1,300	6,528			15,223
May					28,841
Jun.					71,770
Jul					92,132
Aug.					78,132
Sep.	3,365				55,983
Oct.	7,725		610	731	46,401
Nov.	8,948	5,779	1,415	1,691	37,073
Dec.	10,478	13,002	1,853	1,999	42,159
Total	65,162	74,857	5,811	5,312	591,264

Table B-9 Water Requirement and Irrigation Days

Month	GWR (23,410 ha)			Irrigation Days
	10^6cu.m	mm/day	(1) mm	(2) Calculation
Jan.	45.6	6.3	195.3	7.7
Feb.	39.4	6.0	168.0	6.6
Mar.	38.6	5.3	164.3	6.5
Apr.	15.2	2.2	66.0	2.6
May	28.8	4.0	124.0	4.9
Jun.	71.8	10.2	306.0	12.0
Jul.	92.2	12.7	393.7	15.5
Aug.	78.1	10.8	334.8	13.2
Sep.	56.0	8.0	240.0	9.4
Oct.	46.4	6.4	198.4	7.8
Nov.	37.0	5.3	159.0	6.3
Dec.	42.2	5.8	179.8	7.1

Note: GWR; from Table B-8.
(2) = (1)/(2 x 12.7 mm/day)

Table B-10 Major Dimensions of Alternatives
- M2 Irrigation System -

Item	Gravity WL.1.95m	Lifting WL.1.45m	Lifting WL.1.20m
1. Main Canal			
Length (m)	9,250	9,250	9,250
Max capacity (cu.m/s)	28.43	28.43	28.43
Excavation (1,000 cu.m)	317	417	470
Embankment (1,000 cu.m)	369	205	174
2. Secondary Canal			
Length (m)	122,520	122,520	122,520
Excavation (1,000 cu.m)	428	793	991
Embankment (1,000 cu.m)	1,619	787	787
3. M2 Main Pumping Station			
Command area (ha)	5,680	5,680	5,680
Designed capacity (cu.m/s)	16.70	16.70	16.70
Suction water level (Eℓ.m)	1.49	0.99	0.74
Delivery water level (Eℓ.m)	1.95	1.45	1.25
Water head (m)	0.50	0.50	0.50
Number of Pump unit 1/	6	6	6
Pump capacity (cu.m/min)	201	201	201
Bore diameter (mm)	1,200	1,200	1,200
Total head (m)	1.50	1.50	1.50
Motor output (kw)	75	75	75
4. M2-1 Relift Pumping Station 2/	1	-	-
5. M2-2 Relift Pumping Station 2/	1	-	-
6. Small Scale Pumping Stations 2/	-	460	460

Note: 1/ ; including one stand-by unit

2/ ; refer to Table B-11

Table B-11 Dimensions of Relift and Small Scale Pumping Stations

M2-1 Relift Pumping Station

Command area	1,165 ha
Designed capacity	3.43 cu.m/s
Suction water level	1.00 Eℓ.m
Delivery water level	1.50 Eℓ.m
Water head	0.50 m
Number of pump unit (including one stand-by unit)	4
Pump capacity per unit	69 cu.m/min
Bore diameter	700 mm
Total head	1.50 m
Motor output	30 kW

M2-2 Relift Pumping Station

Command area	860 ha
Designed capacity	2.53 cu.m/s
Suction water level	1.00 Eℓ.m
Delivery water level	3.40 Eℓ.m
Water head	2.40 m
Number of pump unit	4
Pump capacity per unit	51 cu.m/min
Bore diameter	700 mm
Total head	3.4 m
Motor output	45 kW

Small Scale Pumping Station per Unit

Command area	21 ha
Designed capacity (1.47 ℓ/s/ha x 0.85 x 8 x 21 ha)	210 ℓ/s
Number of pump unit	1
Pump capacity	12.6 cu.m/min
Bore diameter	350 mm
Engine output: H = 0.50 m	3 ps
H = 0.75 m	3.5 ps
Number of stations (9,670/21)	460

Table B-12 Construction Cost of Alternatives-M2 Irrigation System

(Unit: '000 LE)

Item	Gravity	Lifting	
	WL.1.95m	WL.1.45m	WL.1.20m
1. Irrigation Canal			
Main canal - 9,250m	422	395	429
Secondary canal - 122,520m	2,229	1,193	1,274
Appurtenant - 159	4,438	4,438	4,438
Sub-total	7,089	6,026	6,141
2. Main Pumping Station			
M2 Station			
Equipment - 6 x 75kW	1,536	1,536	1,536
Civil works	1,129	1,129	1,129
M2-1 relift station			
Equipment - 4 x 30kW	380	-	-
Civil works	373	-	-
M2-2 relift station			
Equipment - 4 x 45kW	420	-	-
Civil works	373	-	-
Sub-total	4,211	2,665	2,665
3. Small Scale Pumping Stations			
Equipment	-	5,503	5,746
Civil works	-	2,752	2,873
Sub-total	-	8,255	8,619
Total	11,300	16,946	17,425

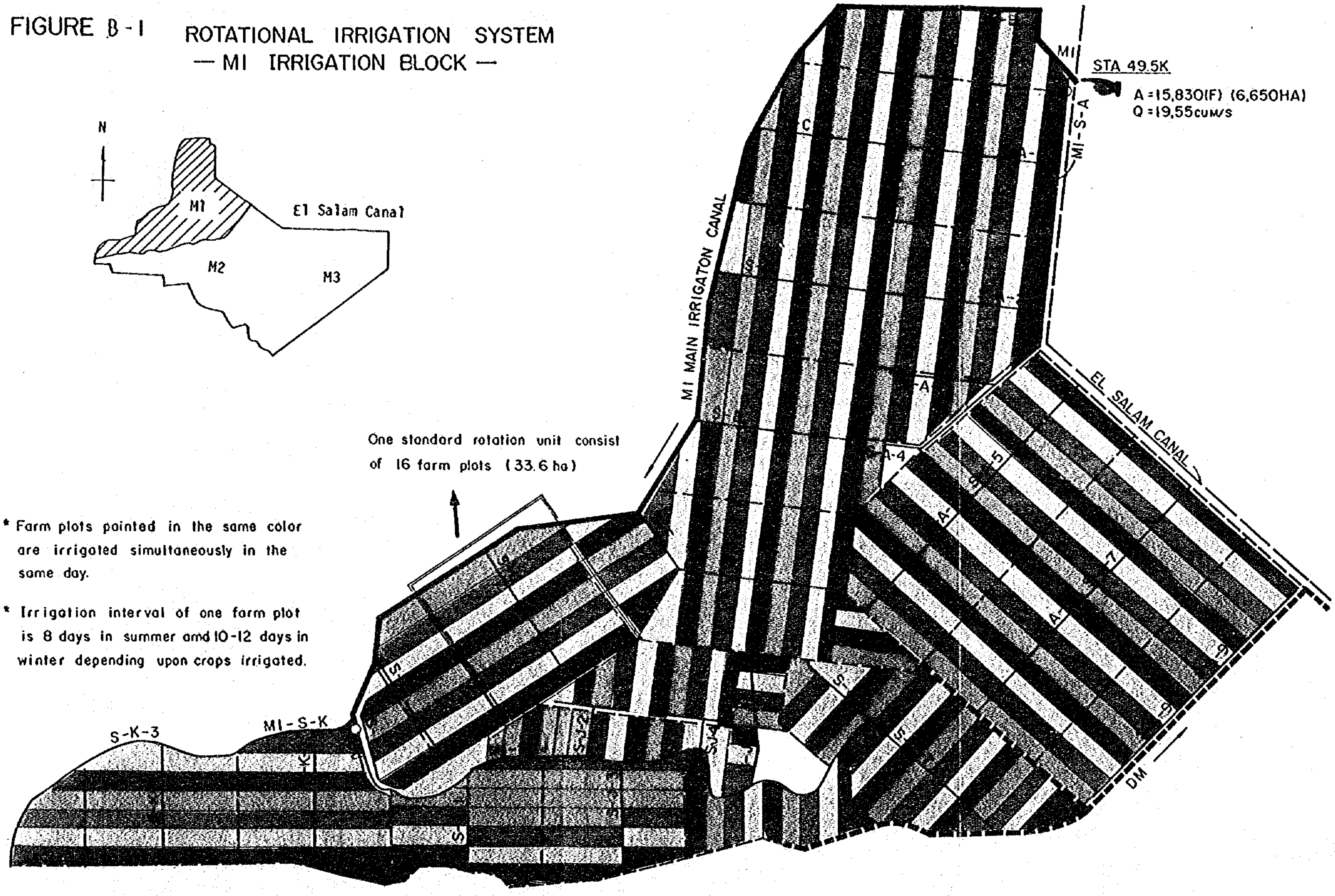
Table B-13 Annual Cost of Gravity and Lifting
- M2 Irrigation System -

(Unit: '000 LE)

Item	Gravity	Lifting	
	WL.1.95m	WL.1.45m	WL.1.20m
1. Construction Cost			
Civil works	8,964	9,907	10,143
Equipment			
- Main pump	2,336	1,536	1,536
- Small pump	-	5,503	5,746
Total	11,300	16,946	17,425
2. Annual Cost			
Amortization 1/	1,140	1,710	1,758
Maintenance 2/	296	550	567
Replacement			
- Main pump 3/	145	95	95
- Small pump 4/	-	580	606
Operation			
- Main pump 5/	36	22	22
- Small pump 6/	-	10	12
Total	1,617	2,967	3,060

Notes: 1/ ; construction cost x 0.1009 (n = 50 yrs, i = 10%)
2/ ; civil works x 0.02 + equipment x 0.05
3/ ; 0.1009 x 0.6135 x main pump (n = 10 yrs, i = 10%)
4/ ; 0.1009 x 1.0451 x small pump (n = 7 yrs, i = 10%)
5/ ; 2,380H x (5 x 75 + 3 x 75)kW x 0.025 LE/kWH
2,380H x 5 x 75kW x 0.025 LE/kWH
6/ ; 460 x 3 ps x 600H x 0.3ℓ/ps.H x 0.04 LE/ℓ
460 x 3.5 ps x 600H x 0.3ℓ/ps.H x 0.04 LE/ℓ

FIGURE B-1 ROTATIONAL IRRIGATION SYSTEM
— MI IRRIGATION BLOCK —



* Farm plots painted in the same color are irrigated simultaneously in the same day.

* Irrigation interval of one farm plot is 8 days in summer amd 10-12 days in winter depending upon crops irrigated.

B.2. Drainage

B.2.1. Drain Spacing

a. Transient Flow Method

The amount of expected deep percolation is computed, following the procedures developed by U.S. Bureau of Reclamation, to discuss spacing of drains and drainage modulus under the following conditions;

- Crop: rice being transplanted in June
- Field application efficiency: 0.75
- Depth of root zone : 0.6 m
- Depth of drain : 1.0 m
- Allowable water table : 0.4 m above drain
- Depth of barrier layer : 4.0 m (assumed)
- Permeability : 2.5×10^{-4} cm/sec = 0.22 m/day
- Deep percolation rate : 10% of surface irrigation inputs
- Specific yield : 5% by volume

A space of 26 m would meet the subsurface drainage requirement that water table should be lowered by 0.6 m below the ground surface (or Yo = 0.4 m). Table B-14 gives the fluctuation of water table.

b. Steady State Formula

Hooghoudt developed the spacing formula applicable to the case of two layers of soils of different conductivity. For homogenous soils the Hooghoudt formula is the same as the formula obtained by Donnan. In Donnan formula,

$$L^2 = \frac{4k(b^2 - a^2)}{Qd}$$

Where;

L = drain spacing, in m

K = hydraulic conductivity, in m/day

a = distance between drain depth and barrier, in m

b = distance between maximum allowable water table height between drains and the barrier, in m, and

Qd = recharge rate in m/day

In the calculation, Qd should be derived by dividing the unit depth of deep percolation from an irrigation application by the number of the days between irrigations during the peak irrigation season. For paddy cropping, peak percolation shall occur during the land preparation and soaking periods; thus, Qd = (125 mm/0.75) x 0.10/6 days = 2.8 mm/day. When, K = 0.22 m/day, a = 3.0 m, b = 3.4 m and Qd = 0.0028 m/day, using Donnan formula: L^2 = (4)(0.22)(11.6 - 9.0)/0.0028 = 2.29/0.0028 = 818, and L = 29 m as compared to 26 m by the transient flow method.

For homogeneous soils with an impermeable layer at certain depth, Do below the level of the drain and Do<1/4L, Ernst formula becomes:

$$h = \frac{qL^2}{8KD} + \frac{qL}{\pi K} \quad \ln\left(\frac{Do}{U}\right)$$

Where;

h = difference between the water level in the drains and midway between the drains, in m (0.4 m)

q = drainage discharge, in m/day (0.0028 m/day)

Do = thickness of the layer for the vertical component, in m (3.0 m)

L = drain spacing, in m

D = Do + h/2 = 3.2 m

U = wetted perimeter of drain, in m (1.0 m), and

K = hydraulic conductivity = 0.22 m/day

$$0.4 = \frac{0.0028 \times L^2}{8 \times 0.22 \times 3.2} + \frac{0.0028 \times L}{3.14 \times 0.22} \quad \ln\left(\frac{3.0}{1.0}\right)$$

L = 24 m as compared to 26 m by the transient flow method.

B.2.2. Discharge from Spaced Drain

The discharge of spaced drains can be computed using the following formulas:

$$qp = \frac{2\pi KYoD}{86,400L} \quad \text{(for drains above a barrier)}$$

Where;

qp = discharge from two sides per unit length of drain, in cu.m/s/m

Yo = maximum height of water table above drain invert, in m

K = weighted average hydraulic conductivity of soil profile between maximum water table and barrier, in m/day

D = average flow depth = D + Yo/2, in m, and

L = drain spacing, in m

Given,

L = 25 m, Yo = 0.4 m, K = 0.22 m/day, and D = 3.2 m,

q = (2 x 3.14 x 0.22 x 0.4 x 3.2)/(86,400 x 25)

$= 1.77/2.16 \times 10^{6} = 0.82 \times 10^{-6}\ m^3/s/m$

In the proposed farm plot of 5 feddan, the length of one drain would be 85 m, resulting in a drainage area of 0.21 ha (or 85 m x 25 m); thus, the discharge would be 0.07 ℓ/s/0.21 ha, or equivalent to 3.0 mm/day.

B.2.3. Open Drain and Pipe Drain

The comparison of drainage methods was made on two options of open drains and pipe drains under the following conditions:

Farm plot size	;	210 x 100 m
Gross area	;	2.1 ha
Drain spacing	;	23 m
No. of drains	;	9
Depth of drain invert	;	1.3 m
Length of drain		
Open drain	;	85 m
Pipe drain	;	95 m

a. Open Drain

i. Construction Works

Total length of drains(9x85m)	;	765 m
Typical cross section of drain		
Bed width	;	0.3 m
Depth	;	1.3 m
Side slope	;	1 : 1
Cross sectional are	;	2.08 sq.m.
Width of drain	;	5.5 m

ii. Costs per 2.1 ha

Excavation(1,591 cu.m x 0.342 LE)	;	544 LE
Embankment(551 cu.m)	;	1,377 LE
Spoiled soils	;	211 LE
Outlets	;	486 LE
Others	;	785 LE
Total	;	3,403 LE
Operation and maintenance (765m/85m/day) x 6/year x 5LE/day)	;	270 LE

iii. Annual economic benefits from crop cultivation

Benefits at full development per ha	;	1,267 LE
Gross area	;	2.1 ha

Right of way(5.5m x 765m)	;	0.42 ha
Net area(2.1 - 0.42)	;	1.68 ha
Total benefits at full development	;	2,129 LE

b. Pipe Drain

i. Construction Works

Total length of drains(9 x 95m)	;	855 m
Typical cross section of drain		
Bed width	;	0.3 m
Depth	;	1.45 m
Side slope	;	0.2 : 1
Cross sectional area	;	0.86 sq.m.

ii. Cost per 2.1 ha

Excavation (735cu.m x 0.342LE)	;	251 LE
Gravel (94cu.m x 16 LE)	;	1,504 LE
Backfill (641cu.m x 1.0 LE)	;	641 LE
Spoiled soils(94cu.m x 2.5 LE)	;	235 LE
Pipe, plastic ø150mm (855mm x 2.2LE)	;	1,880 LE
Others	;	1,353 LE
Total	;	5,864 LE
Operation and maintenance (855m/855m/day) x 6/year x 5 LE/day)	;	30 LE

iii. Annual economic benefits from crop cultivation

Benefits at full development per ha	;	1,267 LE
Net area	;	2.1 ha
Total benefits at full development	;	2,661 LE

c. Economic Consideration

Drainage systems are most often justified by comparing the direct cost of the drains with the direct benefits of maintaing or increasing crop production. Net direct benefits of farm operation are compared with the total cost of the drainage system.

