JAPAN INTERNATIONAL
COOPERATION AGENCY (JICA)

MINISTRY OF PUBLIC WORKS AND
WATER RESOURCES,
THE ARAB REPUBLIC OF EGYPT

THE FEASIBILITY STUDY ON FARMLAND ENVIRONMENTAL IMPROVEMENT PROJECT IN OMOUM AREA

MAIN REPORT

JANUARY, 1996

SANYU CONSULTANTS INC.

JAPAN INTERNATIONAL
COOPERATION AGENCY (JICA)

MINISTRY OF PUBLIC WORKS AND
WATER RESOURCES,
THE ARAB REPUBLIC OF EGYPT

THE FEASIBILITY STUDY

ON

FARMLAND ENVIRONMENTAL IMPROVEMENT

PROJECT

IN OMOUM AREA

MAIN REPORT

JANUARY, 1996

SANYU CONSULTANTS INC.

PREFACE

In response to a request from the Government of Arab Republic of Egypt, the Government of Japan decided to conduct a Feasibility Study on Farmland Environmental Improvement Project in Omoum Area and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent to Arab Republic of Egypt a study team headed by Mr. Seiji Takeuchi, Sanyu Consultants Inc., three times between July, 1994 and September, 1995.

The team held discussions with the officials concerned of the Government of Arab Republic of Egypt, and conducted field surveys at the study area. After the team returned to Japan, further studies ware made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Arab Republic of Egypt for their close cooperation extended to the team.

January, 1996

Kimio Fujita
President
Japan International Cooperation Agency

Mr. Kimio Fujita
President
Japan International Cooperation Agency(JICA)
Tokyo, Japan

January, 1996

Letter of Transmittal

Dear Sir,

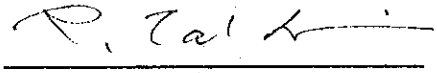
We are pleased to submit herewith the Feasibility Study Report on Farmland Environmental Improvement Project in Omoum Area in Arab Republic of Egypt. The Report, which describes drainage improvement plan emphasizing on farmland environmental improvement through upgrading the related drainage systems, is compiled in reflecting the advice and suggestions for the formulation of the above mentioned project by the authorities concerned of the Government of Japan and your Agency. Also comments made by the Egyptian Public Authority for Drainage Projects (EPADP), Ministry of Public Works and Water Resources are incorporated in the Report.

The study had been carried out in the phasing manners, Phase-I and Phase-II. In the courses of the Phase-I study, Master Plan in terms of Farmland Environmental Improvement Project in Omoum Area was formulated, and Priority Development Area and Project were selected on the basis the study, while during the Phase-II study Feasibility Study on the selected area and project mentioned in the above was made.

As the results of the study, Hares Area having an area of 63,330 feddan (26,600 ha) has been selected as the Priority Development Area, and improvements of El-Max pumping station, Omoum main drain and discharge-channel have been selected as the Priority Development Project. It was revealed through the study that these drainage improvement works will be feasible from technical and economical viewpoints, and furthermore it will be surely believed that project implementation will greatly contribute to the improvement of rural living environment and conservation of water environment and quality of Mariut Lake and its vicinity.