Benefits do not commence at all for three years: one year for construction and two years for initial leaching. Afterwards the benefits increase gradually as follows:

Year	1	2	3	4	5	6	7	8	9	10	11	12
Benefits (LE/ha)	construction	-	-	380	494	634	735	836	963	1,039	1,140	1,267

The financial construction costs are evaluated as economic construction costs by using the conversion factor of 0.8 for foreign exchange components. The comparison is made using the present worths of benefits and estimated costs over the life of 20 years, assuming an interest rate of 10%. The following table gives the summary of costs, present worth of costs and benefits, and benefit cost ratios:

Summary of Economic Evaluation

(Unit: LE)

Item	Open Drain	Pipe Drain
Financial cost,		
Local	2,928	4,579
Foreign	475	1,285
Total	3,403	5,864
Total benefits (full development)	2,129	2,661
Present worth (n = 20 years, i = 10%)		
Benefits	9,169	11,460
Costs		
Construction	3,007	5,097
O & M	2,039	226
Total	5,046	5,323
Benefit-cost (B/C) ratio	1.82	2.15

The pipe drains will have higher B/C ratios than that of open drains, though the construction costs of the pipe drains come expensive. The low B/C ratios of open drains are mainly due to losses of land for open drains.

Table B-14 Water Table Fluctuation with Drain above the Barrier Layer and a Drain Spacing of 26 meters

Irrigation No.	t days	Irrigation (m)	Yo (m)	D (m)	Y (m)
1	20	0.17	0.40	3.19	0.02
2	8	0.07	0.18	3.08	0.09
3	8	0.19	0.16	3.07	0.15
4	8	0.19	0.34	3.07	0.18
5	8	0.19	0.37	3.17	0.19
6	8	0.19	0.38	3.18	0.19
7	8	0.19	0.38	3.18	0.19
8	8	0.19	0.38	3.18	0.19
9	8	0.13	0.38	3.18	0.19
10	8	0.13	0.32	3.15	0.16
11	8	0.13	0.30	3.14	0.15
12	8	0.13	0.28	3.13	0.15
13	8	0.13	0.28	3.13	0.14

Notes: Yo = water table height above drains at midpoint between drains immediately after each buildup

D = average depth of flow

Y = midpoint water table height above drain at end of each drain-out period

Table B-15 B/C of Open Drains

- Unit; LE -

Year	Economic Costs: Initial	O&M	Total	Crop Benefits	Present Worth Values: Costs	Benefits
1	3,308	-	3,308	-	3,007	-
2		90	90	-	74	-
3		180	180	-	135	-
4		270	270	639		436
5		↓		830		515
6				1,065	1,830 (years 6–20)	601
7				1,235		634
8				1,405		655
9				1,618		686
10				1,745		673
11				1,916		672
12				2,129		4,297 (years 12–20)
.				↓		
20						
Total					5,046	9,169

B/C = 9,169/5,046 = 1.82

Notes; Gross area = 2.1 ha
Net area = 1.68 ha
Discount rate = 10 %
Economic initial costs = 2,928 + 475 x 0.8 = 3,308 LE

Table B-16 B/C of Pipe Drains

- Unit; LE -

Year	Economic Costs: Initial	Economic Costs: O&M	Economic Costs: Total	Crop Benefits	Present Worth Values: Costs	Present Worth Values: Benefits
1	5,607	-	5,607	-	5,097	-
2		10	10	-	8	-
3		20	20	-	15	-
4		30	30	798		545
5		|	|	1,038		644
6		|	|	1,331		751
7		|	|	1,543		792
8		|	|	1,756		819
9		|	|	2,022	203	858
10		|	|	2,182		841
11		|	|	2,395		839
12		|	|	2,661		}
.		|	|	|		}
.		|	|	|		}
.		|	|	|		}
.		|	|	|		} 5,371
.		|	|	|		}
.		|	|	|		}
.		|	|	|		}
20		|	|	|		}
Total					5,323	11,460

B/C = 11,460/5,323 = 2.15

Notes; Gross area = 2.1 ha
Net area = 2.1 ha
Discount rate = 10 %
Economic initial costs = 4,579 + 1,285 x 0.8 = 5,607 LE

B.3. On-farm Development

B.3.1. Alternative Study

In due consideration of the limits of manual farm labor for vegetable cropping and effective operation of pipe drains, the length of run of a farm field is designed to be 100 m. As the acreage of a standard farm field is 2.1 ha, the size of farm field shall be 100 m by 210 m. And, the farm field shall be devided into three farm plots, each 100 m by 70 m, so as to introduce the proposed cropping pattern of three-year rotation.

The proposed on-farm development works will arrange the farm plots along the tertiary canals that is taken off from the secondary canals. In arranging the farm fields, there will be two alternatives; to arrange the length of run (100 m long) at a right angle to the tertiary canal, and to arrange the length of run parallel to the tertiary canal (refer to Figure B-2).

The comparison was made between two alternatives for their construction costs, public land, and intensity of road and canal. The layout of road and canal was based on the following criteria;

Road; Each plot shall face the road, or have the access to the road.
- -Farm road along one side of the tertiary irrigation canal
- -O & M road along one side of the tertiary drainage canal, and farm road along the other side of the tertiary drainage canal, if necessary.

Irrigation and Drainage
- -Each plot shall face the tertiary irrigation canal/farm ditch, or have the inlet.
- -Each plot shall face the tertiary drainage canal/farm drain, or have the outlet.

Figure B-2 shows typical layout of on-farm development works. Cost of construction works are given Table B-18 and B-19.

B.3.2. Design of Surface Irrigation System

a. Required Design Variables

Depth of water to be applied: The most important design variable is the depth of water to be applied at each irrigation. This is generally given as an average depth for each field even though the soil-water reservoir may not have been uniformly depleted through the field. Surface irrigation systems are designed to raise the soil water content of the root zone to its field capacity.

Hydraulic variable: The main design variables include the field slope and roughness, both of which may vary within a field.

Topography: The topography of a field limits the types of systems which can be used. Those which have rolling terrain, irregular shapes and shallow soils may be impractical to irrigate with surface systems.

Infiltration: The infiltration characteristic of the soil at each irrigation is a primary input variable. It varies with time and space. The design procedures follow closely those of the Soil Conservation Services (USDA, 1979) and its method of describing water intake by soils is followed. The basis of the SCS design is to classify the soils into intake families. The equation of these families is as follows.

$$F = aT^b + 7$$

where, F = the cumulative intake (mm)
T = the time water is in contact with the soil (min)
a, b = constants unique to each intake family

From the field observation, average infiltration characteristics of the soils in the area may be classified into the intake family of 0.20; a = 0.7772, and b = 0.699.

b. Basin Irrigation

The field to be irrigated by the basin method is divided into level rectangular areas bounded by dikes or ridges. Water is turned in at one or more points until the designed gross volume has been applied to the area. Accurate initial land leveling is essential and level surface must be maintained.

In theory, maximum depth of flow and maximum deep percolation both occur where water is introduced into a basin, usually considered as a strip of unit width for computational purposes.

The opportunity time required for intake of the selected net application depth can be estimated by solution of the cumulative intake equation in the form.

$$Tn = [(Fn - 7)/a]^{1/b} \qquad (1)$$

where, Tn = the net opportunity time (min)
Fn = the desired net application depth (mm)

The time required for the unit flow rate to advance to the far end of the strip is called the advance time, Tt(min). The required advance time for any desired water application efficiency is determined by multiplying the net opportunity time, Tn, by the efficiency advance ratio, R.

Given, Fn = 75 mm, Tn is obtained as

$$Tn = \left(\frac{75 - 7}{0.7772}\right)^{1/0.699} = 600 \text{ min}$$

Efficiency as A Function of the Efficiency Advance Ratio

Efficiency (%)	Efficiency Advance Ratio (R = Tt/Tn)	Efficieny (%)	Efficiency Advance Ratio (R = Tt/Tn)
95	0.16	75	0.80
90	0.28	70	1.08
85	0.40	65	1.45
80	0.58	60	1.90

At efficiency of 0.80 Tt/Tn = 0.58, and Tt = 0.58 x 600 = 348 min

The following mass balance equation can be used to estimate length of the basin strip as a function of unit inflow rate (Qu) and advance time (Tt).

$$L = \frac{6 \times 10^4 QuTt}{\frac{aTt^b}{1+b} + 7.0 + 1{,}798n^{3/8}Qu^{9/16}Tt^{3/16}} \qquad (2)$$

where L is the length (m); Qu is the unit inflow rate (m^2/s); Tt is the required advance time (min); a and b are constants in the cumulative intake equation; and n is Manning's coefficient.

The designed length of the basin strip can be found for any selected inflow rate, efficiency and associated required advance time, by direct solution of equation (2). A similar solution for the unit inflow rate needed for a selected length and efficiency is not possible. A trial and error procedure must be used.

Given; Unit inflow rate, Qu 0.0053 m^2/s

Manning's roughness coefficient, N 0.25

$$L = \frac{6 \times 10^4 (0.0053)(348)}{\frac{(0.7772)(348)^{0.699}}{1 + 0.699} + 7.0 + (1{,}798)(0.25)^{3/8}(0.0053)^{9/16}(348)^{3/16}}$$

= 547 m

The inflow time, the time required to apply the gross application onto the basin, can be computed from equation (3).

$$Ta = \frac{FnL}{600QuE} \qquad (3)$$

where Ta is the inflow time (min) for the unit inflow rate $Qu(m^2/s)$, to apply the net application depth Fn(mm) on a basin strip of length L(m), at an efficiency E(%).

$$Ta = \frac{75(547)}{600(0.0053)(80)} = 161 \text{ min.}$$

The maximum depth of flow can be estimated from equation (4).

$$d = 2{,}250\ n^{3/8} Qu^{9/16} Ta^{3/16} \qquad (4)$$

where d is the flow depth at the inlet end of the basin strip(mm). If advance time, Tt is greater than Ta, use Tt in equation (4) in place of Ta.

$$d = (2{,}250)(0.25)^{3/8}(0.0053)^{9/16}(348)^{3/16} = 210 \text{ mm}$$

c. Border Irrigation

The field to be border irrigated is divided into graded strips by constructing parallel dikes or border ridges. The end of strips are usually not closed. Water is turned in at the upper end and flows as a sheet down the strip. The water not infiltrated is temporarily stored on the ground surface and moves on down the strip to complete the irrigation. Outflow from the strip may be avoided by closing the lower end and ponding the water on the lower reaches of the strip until infiltrated. Border irrigation is best suited to slopes of less than 0.5 percent.

Flow rates in border irrigation must be nonerosive. The maximum flow rate per unit width should not exceed the flow as given by the following empirical criteria. For non-sodforming crops, such as alfalfa and small grains:

$$Qu\ max = (1.765 \times 10^{-4})\ So^{-0.75} \qquad (5)$$

For well-established, dense sod crops

$$Qu\ max = (3.53 \times 10^{-4})So^{-0.75} \qquad (6)$$

where Qu is the inflow rate (m^2/s), and So is the border slope (m/m). The maximum inflow rate for various border slopes and crop conditions are given as follows:

Maximum Inflow Rates, Qu

Border Slope, So (m/m)	Crop Non-sod ($10^3 m^2/s$)	Crop Sod ($10^3 m^2/s$)	Border Slope, So (m/m)	Crop Non-Sod ($10^3 m^2/s$)	Crop Sod ($10^3 m^2/s$)
0.001	31.4	62.8	0.005	9.4	18.8
0.002	18.7	37.3	0.01	5.6	11.2
0.003	13.8	27.5	0.02	3.3	6.6
0.004	11.1	22.2	0.03	2.5	4.9

The flow rate must be large enough to spread over the entire border strip. The minimum inflow rate per unit width can be computed, using equation (7).

$$Qu\ min = (5.95 \times 10^{-6} LSo^{0.5})/n \qquad (7)$$

The following table gives the minimum values of Qu/L for various slopes, So (n = 0.25).

Minimum Values of Qu/L

Border Slope, So (m/m)	Qu/L ($10^{-5}m^2/s$)	Border Slope, So (m/m)	Qu/L ($10^{-5}m^2/s$)
0.001	0.075	0.005	0.168
0.002	0.106	0.01	0.238
0.003	0.130	0.02	0.336
0.004	0.150	0.03	0.412

The maximum allowable slope for a selected net application depth, efficiency, and given intake family can be estimated from equation (7).

$$So\ max = \left(\frac{n}{0.0117E} \frac{En}{Tn} \right)^2 \qquad (7)$$

Given, n = 0.25, E = 70, En = 75 and Tn = 600, So max is obtained as 0.038 m/m (or 3.8%).

The theoretical maximum length for open-end borders is limited by the maximum allowable rate, as limited by erosion hazard on steep slopes or by the border ridge height on flat slopes. The permissible border length on soils of low intake rate and low slopes, as determined using equation (8) may exceed practical limits. The time required to patrol long lengths and the difficulties in determining and making needed inflow rate adjustments usually make these lengths impractical. Border lengths should seldom exceed 400 meters.

$$Lmax = \frac{Qu\ max\ E\ (Tn - T\ell)}{0.00167\ En} \qquad (8)$$

where Qu max is the maximum flow rate in m^2/s, as determined by the equations (5) and (6). Lag time, $T\ell$, is ignored in determination of inflow rate on borders with slopes steeper than 0.4%. Lag time for low gradient borders may be computed from equation (9).

$$T\ell = \frac{n^{1.2} Qu^{0.2}}{120\left[So + \left(\frac{0.0094\ n\ Qu^{0.175}}{Tn^{0.88} So^{0.5}} \right)\right]^{1.6}} \qquad (9)$$

The maximum lengths for steep slopes of 2% and 3% are computed for non-sod crops as follow;

So = 0.03

$$Lmax = \frac{(0.0025)(70)(600)}{(0.00167)(75)} = 838m$$

S = 0.02

$$Lmax = \frac{(0.0033)(70)(600)}{(0.00167)(75)} = 1,107m$$

Table B-17 Intensity of Road and Canal

Item	Proposed	Alternative
1. Total area (ha)	21	42
2. Length (m)		
Tertiary Canal	1,050	1,090
Farm ditch (2 x 210 x 6)	-	2,520
Sub-total	1,050	3,610
Tertiary drainage	1,050	1,090
Farm drain (2 x 210 x 5)	-	2,100
Sub-total	1,050	3,180
Total	2,100	6,800
Farm road	1,050	1,090
Cultivation road	2,100	6,620
Total	3,150	7,710
3. Intensity (m/ha)		
Canal and ditch	50	86
Drainage and drain	50	76
Roads	150	184
4. Public land (ha)		
Canal with roads	0.86	0.82
Drainage with road	1.37	1.00
Farm ditch with road	-	1.41
Farm drain with road	-	2.23
Total	2.23	5.46

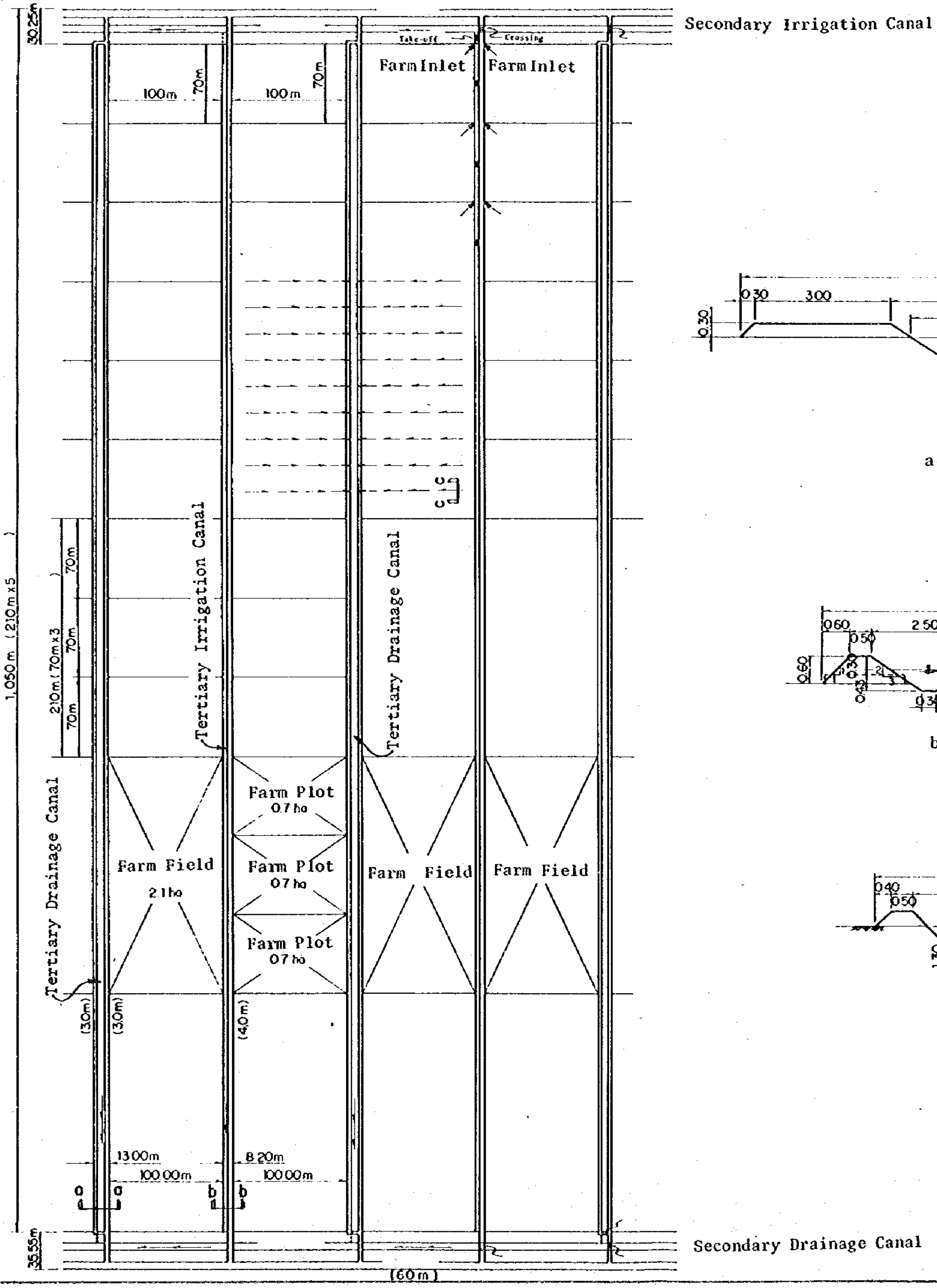
Table B-18 Construction Costs of On-farm Development (Proposed Works; 21 ha)

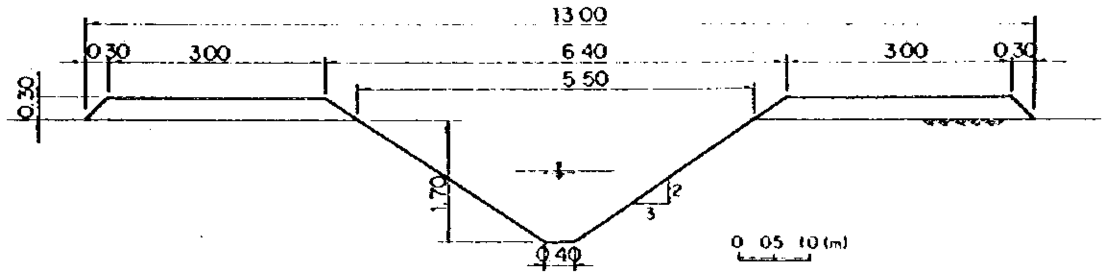
Item	Quantity	Unit Cost (LE)	Cost (LE)
1. Earth Works			
Tertiary canal with road	1,050 m	5.351	5,619
Tertiary drainage with road	1,050 m	3.009	3,159
Open drains (85m x 9 x 10)	7,650 m	2.492	19,064
Land levelling	2,877 cu.m	0.464	1,336
Sub-total			29,178
2. Appurtenant Structures			
Off-take	1	2,093	2,093
Turn-out (A)	15	30	450
Turn-out (B)	15	55	825
Ditch crossing	15	62	930
Outlet	1	820	820
Sub-total			5,118
Total			34,296
3. Cost per ha			
Earth works ; 29,178/21			1,389
Appurtenants; 5,118/21			244
Total			1,633

Table B-19 Construction Costs of On-farm Development (Alternative; 42 ha)

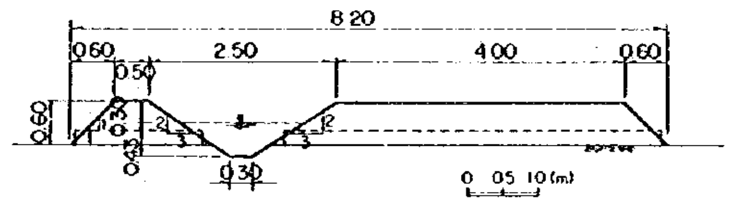
Item	Quantity	Unit Cost (LE)	Cost (LE)
1. Earth Works			
Tertiary Canal with road	1,000 m	3.944	3,944
Tertiary drainage with road	1,000 m	3.788	3,788
Farm ditch with road	2,520 m	1.632	4,112
Farm drain with road	2,100 m	2.725	5,722
Open drain (85m x 9 x 20)	15,300 m	2.66	40,698
Land levelling	5,251 cu.m	0.615	3,229
Sub-total			61,493
2. Appurtenant Structures			
Off-take	1	2,093	2,093
Division box	6	55	330
Turn-out (A)	24	18	432
Turn-out (B)	36	55	1,980
Road crossing	15	990	14,850
Outlet (A)	1	820	820
Outlet (B)	5	891	4,455
Sub-total			24,960
Total			86,453
3. Cost per ha			
Earth works; 61,493/42			1,464
Appurtenants; 24,960/42			594
Total			2,058

FIGURE B-2 LAYOUT OF PROPOSED ON-FARM DEVELOPMENT WORKS

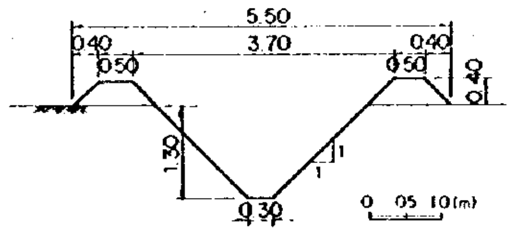




a-a Tertiary Drainage Canal



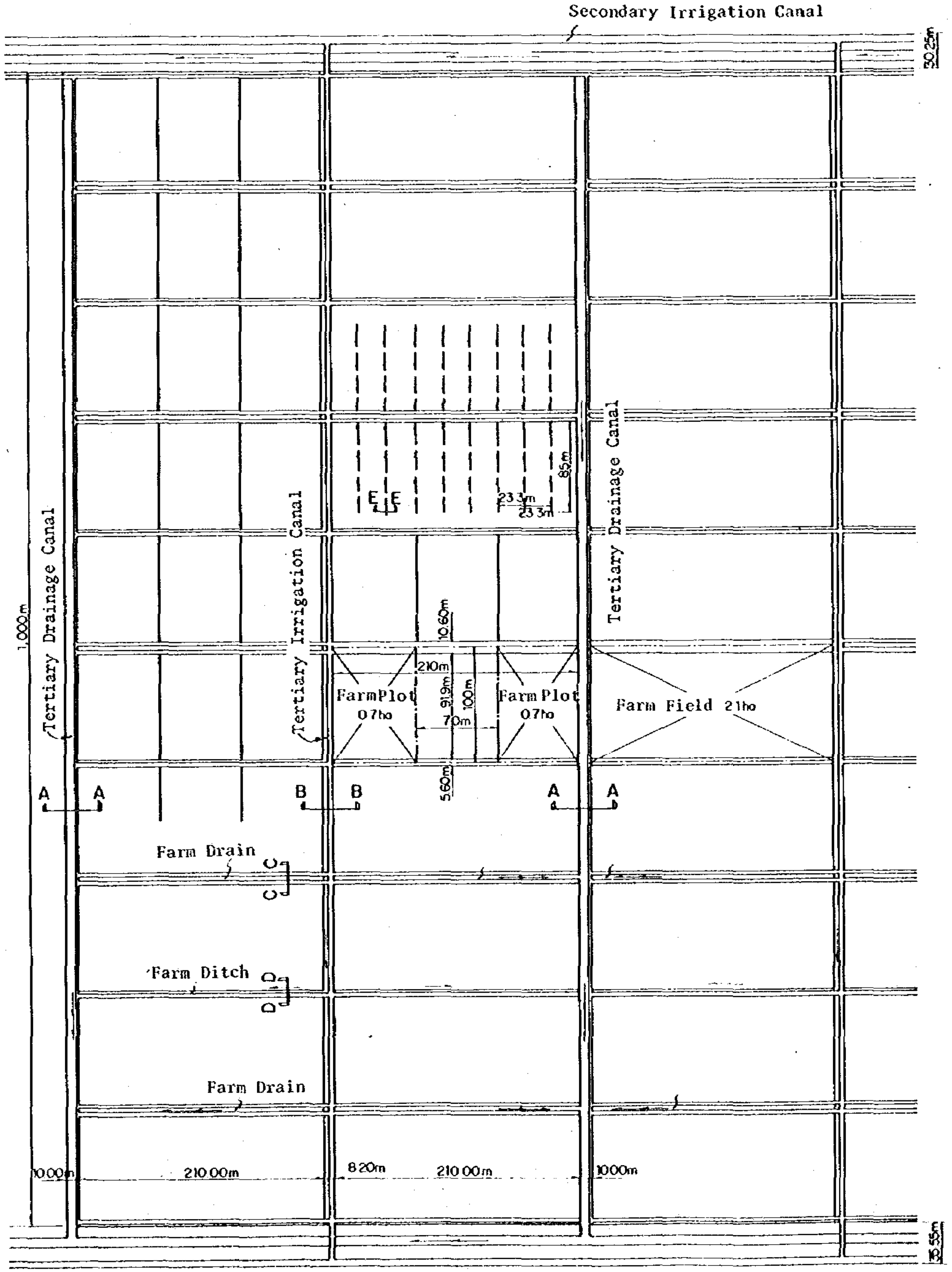
b-b Tertiary Drainage Canal



c-c Farm Drain*

* The farm drain is to be replaced by the pipe drain in the Stage II construction, 4 or 5 years after land reclamaiton has started

ARAB REPUBLIC OF EGYPT MINISTRY OF LAND RECLAMATION	
SOUTH HUSSINIA VALLEY AGRICULTURAL DEVELOPMENT PROJECT	
TYPICAL LAYOUT OF PROPOSED ON-FARM DEVELOPMENT WORKS	
DATE April 1984	DWG NO B-2
JAPAN INTERNATIONAL COOPERATION AGENCY	



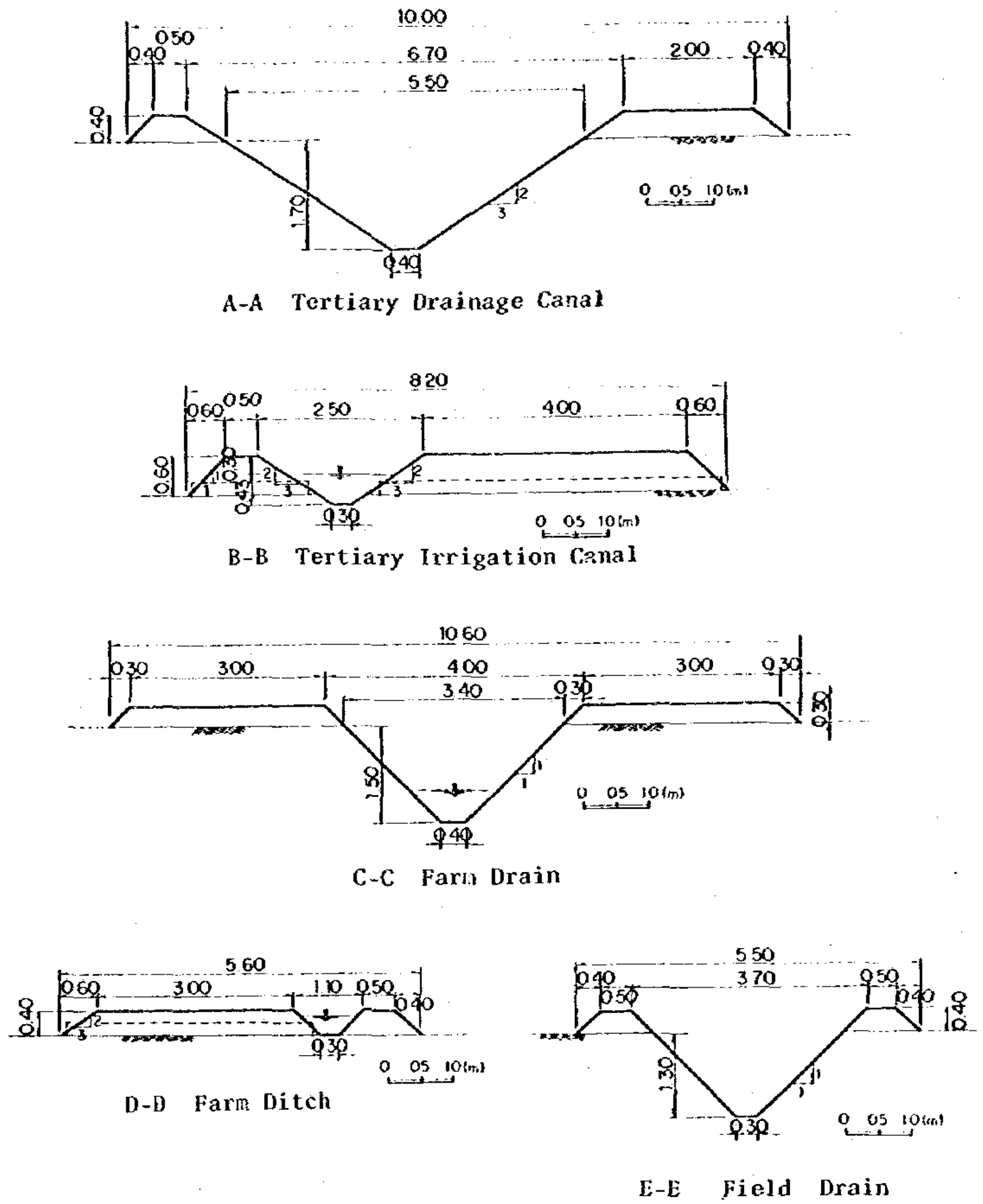


FIGURE B-3 LAYOUT OF ALTERNATIVE ON-FARM DEVELOPMENT WORKS

ARAB REPUBLIC OF EGYPT MINISTRY OF LAND RECLAMATION
SOUTH HUSSINIA VALLEY AGRICULTURAL DEVELOPMENT PROJECT
TYPICAL LAYOUT OF ALTERNATIVE ON-FARM DEVELOPMENT WORKS
DATE April 1984 DWG NO. B-3
JAPAN INTERNATIONAL COOPERATION AGENCY

B.4. Project Works

B.4.1. Alternative Study on Main Irrigation Canal

a. Slopes of Main Irrigation Canals

In consideration of topographic conditions, the project area is divided into three irrigation systems of M1, M2 and M3. The design water levels of El Salam canal and ground elevations of the irrigation systems are given below;

Irrigation System	El Salam Water Level	Irrigation Area (ha)	Ground Elevation (EL. m)
M1	EL. 2.50 m	6,650	- 0.25 ∿ 1.50
M2	EL. 1.95 m	9,670	- 0.25 ∿ 2.50
M3	EL. 1.58 m	7,090	- 0.25 ∿ 2.50

El Salam canal runs along the northern project boundary where the ground elevation is lowest. As can be seen in the above table, parts of M2 and M3 irrigation areas are higher in elevation than the designed water levels of El Salam canal, and need to construct pumping stations. In M3 irrigation area, the constrcution of a pumping station may be necessary when a steep canal slope is proposed, though the ground elevation is higher than the designed water level. In principel, the construction cost of a canal becomes cheaper as a design slope becomes steeper, as far as the designed velocity is permissible. However, the pumping capacity shall increase with increasing the canal slope.