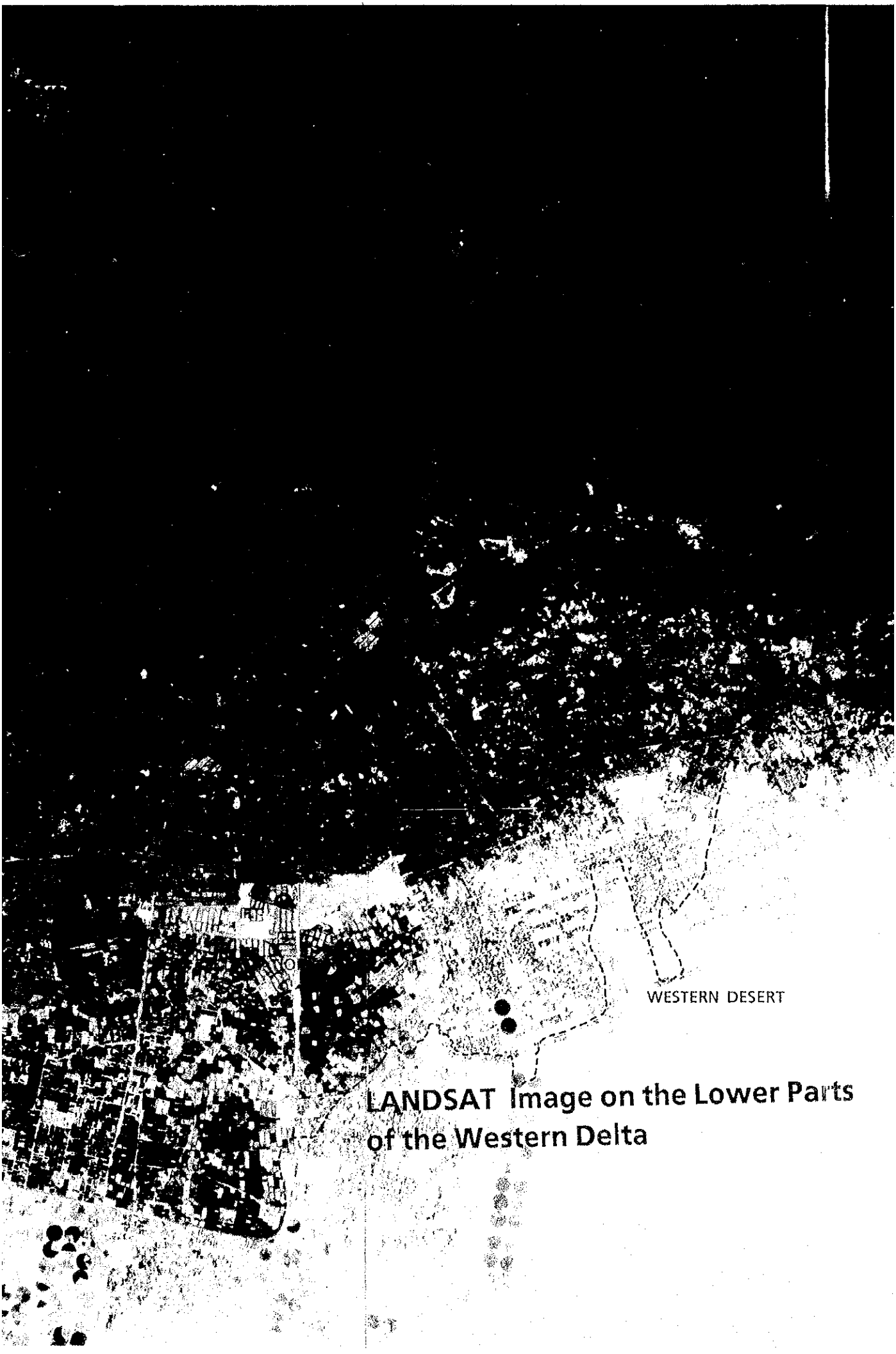
Finally, we take this opportunity to express our sincere gratitude to EPADP, Ministry of Foreign Affairs, Ministry of Agriculture, Forestry and Fisheries of the Government of Japan, and Japan International Cooperation Agency, especially for Advisory Committee which gave useful advice to the study team from time to time so as to smoothen the study.