In order to clarify the optimum slope of main irrigation canals, alternative studies were made for different slopes as summarized below. In the studies, the water levels at the end of the main canals were kept 50 cm above the ground surface so as to enable gravity irrigation at the farm level with the slope of the secondary canals of 1/10,000.

Item	Command Area (ha)			
	1/10,000	1/15,000	1/20,000	1/25,000
M1, Gravity irrigation	4,470	4,700	6,650	6,650
Pump irrigation	2,180	1,950	-	-
M2, Gravity irrigation	2,995	3,570	3,990	4,170
Pump irrigation	6,675	6,100	5,680	5,500
M3, Gravity irrigation	2,340	3,390	4,390	4,590
Pump irrigation	4,750	3,700	2,700	2,500

The topography of M1 irrigation area permits gravity irrigation for the whole area when the slope of the main canals becomes gentle more than 1/15,000. Both M2 and M3 areas need in any case to install pumping facilities in the main canal systems; M2 main station and M3 main station. In addition to M2 main pumping station, two relift stations shall be constructed in M2 area because of complicated topography. Major dimensions of irrigation facilities for alternatives are presented in Table B-20, B-21 and B-22.

The construction costs one summarized below. Details one given in Table B-23.

Item	(Unit; 1,000 LE)			
	1/10,000	1/15,000	1/20,000	1/25,000
M1, Canal	5,543	5,775	5,917	5,953
Pumping station	1,015	790	-	-
Total	6,558	6,565	5,917	5,953
M2, Canal	7,208	7,230	7,350	7,356
Pumping station	5,190	4,431	3,897	3,799
Total	12,398	11,661	11,247	11,155
M3, Canal	5,427	5,340	5,428	5,430
Pumping station	3,257	2,547	1,677	1,492
Total	8,684	7,887	7,105	6,922

Project costs used in comparing the alternative plans include construction costs, and operation and maintenance costs. The annual expenses of operating and maintaining the irrigation systems include the costs of operation, maintenance, and replacements and the costs of electric power for the pumping stations. All costs are reduced to an equivalent annual amount by amortizing over the period of analysis of 50 years. The period of analysis shall encompass that period of time over which the project will usefully serve its intended purpose. In any case, this period shall not exceed 50 years. The interest rate for amortizing costs is assumed to be 10%

The total construction costs are converted to an equivalent uniform annual amount over the period of analysis of 50 years by applying the capital recovery factor of 0.1009 (i=10%, n=50 years). The pumps, the costs of which were included in the project costs, must be replaced every 10 years. The estimated replacement costs must be discounted to the present time by applying the single payment present worth factor of 0.6135 (i=10%, n=10 year) and then this discounted value amortized over the full period of analysis in the same manner as the construction costs. Annual operating hours of pumps are estimated at 2,380 hours, and expenses required for operating pumps would be calculated with a unit cost of 0.025 LE/KWH. The terminal salvage value is disregarded as the value is small

The annual costs are summarized below. Details are given in Table B-24, B-25 and B-26.

Item	(Unit; 1,000 LE)			
	1/10,000	1/15,000	1/20,000	1/25,000
M1, Amortization	662	662	597	601
O & M	184	172	118	119
Total	846	834	715	720
(LE/ha)	(127)	(125)	(108)	(108)
M2, Amortization	1,251	1,177	1,135	1,126
O & M	505	446	405	398
Total	1,756	1,623	1,540	1,524
(LE/ha)	(182)	(168)	(159)	(158)
M3, Amortization	876	796	717	698
O & M	359	301	236	220
Total	1,235	1,097	953	918
(LE/ha)	(174)	(155)	(134)	(129)

The construction costs of main canals decrease as the canal slope becomes steeper, while the costs of pumping station increase, resulting in high annual costs. In the M1 irrigation area, the canal slope of 1/20,000 that conveys the water without lifting gives the most economical annual cost. The alternative with the slope of 1/25,000 is most economical for the areas of M2 and M3. However, the difference of annual costs from the alternative with 1/20,000 is insignificant, because, due to the topographic conditions of the areas, the increase of command area by gravity is limited. From the view point of construction engineering on earth canal, the difference of canal slope between 1/20,000 and 1/25,000 is not always significant. The project has proposed to employ the canal slope of 1/20,000 for the main canals.

As, in order to convey the water without lifting, the M1 main irrigation canal has to maintain water levels 1 ∿ 2.5 m above the ground surface, the canal will be lined with concrete over the reaches for strengthening of canal embankment (refer to B.4.1 b).

b. Lining of M1 Main Irrigation Canal vs. Lifting by Farmers

The M1 irrigation area (6,650 ha) could be irrigated with gravity through the M1 main irrigation canal that is to be lined with concrete 10 cm thick for strengthening of canal embankment. The construction costs of the M1 main irrigation canal amount to 3,961 x 10^3 LE (or, 242 LE/m), the relative cost of which is higher than those of the M2 canal (49 LE/m) and the M3 canal (41 LE/m). This is due to high embankment of canal. An alternative study was examined to save construction costs of main canals by means of lowering water levels in the canals, which needs consequently lifting by farmers at the farm level, however.

In the case of the proposed gravity irrigation method, the designed intake water level in El Salam canal is EL. 2.50 m. The construction costs of main canals varies with the intake water level. A preparatory study to estimate construction costs of main canals was made for different intake water levels of EL. 1.50 m, 1.00 m and 0.75m, and proved the intake water level of EL. 1.00 m to be recommendable, as summarized below;

	Intake Water Level (EL. m)		
Item	1.50 m	1.00 m	0.75 m
Canal Length (m)	....	16,350	....
Earth Works (1,000 cu.m)			
-Excavation	347	480	550
-Embankment	499	343	331
Construction Cost (1,000 LE)	815	679	712

In the alternative of lifting irrigation, the water levels in the main canal vary from 1.00 m above the ground surface at the head of the canal to 0.80 m below the ground surface at the tail of the canal. Designed water levels in the secondary canals range from 0.25 m to 1.30 m below the ground surface. The construction costs of the secondary canals amount to 1,178 x 10^3 LE.

Designed Water Level below Ground Surface	Irrigation Area (ha)	Canal Length (m)	Cost (1,000 LE)
0.25 m	2,705	31,150	416
0.50 m	875	5,750	45
0.75 m	890	5,750	65
1.30 m	2,180	30,900	652
Total	6,650	73,550	1,178

Small scaled pumping stations shall be installed by farmers with a converage of 21 ha per station. Major dimensions of the small scaled pumping station are given as follow;

i. Command Area; 10 farm fields — 21 ha

ii. Peak Irrigation Requirement

Canal level — 1.47 ℓ/s/ha

Field level; 0.85 x 1.47 ℓ/s/ha — 1.25 ℓ/s/ha

iii. Pump Capacity

Rotational water supply at the interval of 8 days;

8 x 1.25 ℓ/s/ha = 10 ℓ/s/ha

Pump capacity; 21 ha x 10 ℓ/s/ha = 210 ℓ/s/ha

or, 12.6 cu.m/min

iv. Pumping Station

Nos. of station;

Water Level	Total Head (H)	Nos. of Stations
0.25 m	0.75 m	2,705/21 = 130
0.50 m	1.00 m	875/21 = 42
0.75 m	1.25 m	890/21 = 48
1.30 m	1.80 m	2,180/21 = 105
		Total 325

Bore diameter (D); $D = 90\sqrt{Q} = 90 \times \sqrt{12.6} = 350$ mm

Engine output (p); $p = 0.375\ Q \times H$

Water Level	P
0.25 m	0.375 x 12.6 x 0.75 = 3.5 ps
0.50 m	0.375 x 12.6 x 1.00 = 5.0 ps
0.75 m	0.375 x 12.6 x 1.25 = 6.0 ps
1.30 m	0.375 x 12.6 x 1.80 = 8.5 ps

Construction costs of the alternative include the cost required for installation of 325 small scaled pumping stations. The construction costs are converted to the annual costs, in the same manner described previously, based on the following conditions;

- period of analysis of 50 years
- annual interest rate of 10%
- useful life of 7 years for pumps and engines
- annual operating hours of pump of 600 hours

Table B-27 and B-28 show the construction costs and annual costs, respectively. The following is a summary of estimated construction costs and annual costs.

Item	Proposed	Alternative
Construction Costs		
-Canal	8,212	4,652
-Pumping station	-	7,123
Total	8,212	11,775
Annual Costs		
-Amortization	829	1,188
-O & M	82	749
Total	911	1,937

The alternative plan may reduce the construction costs of canals by 43 % of the proposed gravity irrigation method. However, the installation costs of 325 small scaled pumping stations have exceeded the cost saved in the construction of canals, which has resulted in high annual costs. The economic evaluation has led to the conclusion that the M1 main irrigation canal should be lined with concrete in order to keep the water levels high enough for introducing gravity irrigation method.

Table B-20 Major Dimensions of Irrigation Facilities (M1 Irrigation System, 6,650 ha)

Item	Main Canal Slope 1/10,000	1/15,000	1/20,000	1/25,000
Main Canal				
Length(m)	13,350	16,000	16.350	21,900
Capacity(cu.m/s)	6.40~19.55	5.7 ~19.55	5.41~19.55	3.88~19.55
Water depth(m)	1.90 ~ 2.00	1.75 ~ 2.10	1.85 ~ 2.20	1.70 ~ 2.25
Bottom width(m)	8.50 ~ 9.50	7.00~10.50	8.00~11.00	7.00~12.00
Excavation(1,000 cu.m)	103	123	120	161
Embankment(1,000 cu.m)	1,259	1,609	1,778	2,066
Secondary Canal				
Length	76,550	73,900	73,550	68,000
Excavation(1,000 cu.m)	396	290	289	243
Embankment(1,000 cu.m)	1,128	1,055	1,050	905
M1 Main Pumping Station				
Location	STA.13+350	STA.16+000	-	-
Command area (ha)	2,180	1,950	-	-
Suction water level(EL.m)	1.17	1.41	-	-
Delivery water level(EL.m)	1.98	1.68	-	-
Water head(m)	0.90	0.30	-	-
Nos. of pump unit 1/	4	4	-	-
Capacity per unit(cu.m/min)	128	115	-	-
Bore diameter(mm)	1,000	900	-	-
Total head(m)	1.90	1.30	-	-
Motor output per unit(kw)	55	37	-	-

Note; 1/:including one stand-by unit

Table B-21 Major Dimensions of Irrigation Facilities (M2 Irrigation System; 9,670 ha)

Item	Main Canal Slope 1/10,000	1/15,000	1/20,000	1/25,000
Main Canal				
Length(m)	4,750	8,700	9,250	10,000
Capacity(cu.m/s)	19.6∿28.4	17.9∿28.4	16.7∿28.4	16.2∿28.4
Water depth(m)	2.4∿2.5	2.3∿2.7	2.4∿2.8	2.5∿2.9
Bottom width(m)	13.5∿15.0	12.5∿16.5	13.0∿18.0	14.5∿19.0
Excavation(1,000 cu.m)	140	298	317	345
Embankment(1,000 cu.m)	160	288	369	381
Secondary Canal				
Length(m)	127,020	123,070	122,520	121,770
Excavation(1,000 cu.m)	548	430	428	425
Embankment(1,000 cu.m)	1,738	1,625	1,619	1,611
M2 Main Pumping Station				
Location	STA.4+750	STA.8+700	STA.9+250	STA.10+000
Command area(ha)	6,675	6,100	5,680	5,500
Suction water level(EL.m)	1.48	1.33	1.49	1.58
Delivery water level(EL.m)	2.40	1.95	1.95	1.95
Water head(m)	1.00	0.70	0.50	0.40
Nos.of pump unit 1/	6	6	6	6
Capacity per unit(cu.m/min)	236	215	201	194
Bore Diameter(mm)	1,350	1,200	1,200	1,200
Total head(m)	2.50	1.90	1.50	1.40
Motor output per unit(kw)	150	106	78	71
Relift Pumping Station 2/				
M2-1, command area(ha)	1,165	1,165	1,165	1,165
M2-2, command area(ha)	860	860	860	860

Notes; 1/ ; including one stand-by unit

2/ ; refer to Table B-11

Table B-22 Major Dimensions of Irrigation Facilities
(M3 Irrigation System ; 7,090 ha)

Item	Main Canal Slope			
	1/10,000	1/15,000	1/20,000	1/25,000
Main Canal				
Length(m)	4,050	6,600	13,000	13,900
Capacity(cu.m/s)	14.0~20.8	10.9~20.8	7.9~20.8	7.4~20.8
Water depth(m)	2.3~2.3	2.2~2.5	2.1~2.6	2.2~2.6
Bottom width(m)	12.0~12.5	11.0~13.5	10.5~15.0	11.5~16.0
Excavation(1,000 cu.m)	108	208	449	455
Embankment(1,000 cu.m)	124	171	291	316
Secondary Canal				
Length(m)	97,370	94,820	88,420	79,420
Excavation(1,000 cu.m)	703	328	196	190
Embankment(1,000 cu.m)	1,244	1,177	1,010	985
M3 Main Pumping Station				
Location	STA.4+050	STA.6+600	STA.13+000	STA.13+900
Command area(ha)	4,750	3,700	2,700	2,500
Suction water level(EL.m)	1.18	1.14	0.93	1.06
Delivery water level(EL.m)	3.75	3.49	2.85	2.85
Water head(m)	2.60	2.40	2.00	1.80
Nos. of pump unit 1/	6	6	6	6
Capacity per unit(cu.m/min)	168	131	96	89
Bore diameter(mm)	1,200	1,000	900	900
Total head(m)	3.70	3.40	3.00	2.80
Motor output per unit(kw)	160	120	75	65

Note ; 1/; including one stand-by unit

Table B-23 Construction Costs of Alternatives

(Unit; 1,000 LE)

Item	Main Canal Slope 1/10,000	1/15,000	1/20,000	1/25,000
M1 Irrigation System				
1. Canal				
Main canal	1,089	1,381	1,531	1,785
Secondary canal	1,659	1,599	1,591	1,373
Appurtenant	2,795	2,795	2,795	2,795
Total	5,543	5,775	5,917	5,953
2. Main Pumping Station				
Motor	253	170	-	-
Pump	231	207	-	-
Accessory	80	62	-	-
Sub-total	564	439	-	-
Civil works	451	351	-	-
Total	1,015	790	-	-
Total(1 and 2)	6,558	6,565	5,917	5,953
M2 Irrigation System				
1. Canal				
Main Canal	187	323	454	472
Secondary canal	2,583	2,469	2,458	2,446
Appurtenant	4,438	4,438	4,438	4,438
Total	7,208	7,230	7,350	7,356
2. Main Pumping Station				
Motor	1,033	730	517	489
Pump	708	647	603	584
Accessory	283	226	186	179
Sub-total	2,024	1,603	1,306	1,252
Civil works	1,620	1,282	1,045	1,001
Total	3,644	2,885	2,351	2,253

- to be continued -

- brought forward -

Item	Main Canal Slope 1/10,000	1/15,000	1/20,000	1/25,000
3. Relift Pumping Station				
-M2-1 station				
Motor	140	140	140	140
Pump	164	164	164	164
Accessory	76	76	76	76
Civil works	373	373	373	373
Sub-total	753	753	753	753
-M2-2 station				
Motor	208	208	208	208
Pump	120	120	120	120
Accessory	92	92	92	92
Civil works	373	373	373	373
Sub-total	793	793	793	793
Total	1,546	1,546	1,546	1,546
Total (1,2 and 3)	12,398	11,661	11,247	11,155
M3 Irrigation System				
1. Canal				
Main canal	146	236	528	530
Secondary canal	1,951	1,773	1,569	1,569
Appurtenant	3,331	3,331	3,331	3,331
Total	5,427	5,340	5,428	5,430
2. Main Pumping Station				
Motor	1,102	827	517	448
Pump	503	393	286	266
Accessory	204	195	129	115
Sub-total	1,809	1,415	932	829
Civil works	1,448	1,132	745	663
Total	3,257	2,547	1,677	1,492
Total (1 and 2)	8,684	7,887	7,105	6,922

Table B-24 Estimates of Annual Costs
(MI Irrigation System, 6,650 ha)

(Unit: 1,000 LE)

Item	1/10,000	1/15,000	1/20,000	1/25,000
1. Construction Costs				
Canal	5,543	5,775	5,917	5,953
Pumping Station				
-Equipment	564	439	-	-
-Civil Works	451	351	-	-
Total	6,558	6,565	5,917	5,953
2. Annual Costs				
Amortization 1/	662	662	597	601
Maintenance				
-Canal 2/	111	116	118	119
-Pumping staion 3/	28	22	-	-
Operation of pump 5/	10	7	-	-
Replacement of equip. 4/	35	27	-	-
Total	846	834	715	720

Notes; 1/: 0.1009 x total construction costs (i=10%, n=50 yrs)

2/: 0.02 x construction costs

3/: 0.05 x equipment costs

4/: 0.1009 x 0.6135 x equipment costs, (i=10%, n=10 yrs)

5/: 1/10,000; 2,380 Hr x (3 x 55 KW) x 0.025 LE/KWH

1/15,000; 2,380 Hr x (3 x 37 KW) x 0.025 LE/KWH

Table B-25 Estimates of Annual Costs
(M2 Irrigation System, 9,670 ha)

(Unite; 1,000 LE)

Item	1/10,000	1/15,000	1/20,000	1/25,000
1. Construction Costs				
Canal	7,208	7,230	7,350	7,356
Pumping station				
-Equipment	2,824	2,403	2,106	2,052
-Civil works	2,366	2,028	1,791	1,747
Total	12,398	11,661	11,247	11,155
2. Annual Costs				
Amortization 1/	1,251	1,177	1,135	1,126
Maintenance				
-Canal 2/	144	145	147	147
-Pumping station 3/	141	120	105	103
Operation of pump 5/	45	32	23	21
Replacement of equip. 4/	175	149	130	127
Total	1,756	1,623	1,540	1,524

Notes; 1/ : 0.1009 x total construction costs (i=10%, n=50 yrs)

2/ : 0.02 x construction costs

3/ : 0.05 x equipment costs

4/ : 0.1009 x 0.6135 x equipment costs, (i=10%, n=10 yrs)

5/ : 1/10,000 ; 2,380 Hr x (5 x 150 KW) x 0.025 LE/KWH
1/15,000 ; 2,380 Hr x (5 x 106 KW) x 0.025 LE/KWH
1/20,000 ; 2,380 Hr x (5 x 78 KW) x 0.025 LE/KWH
1/25,000 ; 2,380 Hr x (5 x 71 KW) x 0.025 LE/KWH

Table B-26 Estimates of Annual Costs
(M3 Irrigation System, 7,090 ha)

(Unit ; 1,000 LE)

Item	1/10,000	1/15,000	1/20,000	1/25,000
1. Construction Costs				
Canal	5,427	5,340	5,428	5,430
Pumping station				
-Equipment	1,809	1,415	932	829
-Civil works	1,448	1,132	745	663
Total	8,684	7,887	7,105	6,922
2. Annual Costs				
Amortization 1/	876	796	717	698
Maintenance				
-Canal 2/	109	107	109	109
-Pumping station 3/	90	70	47	41
Operation of pump 5/	48	36	22	19
Replacement of equip. 4/	112	88	58	51
Total	1,235	1,097	953	918

Notes; 1/ : 0.1009 x total construction costs (i=10%, n=50 yrs)
2/ : 0.02 x construction costs
3/ : 0.05 x equipment costs
4/ : 0.1009 x 0.6135 x equipment costs, (i=10%, n=10 yrs)
5/ : 1/10,000 ; 2,380 Hr x (5 x 160 KW) x 0.025 LE/KWH
1/15,000 ; 2,380 Hr x (5 x 120 KW) x 0.025 LE/KWH
1/20,000 ; 2,380 Hr x (5 x 75 KW) x 0.025 LE/KWH
1/25,000 ; 2,380 Hr x (5 x 65 KW) x 0.025 LE/KWH

Table B-27 Construction Costs of Alternative (MI Irrigation System)

(Unit; 1,000 LE)

Item	Proposed	Alternative
1. Canal		
Main canal - 16,350 m	3,961	679
Secondary canal - 73,550 m	1,456	1,178
Appurtenant	2,795	2,795
Total	8,212	4,652
2. Small Scaled Pumping Station		
130 stations (0.25 m)		
Equipment, 3.5 ps	-	1,623
Civil works	-	812
42 stations (0.50 m)		
Equipment, 5.0 ps	-	586
Civil works	-	293
48 stations (0.75 m)		
Equipment, 6.0 ps	-	714
Civil works	-	357
105 stations (1.30 m)		
Equipment, 8.5 ps	-	1,825
Civil works	-	913
Total	-	7,123
Total (1 and 2)	8,212	11,775

Table B-28 Estimates of Annual Costs of Alternative (MI Irrigation System)

(Unit; 1,000 LE)

Item	Proposed	Alternative
1. Construciton Costs		
Canal	8,212	4,652
Small Scaled Pumping Station		
-Equipment	-	4,748
-Civil works	-	2,375
Total	8,212	11,775
2. Annual Costs		
Amortization 1/	829	1,188
Maintenance		
-Canal 2/	82	93
-Pumping station 3/	-	142
Operation of pump 5/	-	13
Replacement of equipment 4/	-	501
Total	911	1,937

Notes; 1/ : 0.1009 x total construction costs (i=10%, n=50 yrs) .

2/ : 0.01 x construction costs for proposed plan
0.02 x construction costs for alternative

3/ : 0.03 x equipment cost

4/ : 0.1009 x 1.0442 x equipment cost

5/ : annual operating hours of 600 hr .
fuel consumption; 600 hrs x 0.3 ℓ/ps.hr.= 180 ℓ/ps
annual fuel cost; 0.04 LE/ℓ x 180 ℓ/ps = 7.2 LE/ps
total cost; (130 x 3.5 ps + 42 x 5.0 ps + 48 x 6.0 ps + 105 x 8.5 ps) x 7.2 LE/ps

B.4.2. Irrigation Canal

a. Canal Alignment

The irrigation canals have been aligned based on the topographic map at the scale of 1;10,000 with 25 cm contours. Prior to alignment works on the basis of the above topographic map, due considerations were given to various items as follows:

- Designed water level in the El Salam canal now under construction,

- Comparison of construction costs of main and lateral canals by the irrigation method taken at on-farm level,

- Alignment of the main and lateral canals in view of the land consolidation, and

- Selection of station sites for booster pumps.

An intensive on-farm development program will be employed in the Project in consideration of the fact that the farm lands are newly-reclaimed lands to realize the rational farm management in future. As a consequence, each farm field will be of rectangle with 210 m in length of run and 100 m in width, and the long side shall face the farm road and the tertiary irrigation canal. The canal alignment has been made in taking into account the layout mentioned above so as to reduce the land levelling cost in earth works.

The Project Area is unevely divided by the Ramses Drain running through the Area into two; one covers 6,650 ha, namely M_1 block, and the other 16,760 ha. Conveniently, however, the topographic map indicates that two hillocks cross in direct angle to the El Salam canal, and in making better use of these hillocks, the Area can be divided into three irrigation blocks, namely M_1, M_2 and M_3, which cover 6,650 ha, 9,670 ha and 7,090 ha, respectively, in approximately even acreages.

One main canal will be provided in each irrigation block and these main canals will extend about 16 km, 9 km and 13 km, respectively, and their alignment shall run along the possibly elevated parts of the Area to sufficiently secure the water head given by the El Salam Canal.

Block M1 (6,650 ha)

The water to be supplied to this block shall be diverted at the Station No.49.6 on the El Salam canal and the main canal is laid out along the relatively higher-elevated portion along the Saft drain. Consideration was given to provision of gravity irrigation system to cover the whole Project Area according to the designed water level of the El Salam canal, which has become available since canals were designed to be lined with concrete.

Block M2 (9,670 ha)

Diverting the water to this block shall be made at Station No.61.0 on the El Salam canal, and the main irrigation canal is to be laid out along the high elevated strip land extending southwest. In this case, it has become necessary to install booster pumps at the end point of the main canal, the Station No.9.3 km on the secondary canal S-M and at the end point of the secondary canal S-N-2, although the designed water level ot the El Salam canal is planned to be fully utilized. This is unavoidable due to the fact that the elevation of the irrigable area in the southwest is comparatively high.

Block M3 (7,090 ha)

The water diversion point for this Block is the Station No.70.3 on the El Salam canal. In the topographic conditions quite similar to those of the Block M2 booster pumps shall be installed at the end point on the main irrigation canal even with the designed water level of the El Salam canal to be fully utilized.

Alignment for the secondary canals should be made in considering the topographic conditions prevailing in the related areas as well as for the main canals. The proposed secondary canal alignment has been so arranged as to run along the hillocks for the intricated topography, while about 2 km intervals for the flat lands to cope with the requirement of land consolidation works. When the water is diverted directly from the main canal to the tertiary canal, double channels shall be provided along the main canal for smooth water diversion.

b. Canal Profile (refer to Drawing No.4 and 5)

The canal profile has been determined based on the proposed canal route drawn in the topographic maps developed from the field surveyings. And then the canal section has been determined as well as water head has been properly allocated based on the design discharge and canal type. The Manning's formula was applied to the hydraulic computation for the purpose.

Cross-section

The cross section of canal will be of trapezoidal shape with side slopes determined from stability studies of bank materials and empirical considerations. Usually, a side slope of 1-1/2 : 1 is used. Roughness coefficients (n) are 0.025 for earth canal and 0.015 for concrete lined canal.

Freeboard

An adequate freeboard should be provided to furnish a factor of safety against rise of water surface above the computed normal flow due to error in operation, and variation in the canal friction coefficient. The freeboard so provided will also allow, to a certain extent, operational flexibility such as occasionally applying a larger than the designed amount of water over a short period of time. Usually, the freeboard will be determined by 50 cm.

Road and Berm

The canal will be provided with a road on one side. The Road width is determined by either requirement for operating equipment or requirement for minimizing seepage and protecting the integrity of the canal against by damage from mechanized farm equipments, the width shall be 6.0 m for secondary canal and 8.0 m for main canals. Adjacent to the road, outside the canal, 6 m wide lots are provided for street trees, costs of which are not included in the project, however. On the other side of canal, berm with 5 m width is provided for use of heavy equipment for operation and maintenance. When water section is partially or entirely on fill, careful compaction of embankment is necessary to prevent excess seepage and percolation through fill.

Hydraulic dimensions of irrigation canals are presented in Table B-29 and Drawing No.4 and 5.

c. Canal Length

Total canal length amounts to 323,090 m, as summarized below. Details of canal length are listed in Table B-30 and B-31.

Irrigation System	Canal Length (m) Main	Secondary	Total
M1	16,350	73,550	89,900
M2	9,250	122,520	131,770
M3	13,000	88,420	101,420
Total	38,600	284,490	323,090

Note: Refer to Figure B-4 " Irrigation and Drainage System"

The tail escape canals will be constructed to connect the irrigation canal with the drainage canal for better water management. The cross section is same as S1 irrigation canal and the outlet facility with a sluice gate is installed at the end of irrigation canal. The total length of tail escape canals amount to 14,500 m as summarized below;

Irrigation System	Length (m)	Outlet
M1	4,250	28
M2	6,550	37
M3	3,700	28
Total	14,500	93

d. Water Measuring Devices

Effective use of water requires that flow rate and volumes be measured and expressed quantatively. Water measurement is based on application of the formular; Q = a.v, where, Q = flow rate, volume per unit time, a = cross sectional area of flow, and v = mean velocity of flow. Flow measurement involves the determination of mean velocity and area of flow. Thus, some techniques utilize each of these determinations separately and use them directly as in the above equation.

In the selection of a measuring device suited to the project, the following locational situation is considered;

- The water head loss shall be small as the topography of the area is very flat.
- The measuring device shall not cause silting in the structures as most canals are of earth canal, having relatively small velocity.
- Operation and Maintenance shall be easy.
- Costs for construction and maintenance shall be economical

There are various kinds of measuring devices available with built-in avantages and disadvantages depending on the locational situation. The various types of measuring devices include the following;

i. Parshall flume - it is a device used to measure the flow of water by nothing the loss of head caused by forcing a stream of water through a throat or section of a flume with a depressed bottom. Advantages are; (1) relatively accurate, (2) small head loss, (3) wide range of measurement capability, (4) non-silting, and (5) accuracy is affected only very slightly by velocity of approach. Disadvantages are; (1) high construction cost, (2) higher skill needed in construction, (3) a straight canal is needed for its installation, and (4) it can not be used in close combination with turnouts because the inflow must be uniform and the water surface relatively smooth.

ii. Weir - It is a simple and practical device commonly used in measuring water supplies. It is an accurate measuring device when operated under properly controlled conditions. It obstructs flow of water to creat a pond and the water passed over a crest for measurement. Advantages are; (1) a relatively high degree of accuracy, and (2) easy construction. Disadvantages are; (1) large head loss, (2) removal of collected debris and deposits is needed, and (3) accurancy is affected by velocity of approach.

iii. Open-flow meter - It is a propeller-type meter which may be installed at the end of a gravity pipe turnout to measure and record the rate of flow of water. Open-flow meters are commercially available for pipe diameters ranging from 4 to 72 inches. Advantages are; (1) flow rate and volume can be read directly thus eliminating computation, (2) relatively high accuracy; however, measurement accuracy is likely to be affected when the velocity of the water is less than about 0.45 m/s, and (3) the head loss is very small. Disadvantages are; (1) initial cost of open-flow meter is usually relatively high, (2) maintenance costs may be high, particularly if the meter is used in the water that contains appreciable sediment, and (3) meters should be inspected and serviced at regular intervals.

The open-flow meter is not recommendable to the project because of its high costs for construction and maintenance, and debris and sediment anticipated. As the topography of the area is very flat, the measurement device to be employed must be a type that the water loss required for measurement is smallest as much as possible. In this regard, the Parshall flume is best suited and is recommendable. Besides large head loss, disadvantages of the weir type are deposits at the upstream of the weir, which affects the measurement accuracy, and scoring the foundation of canals downstream the weir.