Respectfully yours,



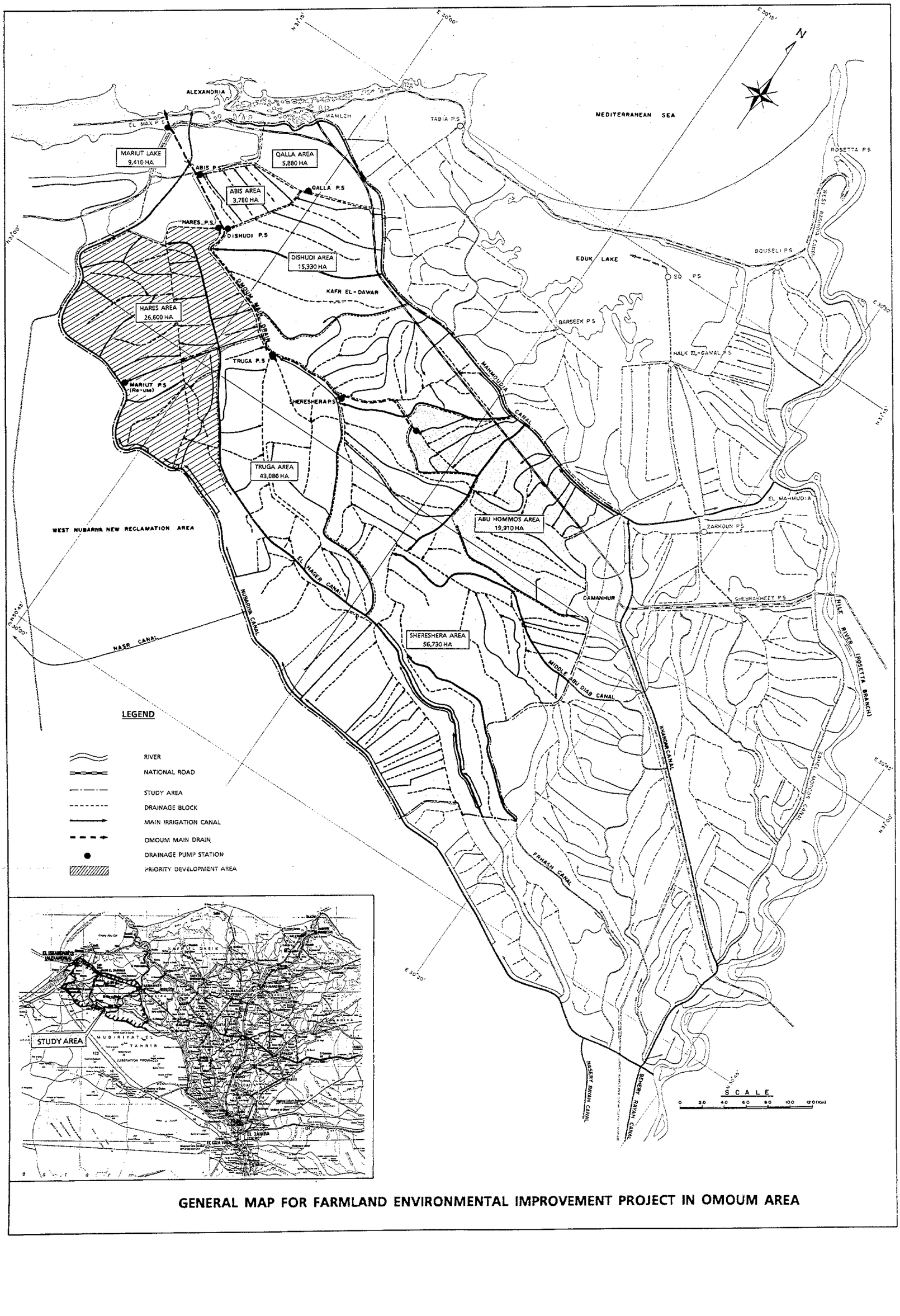
Seiji Takeuchi
Team Leader of Study Team