Even if the topography of the area permits to install the wier, the canal upstream the weir must be lined for a reach about 5 ∿ 10 times water depth, to creat smooth flow of water, and the downstream canal from the weir be protected against scoring. These additional works needed for maintaining accuracy of measurement shall increase installation costs of the weir. According to a case study (Q = 2.0 cu.m/s, I = 1/10,000), costs required for the constrcution of the weir exceeded costs for Parshall flume.

B.4.3. Drainage Canal

a. Canal Alignment and Profile

The drainage canal alignment as well as the irrigation canal alignment is determined depending on the topography prevailing in the related areas. The Project Area, in general, dips from southeast to northeast, although partially intricated in its topography. The drainage canal alignment, accordingly, has been made to meet the requirements of land consolidation in the flat lands, while to meet the topography in the intricate land conditions. The main drainage canal, aligned along the El Salam canal, shall be linked with drainage pumping station so as to drain the water to the Bahr Baqar drain.

The studies on the main and lateral canal profiles based on the topographic maps developed from the field surveyings, have resulted in a plan to construct a main drainage canal and three sub-main canals. The canal slopes were designed by 1/20,000 for the main canals and 1/10,000 for the lateral canals. When adopting these values in slopes, the average flow velocity ranges from 0.25 m/sec to 0.4 m/sec. The cross-section of drainage canals was determined, taking into account the designed drainage discharge, canal profile and canal type. And detailed studies on the most effective cross-section in hydraulics and safety to scouring have resulted in employing the criteria provided by the Egyptian Government (MOI).

Hydraulic dimensions of drainage canals are presented in Table B-32 and Drawing No.6.

b. Canal Length

Total canal length amounts to 295,550 m ; 44,350 m of main canals and 251,200 m of secondary canals (refer to Table B-33).

Table B-29   Hydraulic Dimensions of Irrigation Canal

Canal	Bed Width (m)	Water Depth (m)	Flow Area (sq.m)	Velocity (m/s)	Discharge (cu.m/s)
-Main Canal (concrete lining ; I = 1/20,000)					
M1-1	11.0	2.15	30.58	0.65	19.88
M1-2	8.5	1.90	21.57	0.59	13.73
M1-3	7.5	1.80	18.36	0.57	10.47
M1-4	6.0	1.55	12.90	0.50	6.45
M3-1	11.3	2.20	32.12	0.66	21.20
-Main Canal (earth canal ; I = 1/20,000)					
M2-1	18.0	2.75	60.84	0.48	29.20
M2-2	16.0	2.60	51.74	0.46	23.80
M2-3	13.3	2.37	39.97	0.42	16.79
M3-2	15.0	2.53	47.55	0.44	20.92
M3-3	12.0	2.25	34.59	0.41	14.18
M3-4	10.5	2.10	28.67	0.38	10.89
-Secondary canal (earth canal ; I = 1/20,000)					
M1-S-A	8.6	1.91	21.90	0.36	7.88
M1-S-J	6.0	1.57	13.12	0.31	4.07
M2-S-C	6.0	1.57	13.12	0.31	4.07
M2-S-M	8.8	1.93	22.57	0.36	8.13
M2-S-N	9.2	1.97	23.95	0.37	8.86
M2-S-N-2	6.9	1.71	16.19	0.33	5.34
M3-S-Q	6.4	1.64	14.53	0.32	4.65
-Secondary Canal (earth canal ; I = 1/10,000)					
S1	1.5	0.75	1.97	0.24	0.47
S2	2.0	1.00	3.50	0.29	1.02
S3	2.5	1.25	5.47	0.34	1.86
S4	3.0	1.50	7.88	0.38	2.99
S5	3.5	1.75	10.72	0.42	4.50

Table B-30 Lists of Main Irrigation Canal

Canal	Length (m)	Service Area (ha)	Water Requirement (cu.m/s)
(M1 Irrigation System)			
M1-1	50	6,650	19.55
M1-2	7,700	4,190	12.32
M1-3	5,600	3,420	10.05
M1-4	3,000	2,180	6,41
Sub-total	16,350 1/		
(M2 Irrigation System)			
M2-1	1,450	9,670	28,43
M2-2	5,450	8,050	23.67
M2-3	2,350	5,680	16.70
Sub-total	9,250		
(M3 Irrigation System)			
M3-1	700 1/	7,090	20.84
M3-2	3,350	6,885	20.24
M3-3	2,550	4,750	13.97
M3-4	6,400	3,700	10.88
Sub-total	13,000		
Total	38,600	23,410	

Note ; 1/ ; concrete lining canals

Table B-31 List of Secondary Irrigation Canal

Canal	Length (m)	Service Area (ha)	Canal Capacity (cu.m/s)	Canal Type
(M1 Irrigation System)				
S-A	8,800	2,460	7.23	M1-S-A
S-A-1	1,900	340	1.00	S-2
S-A-2	1,950	310	0.91	S-2
S-A-3	1,400	90	0.26	S-1
S-A-4	500	30	0.09	S-1
S-A-5	1,900	290	0.85	S-2
S-A-6	1,900	310	0.91	S-2
S-A-7	1,900	350	1.03	S-3
S-A-8	1,900	340	1.00	S-2
S-A-9	2,000	330	0.97	S-2
S-A-9a	1,900	175	0.51	S-2
S-A-9b	1,900	160	0.47	S-1
S-B	3,200	245	0.72	S-2
S-C	1,700	285	0.84	S-2
S-D	2,000	240	0.71	S-2
S-E	2,050	350	1.03	S-3
S-F	3,850	575	1.69	S-3
S-G	1,900	315	0.93	S-2
S-H	1,400	151	0.44	S-1
S-I	1,200	70	0.21	S-1
S-J	8,950	1,320	3.88	M1-S-J
S-J-1	1,200	195	0.57	S-2
S-J-2	1,650	65	0.19	S-1
S-J-3	1,450	195	0.57	S-2
S-J-4	1,050	85	0.25	S-1
S-J-5	1,550	90	0.26	S-1
S-J-6	1,100	80	0.24	S-1
S-J-7	2,950	315	0.93	S-2
S-K	2,700	639	1.88	S-4
S-K-1	1,600	265	0.78	S-2
S-K-2	1,350	250	0.74	S-2
S-K-3	2,750	75	0.22	S-1
Sub-total	73,550			
(M2 Irrigation System)				
S-A	1,800	85	0.25	S-1
S-B	1,000	60	0.18	S-1
S-C	5,750	1,350	3.97	M2-S-C
S-C-1	2,200	280	0.82	S-2
S-C-2	2,200	210	0.62	S-2

Canal	Length (m)	Service Area (ha)	Canal Capacity (cu.m/s)	Canal Type
S-C-3	1,650	140	0.41	S-1
S-C-4	1,950	290	0.85	S-2
S-C-5	450	55	0.16	S-1
S-D	1,800	125	0.37	S-1
S-E	50	525	1.54	S-3
S-E-1	1,900	180	0.53	S-2
S-E-2	3,900	345	1.01	S-2
S-F	2,100	135	0.40	S-1
S-G	2,850	110	0.32	S-1
S-H	4,600	280	0.82	S-2
S-I	2,350	200	0.59	S-2
S-J	1,900	125	0.37	S-1
S-K	1,650	780	2.29	S-4
S-K-1	1,900	160	0.47	S-1
S-K-2	1,900	160	0.47	S-1
S-K-3	1,350	90	0.26	S-1
S-K-4	2,900	370	1.09	S-3
S-L	2,150	215	0.63	S-2
S-M	9,300	2,730	8.03	M2-S-M
S-M-1	2,350	200	0.59	S-2
S-M-2	2,450	190	0.56	S-2
S-M-3	3,450	560	1.65	S-3
S-M-3a	600	65	0.19	S-1
S-M-3b	1,150	135	0.40	S-1
S-M-4	1,770	325	0.96	S-2
S-M-5	1,200	360	1.06	S-3
S-M-5a	2,000	125	0.37	S-1
S-M-5b	1,250	145	0.43	S-1
S-M-6	2,400	335	0.98	S-2
S-M-7	5,950	805	2.37	S-4
S-M-7a	1,300	65	0.19	S-1
S-M-7b	2,700	135	0.40	S-1
S-N	1,100	2,950	8.67	M2-S-N
S-N-1	3,300	270	0.79	S-2
S-N-2	5,100	1,750	5.15	M2-S-N-2
S-N-2a	2,420	495	1.46	S-3
S-N-2b	900	45	0.13	S-1
S-N-2c	1,900	55	0.16	S-1
S-N-2d	1,750	170	0.50	S-2
S-N-2e	1,700	155	0.46	S-1
S-N-2f	3,840	380	1.12	S-3
S-N-2g	2,570	325	0.96	S-2
S-N-3	3,800	930	2.73	S-4
S-N-3a	2,400	325	0.96	S-2
S-N-3b	1,250	180	0.53	S-2
S-N-3c	1,520	280	0.82	S-2
S-N-3d	800	145	0.43	S-1
Sub-total	122,520			

Canal	Length (m)	Service Area (ha)	Canal Capacity (cu.m/s)	Canal Type
(M3 Irrigation System)				
S-A	1,900	125	0.37	S-1
S-B	1,900	80	0.24	S-1
S-C	3,400	325	0.96	S-2
S-D	1,770	670	1.97	S-4
S-D-1	1,900	325	0.96	S-2
S-D-2	1,900	345	1.01	S-2
S-E	4,000	225	0.66	S-2
S-F	800	100	0.29	S-1
S-G	2,150	735	2.16	S-4
S-G-1	1,900	180	0.53	S-2
S-G-2	1,000	80	0.24	S-1
S-G-3	1,900	360	1.06	S-3
S-G-4	2,050	125	0.37	S-1
S-H	2,900	80	0.24	S-1
S-I	1,150	1,050	3.09	S-5
S-I-1	3,500	715	2.10	S-4
S-I-1a	1,900	345	1.01	S-2
S-I-1b	620	125	0.37	S-1
S-I-1c	1,900	180	0.53	S-2
S-I-1d	630	65	0.19	S-1
S-I-2	1,400	265	0.78	S-2
S-I-2a	600	55	0.16	S-1
S-I-2b	900	45	0.13	S-1
S-J	3,000	290	0.85	S-2
S-K	1,000	55	0.16	S-1
S-L	3,000	235	0.69	S-2
S-M	2,500	110	0.32	S-1
S-N	2,500	165	0.49	S-2
S-O	2,250	145	0.43	S-1
S-P	4,600	1,150	3.38	S-5
S-P-1	2,650	200	0.59	S-2
S-P-2	1,650	185	0.54	S-2
S-P-3	1,900	135	0.40	S-1
S-P-4	2,700	235	0.69	S-2
S-P-5	800	45	0.13	S-1
S-Q	5,200	1,550	4.56	M3-S-Q
S-Q-1	2,800	240	0.71	S-2
S-Q-2	1,900	345	1.01	S-2
S-Q-3	1,000	415	1.22	S-3
S-Q-3a	2,100	160	0.47	S-1
S-Q-3b	1,900	180	0.53	S-2
S-Q-3c	2,900	75	0.22	S-1
Sub-total	88,420			
Total	284,490			

Table B-32 Hydraulic Dimensions of Drainage Canal

Canal	Bed Width (m)	Water Depth (m)	Flow Area (sq.m)	Velocity (m/s)	Discharge (cu.m/s)
- Main Canal (earth canal, I = 1/20,000)					
DM(1)	13.0	1.85	29.18	0.37	10.80
DM(2)	11.0	1.60	21.44	0.33	7.08
DM(3)	10.5	1.46	18.53	0.32	5.93
DM(4)	8.0	1.10	10.62	0.26	2.76
DM(5)	7.5	1.12	10.28	0.26	2.67
DM-1	7.0	1.01	8.60	0.25	2.15
DM-2	7.5	1.12	10.28	0.26	2.67
DM-3	7.5	1.09	9.96	0.26	2.59
- Secondary Canal (earth canal, I = 1/10,000)					
DM, L-J	3.5	0.50	2.13	0.22	0.47
DM, L-O	5.5	0.80	5.36	0.30	1.61
DM, L-P	4.5	0.68	3.75	0.26	0.98
DM1, L-B	4.5	0.68	3.75	0.26	0.98
DM1, L-C	4.0	0.53	5.91	0.23	0.58
DM3, L-C	5.0	0.76	4,67	0.28	1.31
DM3, L-D	4.0	0.62	3.06	0.25	0.77
S-1	0.5	0.25	0.22	0.12	0.03
S-2	1.0	0.50	0.88	0.18	0.16
S-3	1.5	0.75	1.97	0.24	0.47
S-4	2.5	0.75	2.72	0.26	0.71

Table B-33 List of Drainage Canal

1. Main Canal

Canal	Length (m)	Drainage Area (ha)	Canal Capacity (cu.m/s)	Canal Type
DM (1)	9,850	19,820	12.09	DM (1)
(2)	5,570	11,500	7.02	DM (2)
(3)	4,150	9,380	5.72	DM (3)
(4)	2,850	4,500	2.75	DM (4)
(5)	1,480	4,370	2.67	DM (5)
Sub-total	23,900			
DM-1	8,850	3,425	2.09	DM-1
DM-2	8,650	4,380	2.67	DM-2
DM-3	2,950	4,160	2.54	DM-3
Sub-total	20,450			
Total-Main	44,350			

2. Secondary Canal

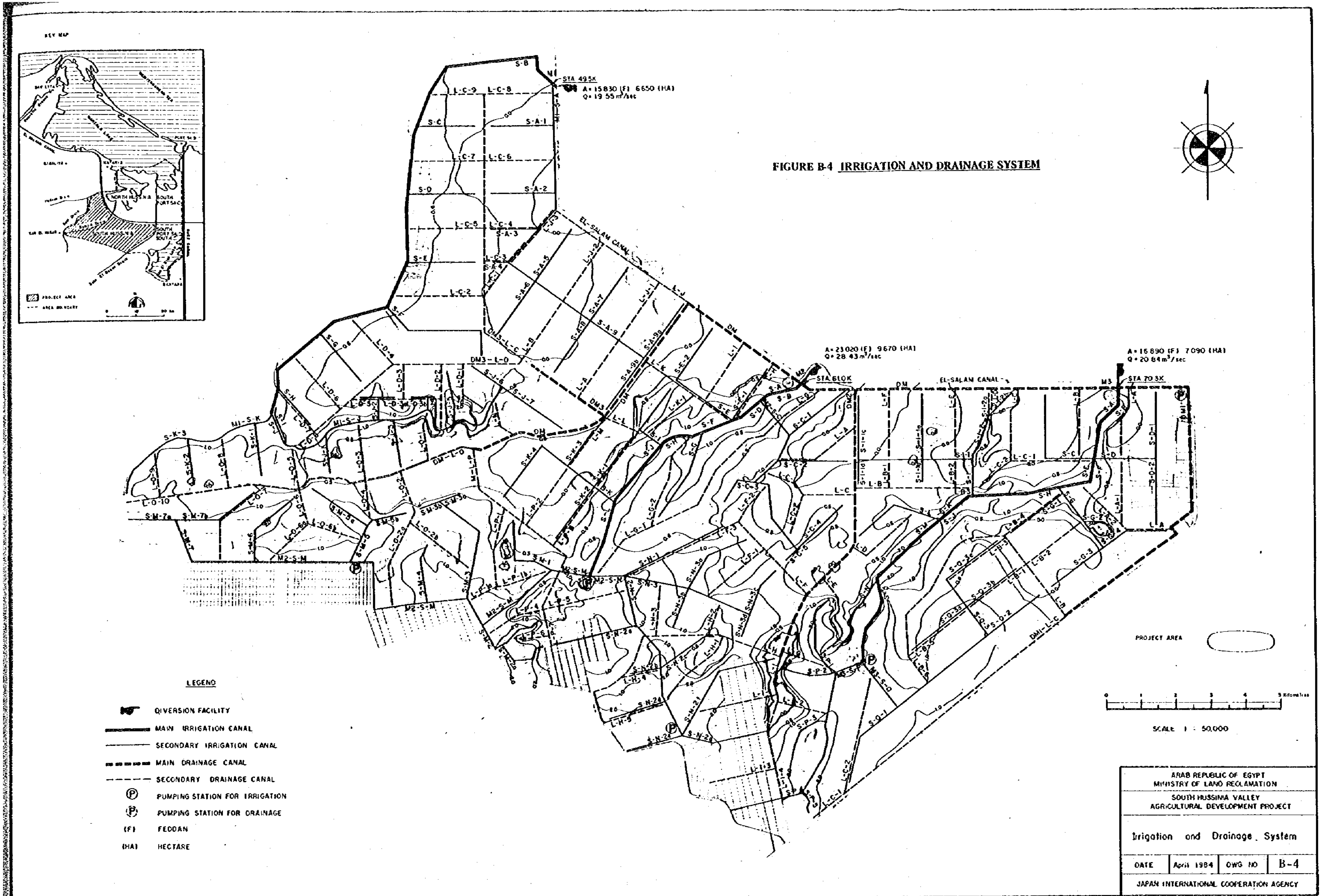
Canal		Canal Length (m)	Drainage Area (ha)	Canal Capacity (cu.m/s)	Canal Type
DM	L-J	3,000	770	0.47	DM L-J
	L-O	9,300	2,610	1.59	DM L-O
	L-P	7,100	1,590	0.97	DM L-P
DM1	L-B	8,250	1,595	0.97	DM1 L-B
	L-C	8,300	940	0.57	DM1 L-C
DM3	L-C	8,400	2,140	1.31	DM3 L-C
	L-D	5,800	1,220	0.74	DM3 L-D
Sub-total		50,150			

Canal		Length (m)	Drainage Area (ha)	Canal Capacity (cu.m/s)	Canal Type
DM	L-A	2,150	205	0.13	S-2
	L-B	2,100	260	0.16	S-2
	L-C	2,250	470	0.29	S-3
	L-C-1	2,350	155	0.09	S-2
	L-C-2	1,400	85	0.05	S-2
	L-D	800	30	0.02	S-1
	L-E	2,100	270	0.16	S-2
	L-F	2,100	310	0.19	S-3
	L-G	6,550	1,020	0.62	S-4
	L-G-1	2,300	200	0.12	S-2
	L-G-2	2,850	190	0.12	S-2
	L-H	2,100	70	0.04	S-2
	L-I	2,100	310	0.19	S-3
	L-J-1	2,100	320	0.20	S-3
	L-J-2	2,100	320	0.20	S-3
	L-J-3	3,800	130	0.08	S-2
	L-K	3,000	180	0.11	S-2
	L-K-1	1,850	130	0.08	S-2
	L-L	3,100	105	0.06	S-2
	L-M	1,800	145	0.09	S-2
	L-N	1,350	60	0.04	S-2
	L-O-1	1,500	90	0.05	S-2
	L-O-2	1,650	570	0.35	S-3
	L-O-2a	2,650	300	0.18	S-3
	L-O-2b	2,300	270	0.16	S-2
	L-O-3	1,700	220	0.13	S-2
	L-O-4	1,200	90	0.05	S-2
	L-O-5	1,200	190	0.12	S-2
	L-O-6	1,050	270	0.16	S-2
	L-O-6a	1,650	160	0.10	S-2
	L-O-6b	1,650	110	0.07	S-2
	L-O-7	2,800	270	0.16	S-2
	L-O-8	1,500	220	0.13	S-2
	L-O-9	1,400	180	0.11	S-2
	L-O-10	1,000	45	0.03	S-1
	L-P-1	2,350	270	0.16	S-2
	L-P-1a	950	70	0.04	S-2
	L-P-1b	1,500	80	0.05	S-2
	L-P-2	2,100	300	0.18	S-3
	L-P-3	2,100	170	0.10	S-2
	L-P-4	1,800	130	0.08	S-2
	L-P-5	2,600	290	0.18	S-3
	L-P-6	1,100	20	0.01	S-1
	L-P-7	1,500	170	0.10	S-2
Sub-total		89,500			

Canal		Length (m)	Drainage Area (ha)	Canal Capacity (cu.m/s)	Canal Type
DM1	L-A	1,600	310	0.19	S-3
	L-A-1	1,950	240	0.15	S-2
	L-A-2	1,600	70	0.04	S-2
	L-B-1	2,100	145	0.09	S-2
	L-B-2	2,100	320	0.20	S-3
	L-B-3	2,100	160	0.10	S-2
	L-B-4	2,100	80	0.05	S-2
	L-B-5	2,300	170	0.10	S-2
	L-B-6	1,000	110	0.07	S-2
	L-C-1	1,200	65	0.04	S-2
	L-C-2	3,500	330	0.20	S-3
Sub-total		21,550			
DM2	L-A	2,600	210	0.13	S-2
	L-B	3,000	340	0.21	S-3
	L-B-1	850	120	0.07	S-2
	L-B-2	850	90	0.05	S-2
	L-B-3	500	50	0.03	S-1
	L-C	1,600	350	0.21	S-3
	L-C-1	1,300	100	0.06	S-2
	L-C-2	1,300	100	0.06	S-2
	L-D	2,450	170	0.10	S-2
	L-E	2,900	90	0.05	S-2
	L-F	2,950	600	0.37	S-3
	L-F-1	2,250	240	0.15	S-2
	L-F-2	1,300	110	0.07	S-2
	L-F-3	3,700	170	0.10	S-2
	L-G	1,400	40	0.02	S-1
	L-H	6,400	1,020	0.62	S-4
	L-H-1	2,500	200	0.12	S-2
	L-H-2	1,000	150	0.09	S-2
	L-H-3	1,500	145	0.09	S-2
	L-H-4	1,200	85	0.05	S-2
	L-H-5	2,850	135	0.08	S-2
	L-I	3,400	860	0.52	S-4
	L-I-1	2,400	310	0.19	S-3
	L-I-2	1,600	170	0.10	S-2
	L-I-3	2,000	250	0.15	S-2
	L-I-4	950	45	0.03	S-1
Sub-total		54,750			
DM3	L-A	2,100	310	0.19	S-3
	L-B	2,100	310	0.19	S-3
	L-C-1	1,200	150	0.09	S-2
	L-C-2	2,600	350	0.21	S-3
	L-C-3	1,550	80	0.05	S-2
	L-C-4	2,400	140	0.09	S-2

Canal	Length (m)	Drainage Area (ha)	Canal Capacity (cu.m/s)	Canal Type
L-C-5	2,250	320	0.20	S-3
L-C-6	2,100	320	0.20	S-3
L-C-7	2,100	240	0.15	S-2
L-C-8	2,100	310	0.19	S-3
L-C-9	1,550	190	0.12	S-2
L-D-1	1,800	70	0.04	S-2
L-D-2	2,000	60	0.04	S-2
L-D-3	1,000	50	0.03	S-1
L-D-3a	700	30	0.02	S-1
L-D-3b	700	20	0.01	S-1
L-D-4	1,850	240	0.15	S-2
L-D-5	750	35	0.21	S-3
L-D-6	2,100	290	0.18	S-3
L-D-7	1,600	70	0.04	S-2
L-D-8	700	15	0.01	S-1
Sub-total	35,250			
Total-Secondary	251,200			

FIGURE B-4 IRRIGATION AND DRAINAGE SYSTEM



ANNEX C AGRICULTURAL DEVELOPMENT

Appendix C Agricultural Development

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C.1. Land Disposal Plan

C.1.1. The land disposal in the land reclamation projects in Egypt is carried out by the two systems of distribution and selling by auction. Distribution system is adapted to establish small holder and large holder. Small holder have traditionally been distributed at 1 to 8 feddans on which small land or landless farmer and retired soldiers settled, large holders having 10 to 30 feddans and having agricultural secondary school diploma having or being university graduates. The proportion of allocation of the reclamation project land between the distribution system and the auction system is reported at 40 percent for distribution and 60 percent by auction. The maximum acreage auction is limited to 400 feddans of reclaimed land.

C.1.2. The land holding system as mentioned above aims at the development of a large number of successful family farms. In parallel with this process, the Government has established large size farms such as state farms, land reclamation co-operative farms and corporate farms. These concepts also involve implementing direction of the land reclamation projects. An implementing direction is classified by government, co-operative & persons and companies. According to the Five Year Development Plan, 1982/87, the percentage of the implementing land between government, co-operative & persons and companies were 48, 49 and 3 percent respectively. It is considered that the Government is attempting to mobilize private capital through a realization of implementing direction by co-operative & persons and companies.

C.1.3. According to the General Department of Plants Production, GARPAD, Egypt has 13 state farms which are managed by the agricultural companies under the Government. Reportedly, the size of these state farms ranges from 15,000 to 50,000 feddans, and one state farm is composed of several production units. One production unit covers 5,000 feddans.

The Ismailia Agricultural Development Co. with 19,000 feddans is one of the representative government farms and has been developed into by 11,000 feddans since its start in 1978. The Sharkia Governrate developed the cattle fattening farm in 1976. At present 3,000 feddans have been reclaimed as part of the general plan for 13,000 feddans. The representative company farm is the Salhia Pilot Agricultural Projected invested by the Arab Contractor Company in Ismailia Governorate in 1978. This has a project area of 23,000 feddans in the North Block and 33,000 feddans in the South Block.
Land reclamation co-operatives have been organized to attain the following objects.

- to mobilize idle private capital,
- to give employment opportunities to landless farms,
- to train the farmers employed by the co-operative to become independent in future.

The land reclaimed by the co-operative is sold to members and small farmers recieve a minimum of 25 percent of land owned by the co-operative.

C.1.4. The land disposal system as studied above could be adjusted as follows:

Implementing Direction	Land Disposal System	Traditional Size of Farm (feddan)
(1) Government	° Distribution	1. Small holder 1 to 8 2. Large holder 10 to 30
	° Auction selling	max. 400
	° State farm	
(2) Land Reclamation Co-operative	° Land reclamat. co-operative farm (Auction)	Land sold to membership less 5 fd. ... 5,000 fd. 5 to 20 fd. .. larger 5,000 fd.
(3) Company	° Company farm	

C.1.5. Decision of the Implementing Direction

Since the implementing direction to company farm is not so important in the Five Year Development Plan, company farms shall be not considered in this land disposal study. The implementing direction by Government and Land Reclamation Co-operative shall be recommended in the South Hussinia Valley Project. The main reason for the Land Reclamation Co-operative is to mobilize idle private capital. The large size state farm should be not recommended. Those are two reasons for this. One is that the size of the Project Area is insufficient to share its large area with state farms. Another is the inefficiency of employment labor when their farm operation is controlled by working hours of eight hours, though family farm labor can willingly work overtime. However the state farm shall be recommended under the following special condition: According to the results of soil survey and the land classification, the bad drainable land is found in the Project Area. This land class belongs to the marginal arable land or the low class arable land. It is not proper to distribute these lands to settlers directly after completion of land reclamation work.

In this case, the reasonable land disposal method is for the farm land mentioned above to be managed by the state farm during the initial period. After the bad drainable land has been converted to drainable land and the soil salinity has been improved, these lands can be re-distributed to individual settlers.

C.1.6. Allocation of the Reclamation Land

Allocation of the reclamation land could be studied using the following procedure.

a. Total land of 74,700 feddans is to be allocated between two implementing direction of Government and Land Reclamation Cooperation. The alternative of land allocation is studied by 9:1, 8:2, 7:3 and 6:4. (Table C-1)
Land value sold to Land Reclamation Cooperative is estimated by each proportion. This value should be used as local currency cost of social infrastructure construction.

b. The land acreage allocated to Government direction again should be allocated by both the distribution system and the auction system. (Table C-2)

c. The land value sold by auction system is estimated. (Table C-3)

d. The private capital to be mobilized to social infrastructure cost from land value sold is estimated by proportion allocated. (Table C-4)

e. The available private capital could be compared with the social infrastructure cost. The optimum percentage on allocation and auction is decided at the combination point where capital value is more than infrastructure cost. (Table C-5)

The optimum allocation shall be recommended as follows.

Percent of allocation to Land Reclamation Co-operative

	20%	30%
Percent of allocation to auction system on land allocated to the Government	30 - 40%	10 - 20%

Table C-1 Allocation of Land and Land Value Sold to Land Reclamation Cooperative

Allocation (%)	Government (feddan)	Land Reclamation Co-operation (feddan)	Land Value sold to Land Reclamation Cooperation Unit(LE)	Total(10^6 LE)
10:0	74,700	-	-	-
9:1	67,230	7,470	2,090	15.6
8:2	59,760	14,940	2,090	31.2
7:3	52,290	22,410	2,090	46.8
6:4	44,820	29,880	2,090	62.4

Note: 1. Land price is tentatively estimated at 2,000 L.E. per feddan.

2. The members of the Land Reclamation Co-operative (L.R.Co-po) have to pay 25% of the land price at the start of reclamation works, 50% at the land disposal stage and 25% at an interest rate of 9% for ten years. The value of the land sold should be used as the local cost of social infrastructure. Hence during the construction period of social infrastructure, the following value could be used for local cost.

A. Start period of works

2,000 LE/fd. x 0.25 = 500 LE.

B. Land disposal stage

2,000 LE/fd. x 0.5 = 1,000 LE.

C. Repayment value during five years

2,000 LE/fd. x 0.25 = 500 LE.

D. A + B + C = 2,090 LE/fd.

Table C-2. Allocation of Land between Distribution and Auction

(Government Allocation: feddans)

D:A	67,230 (9:1) D	67,230 (9:1) A	59,760 (8:2) D	59,760 (8:2) A	52,290 (7:3) D	52,290 (7:3) A	44,820 (6:4) D	44,820 (6:4) A
	- Feddans : D: Distribution, A: Auction -							
10:0	67,230	-	59,760	-	52,290	-	44,820	-
9:1	60,507	6,723	53,784	5,976	47,061	5,229	40,338	4,482
8:2	53,784	13,446	47,808	11,952	41,832	10,458	35,856	8,964
7:3	47,061	20,169	29,880	17,928	36,603	15,687	31,374	13,446
6:4	40,338	26,892	23,904	23,904	31,374	20,916	26,892	17,928

Table C-3. Land Value Sold by Auction

(Government Allocation : feddans)

% of Auction	67,230 (9:1)	59,760 (8:2)	52,290 (7:3)	44,820 (6:4)
	- 10^6 LE. (Unit price : 1,100 LE/fd.) -			
10	7.4	6.6	5.8	4.9
20	14.8	13.2	11.6	9.8
30	22.2	19.8	17.4	14.7
40	29.6	26.4	23.2	19.6

Note : Land value sold by auction should be paid at the rate of 25% of total value at the auction stage. The remainder, 75% should be paid in five installments over ten years. Hence the during construction period of social infrastructure, the following value could be used for local cost.

A. Auction period 2,000 LE. x 0.25 = 500 LE/fd.

B. Installment Value during five years

0.75/5 x 2 = 0.3 2,000 LE. x 0.3 = 600 LE/fd.

C. A + B = 1,100 LE/fd.

Table C-4 Private Capital to be mobilized to Social Infrastructure Cost from Land Value Sold

- Land Reclamation Cooperation Allocation -

(10^6 LE)

% of Auction	10 % L.R.Co-op	10 % Auction	10 % Total	20 % L.R.Co-op	20 % Auction	20 % Total
10	15.6	7.4	23.0	31.2	6.6	57.8
20	15.6	14.8	30.4	31.2	13.2	44.4
30	15.6	22.2	37.8	31.2	19.8	51.0
40	15.6	29.6	45.2	31.2	26.4	57.6

% of Auction	30 % L.R.Co-op	30 % Auction	30 % Total	40 % L.R.Co-op	40 % Auction	40 % Total
10	46.8	5.8	52.6	62.4	4.9	67.3
20	46.8	11.6	58.4	62.4	9.8	72.2
30	46.8	17.4	64.2	62.4	14.7	77.1
40	46.8	23.2	70.0	62.4	19.6	82.0

Table C-5 Comparison between Social Infra. Cost and Private Capital to be Mobilized

- Land Reclamation Co-operative Allocation -

(10^6 LE)

% of Auction	10 % Infra.	10 % Capital	20 % Infra.	20 % Capital	30 % Infra.	30 % Capital	40 % Infra.	40 % Capital
10	53.8	23.0	53.8	37.8	53.8	52.6	53.8	67.3
20	53.8	30.4	53.8	44.4	53.8	58.4	53.8	72.2
30	53.8	37.8	53.8	51.0	53.8	64.2	53.8	77.1
40	53.8	45.2	53.8	57.6	53.8	70.0	53.8	82.0

Note: Social infrastructure cost per feddan 1,200 LE.
Local currency 1,200 x 0.6 = 720 LE/feddan
Total cost of local currency
720 x 74,700 feddan = 53.8 10^6LE.

There is some anxiety that the auction of land would encourage land speculation with people buying and waiting for the price of land to rise in value in the future. Hence, the development of selling wide acreage by auction shall be undesirable from the social point of view. As a results, 30 percent to Land Reclamation Co-operative with 20 percent sold by auction system would be recommended.

C.1.7. Decision of the Size of Land Disposal

The size of land disposal should be decided taking into consideration of the following requirements;

a. The settlers shall have a sufficient income suitable for their educational level, qualifications, capital investment, and technical level, etc.

b. The settlers shall have a sufficient income to afford the rising living standard in future, and to pay the amortization of land and buildings, etc.

c. The settlers shall have a higher income than neighboring farmers around the Project Area on average.

d. A great deal of labor shall be mobilized to the Project Area in the early stage of land reclamation for constructing farm ditches, etc. Hence, the disposal of large lands should be limited.

e. The distributed acreage is traditionally from four to six feddans to small holders, and 10 to 20 feddans to graduate settlers. Since the graduate settlers are expected to be the leaders of farmers, their number should be limited.

f. As a result of alternative studies, net income by farm sizes is estimated as follows;

g. The following distributed acreage to settlers is recommendable in consideration of the above-mentioned e) and f);

Small holders .... 5 feddans

Graduates .....Agricultural secondary school graduate .... 15 feddans

University graduates ... 20 feddans

Table C-6. Preliminary Analysis on Farm Budget

(Unit: L.E.)

I. Small holders:	Farm Size in Feddan				
	3.0	4.0	5.0	6.0	7.0
Milk Cow Breeding (Friesian)	-404	204	773	1,356	1,842
Beef Cattle Breeding (Baladi)	-771	-280	182	648	1,027
II. Large holders:					
	10.0	15.0	20.0	30.0	40.0
Milk Cow Breeding (Friesian)	1,312	2,723	4,092	6,946	9,771
Beef Cattle Breeding (Baladi)	124	946	1,792	3,485	5,067

Note: This table is based on the economic analysis of the North Hussinia Project Team. Since the cropping patterns of both Projects are almost similar to each other, the above figures are adaptable to the study on the South Hussinia Project.

C.1.8. Previous Study on allocation of land between small holder and large holder

a. An alternative study on small and large land holdings could be carried out in consideration of the socio-economic conditions as follows;

(1) According to the rural development plan, the land acreage to be distributed to one satellite village is as follows;

Gross Area .... 74,700 feddans
Number of Satellite Village 29
Gross Area per Village ...... 74,700 ÷ 29
= 2,575 feddans
Acreage to be Distributed or Sold ...
2,575 x 0.85 = 2,188 = 2,180 feddans

(2) Alternative plan for land disposal per satellite village

	Case-A	Case-B	Case-C
Distributed Land (feddan)	2,180	2,180	2,180
Small Holders (%)	80	70	60
Large Holders (%)	20	30	40
of which 15 feddans (%)	60	60	60
20 feddans (%)	40	40	40
Small Holders (feddan)	1,745	1,525	1,310
Large Holders (feddan)	435	655	870
of which 15 feddans	255	395	510
20 feddans	180	260	360
Number of Settlers			
Small Holders	349(93%)	305(89%)	262(83%)
Large Holders			
of which 15 feddans	17 (5%)	26 (7%)	34(11%)
20 feddans	9 (2%)	13 (4%)	18 (6%)
Total	375(100%)	344(100%)	315(100%)

	Case-A	Case-B	Case-C
Total Households	375	344	315
Family Population	1,875	1,720	1,575
Net Farm Income per Household (L.E.)			
5 feddans	182	182	182
15 feddans	946	946	946
20 feddans	1,792	1,792	1,792
Total Net Farm Income per One Satellite Village (L.E.)			
5 feddans	63,518	55,510	47,684
15 feddans	16,082	24,596	32,164
20 feddans	16,128	23,296	32,256
Total	95,728	103,402	112,104
Total Credit of Household's Land and House (1,000 L.E.)			
5 feddans	4,363	3,813	3,275
15 feddans	646	988	1,292
20 feddans	432	624	864
Total	5,441	5,425	5,431

(3) Alternative plan for land disposal for whole Project Area

	Case-A	Case-B	Case-C
a. Number of Households	10,875	9,976	9,135
(%)	(100)	(92)	(84)
b. Number of Population	54,400 - 65,200	50,000 - 60,000	45,700 - 54,800
(%)	(100)	(92)	(84)
c. Net Farm Income (Million L.E.)	2.8	3.0	3.3
(%)	(100)	(107)	(118)
d. Credit (Million L.E.)	158	157	157
(%)	(100)	(100)	(100)

(4) In this Project a cultivation unit of 102 feddans, which will be located at both sides of a tertiary canal, is planned to be a unit for rotational irrigation. A farmers' group will be organized by farmers to settle this cultivation unit for farm practices. The graduate settlers shall play the role of leader of farmers in various activities of the farmers' group. The size of farmers group for a satellite village in Case A would be as follows:

One Satellite Village: 2,180 feddans

		(Farming Unit)						
Feddans per unit:		310	310	310	310	310	315	315
Settlers per unit: of which		55	55	55	55	53	51	51
5 feddans:	Area	260	260	260	260	245	230	230
	Farms	52	52	52	52	49	46	46
15 feddans:	Area	30	30	30	30	45	45	45
	Farms	2	2	2	2	3	3	3
20 feddans:	Area	20	20	20	20	20	40	40
	Farms	1	1	1	1	1	2	2

One Farming Unit with Three Cultivation Units

		(Cultivation Unit)		
Feddans per unit:		100	105	105
Settlers per unit: of which		18	19	18
5 feddans:	Area	85	90	85
	Farms	17	18	17
15 or 20 feddans:	Area	15	15	20
	Farms	1	1	1

One cultivation unit is organized from 18 to 19 farm households of which one household is a large land holder.

(5) The land allocation rate to small and large land holders shall be decided to create as many employment opportunities as possible and to realize the highest possible net farm income. The rural population in Sharkia Governorate was about 2,091,000 persons in 1979. This population is expected to increase to 2,858,000 persons in the year 2000. The incremental population is estimated at 767,000 persons. This Project can absorb 7.1 to 8.5 percent of this incremental population in Case A, 6.5 to 7.8 percent in Case B, and 6.0 to 7.1 percent in Case C. The net farm income is estimated by deducting the living

cost, annual amortization, and annual charge from the farm income. This value shall be disposed in upgrading living standards, savings, and additional inputs for production. The increase in net farm income results in the stabilization of farm management in the Project Area, and in the prevention of people giving up farming. The credits necessary would consist of L.E. 2,000 for land per feddan, L.E. 2,500 for small land holder's house, and L.E. 8,000 for large land holder's house. The total credit amounts in Case A, Case B, and Case C are not much different.

C.1.9. Decision of Allocation of Land between Small Holder and Large Holder

The proper land allocation between small holder and large holder could be studied using the following procedure.

a. Total requirement of labor days in the Project Area is estimated at about 4.1 million days. Total requirement of family labor is calculated at about 13,660 persons using average annual days of 300 per labor(Table C-7).

b. The labor balance on Gross Project area of 74,700 feddans and Farm land area of 55,740 feddans are compared using proportion to be allocated between small and large holder. (9:1, 8:2, 7:3, and 6:4) (Table C-8)
Assuming average family labor of 1.5 persons per farm, total number of farming labor is calculated by proportion allocated. These figures are compared with total requirement of family labor. The balance of 70:30 indicates positive in marginal but a 60:40 balance is negative.
The optimum proportion is recommended as 80 percent of small holder and 20 percent large holder allowing some room for balance.

C.1.10. Decision of Number of Settle Farmer

The number of new farmers could be estimated using the proportion of land allocation mentioned above as follows: (Table C-9.)

	Government	Land Reclamation Company	Total
Small holder 5 fd	4,992	2,844	7,836
Larger holder 15 fd	562	100	662
20 fd	281	50	331
Total	5,835	2,994	8,829

C.1.11. Proposed Land Use

The gross area of the Project Area is 74,700 feddans (31,400 ha) including the existing farm lands distributed along Bahr Saft drain on the western border of the Project Area, along the existing canal on the southern border, and along Bahr Baqar drain on the eastern border. These existing farm lands at three portions cover 7,800 feddans (3,300 ha) according to the results of soil survey.

The proposed land use shall be decided taking into consideration how to deal with these existing farm lands. Two methods are considered; one is to include the existing farm lands within the Project Area and the other is to exclude them from the Project Area. The former method can be further divided into two methods as regards how to deal with the farmers presently living in the Project Area; one method is to make those farmers participate in the Project, and the other is to make the farmers turn out from the Project Area. The most appropriate method shall be selected through an alternative study as follows;

- Alternatives in Dealing with Existing Farm Lands in the Project Area -

	To include them in the Project Area		To Exclude them from the Project Area
	Farmers' Participation	Farmers' Turn-out	
Merits:	* Enlargement of the Project Area * Quick benefit	* Non	* No trouble
Demerits:	* Trouble in case of un-willing participation	* Violation of human rights	* Necessity of compensation

As a conclusion, the method including the existing farm lands in the Project Area and making the farmers presently engaging in agriculture at such lands participate in the Project would be most recommendable.

The important items to be arranged for participation of the squatters are four items such as land holding, on-farm work and irrigation and drainage facilities, rural development and farm organization & marketing. Decision of an executing methods should be controlled by the regulation or law of the Government. The following study is carried out as a reference.

a. Land Holding

The boundaries of squatter's cultivated land are not clear. It is impossible to compel the standarized size of 5 feddans to the squatters or existing farmers, that is, to reduce farm area of squatters from larger size than 5 feddan to 5 feddans. The squatters with smaller size than 5 feddans shall be able to enlarge up to 5 feddans. Final plan should be made after confirmation of squatter's minds. Hence in an initial stage of settlement the squatters should be participated keeping the present cultivated land tenure conditions.

b. On-Farm Work and Irrigation and Drainage Facilities

The irrigation water sources for existing cultivated land are Bahr Saft Drain, Bahr Baqar Drain and drainage water discharged from outside of the Project Area. Since qualities and quantities of these water sources are instability, the stabilized water source have to be urgently developed. The irrigation water for the existing field of 7,800 feddans shall be taken from El Salaam Canal. The on-farm works and irrigation and drainage facilities in the 7,800 feddans should be re-implemented based on the Project contents. However, actual on-farm works have to e carefully carried out through confirmation of squatter's willingness and land register survey to be carried out during the construction period in respect to keep the present cultivated land tenure system.

c. Rural Development

The squatter's houses have been built since the past 15 years. It is actually impossible to settle the existing inhabitants into new villages after abandonment of their buildings. Hence the existing inhabitants shall participate the Project keeping the existing situation of building. However, the social functions given new villages, that is, administration, education, commerce, public welfare, transportation, police and fire fighting could be used by the squatters. The roads to connect new villages with existing villages shall be planned in the rural development plan.

d. Farm Organization and Marketing

Irrigation water requirement and cropping pattern which are operated by the squatters shall be controlled by the Government under same rule adapted to new settlers. Existing farmers shall be requested to establish an irrigation group for operation and maintenance of terminal facilities.

Table C-7 Requirement of Family Labor

A. Requirement of Labor for Cropping

Crop	Cropped Area (fd)	Labor Hours per feddan	Labor Days per feddan	Total Labor Days (1000 days)
Rice	18,500	80.2	10.0	186
Soybean	18,580	64.0	8.0	149
Sorghum	10,580	85.5	10.6	112
Berseem	18,580	108.5	13.6	252
Sugarbeet	18,580	150.4	18.8	349
Tomato	8,000	700.0	87.5	700
Onion	13,000	298.0	37.3	485
Cauliflower	2,800	298.0	37.3	104
Cabbage	2,780	298.0	37.3	104
Total	111,480			2,441

Workable days per year per family labor .... 300 days (25 days x 12 month)

Requirement of family labor for cropping .... 2,441,000 300 = 8,136 persons

B. Requirement of Labor for Animal Breeding

Milk cow	37,800 heads x 0.8 hour x 365 days 8 hours =	1,380,000 days
Fatting cattle	14,550 heads x 0.2 hour x 365 days 8 hours =	133,000 days
Calf	11,440 heads x 0.1 hour x 365 days 8 hours =	52,000 days
Sheep	10,180 heads 40 head x one person x 365 day=	93,000 days
	Total	1,658,000 days

Requirement of family labor for cropping 1,658,000 300 = 5,526 person

C. Total Requirement Labor Days 2,441,000 + 1,658,000 = 4,099 days

D. Total Requirement of Family Labor 8,136 + 5,526 = 13,662 persons

Table C-8 Alternative of Labor Balance

A. Gross Area .... 74,700 feddans.		Farm Land Area .... 55,740 feddans			
B. Proportion Allocation (%)					
Small holder	100	90	80	70	60
Large holder	0	10	20	30	40
C. Acreage Allocated (feddans)					
Small holder	55,740	50,170	44,600	39,020	33,440
Large holder	0	5,570	11,140	16,720	22,300
D. No. of Settler (farmers)					
Small: 5 fd.	11,148	10,034	8,920	7,804	6,688
Large: 15 fd.	0	223	445	669	892
: 20 fd.	0	111	223	334	446
Total	11,148	10,368	9,588	8,807	8,026
E. No. of Family Labor	- persons (1.5 persons per farm) -				
Total	16,722	15,552	14,382	13,211	12,039
F. Requirement of Family Labor	13,662	13,662	13,662	13,662	13,662
G. Balance	3,110	1,890	720	-451	-1,623

Table C-9 Allcation between Small Holder and Large Holder Using 80:20

	Goverment		Land Reclamation Cooperative		Total
1. Proportion of allocation	70%		30%		
2. Gross land fd.	52,290		22,410		74,700
	Distribution	Auction	Membership	Small holder	Total
3. Allocation %	80	20	75	25	
4. Gross land fd.	41,830	10,460	16,800	5,610	74,700
5. Farm land fd.	31,200	7,810	12,540	4,190	55,740
6. Small holder %	80	-	80	-	-
6-1. 5 fd.	24,960	-	10,030	4,190	39,180
6-2. No. of settler	4,992	-	2,006	838	7,836
7. Large holder %	20	100	20	-	-
7-1. 15 fd.	3,740	4,690	1,506	-	9,936
20 fd.	2,500	3,120	1,004	-	6,624
7-2. No. of settler					
15 fd.	249	313	100	-	662
20 fd.	125	156	50	-	331
8. Total No. of settler	5,366	469	2,156	838	8,829
	5,835		2,994		8,829
9. Grand total No. of settler		8,829			