MEDITERRANEAN SEA
KAFR EL DAWWAR
ALEXANDRIA
QALLA P.S
ABIS P.S
DEKHUDI P.S
EL-MAX P.S
MARIUT
PROJECT AREA
A = 26 000 ha

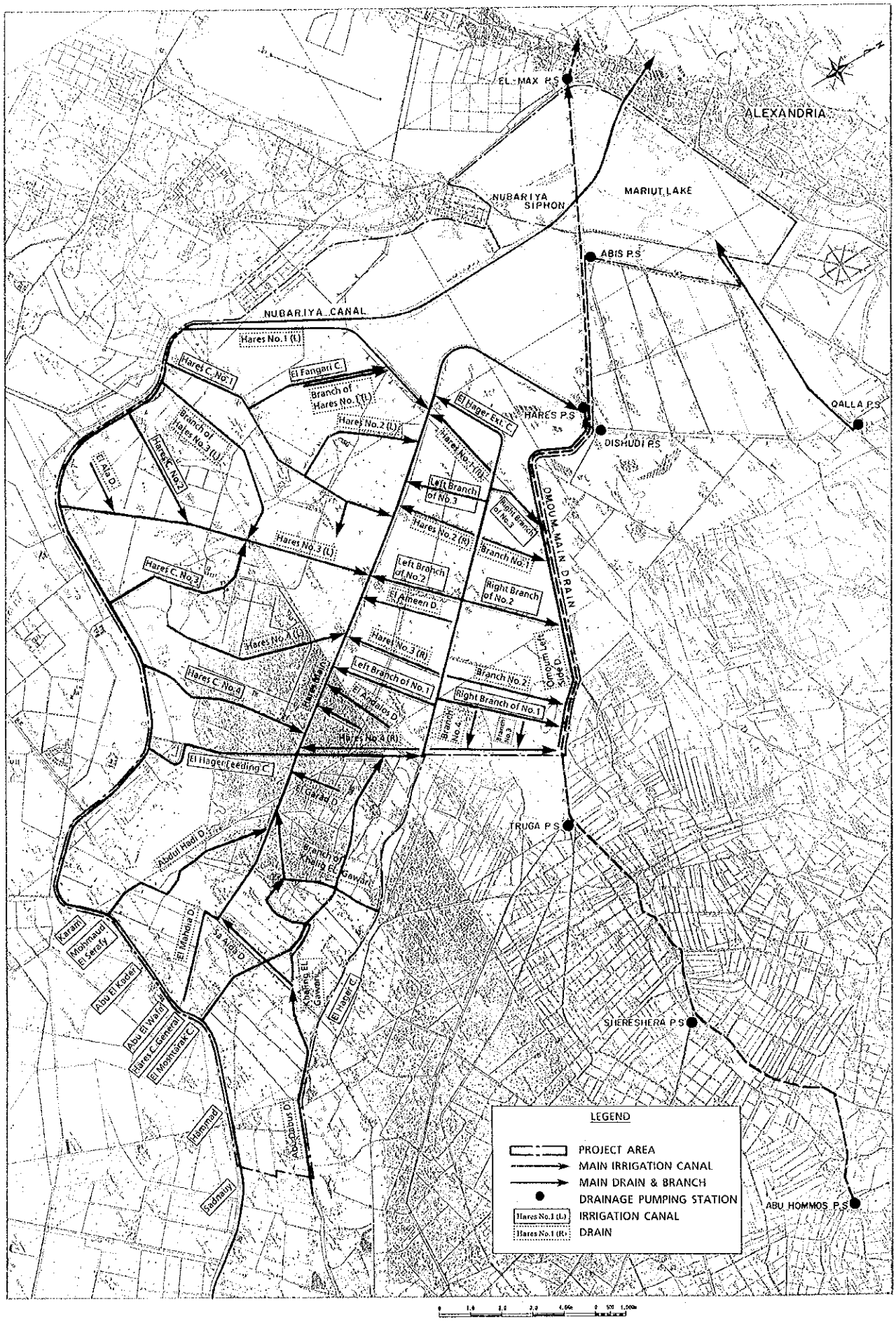


LANDSAT Image on the Lower Parts of the Western Delta

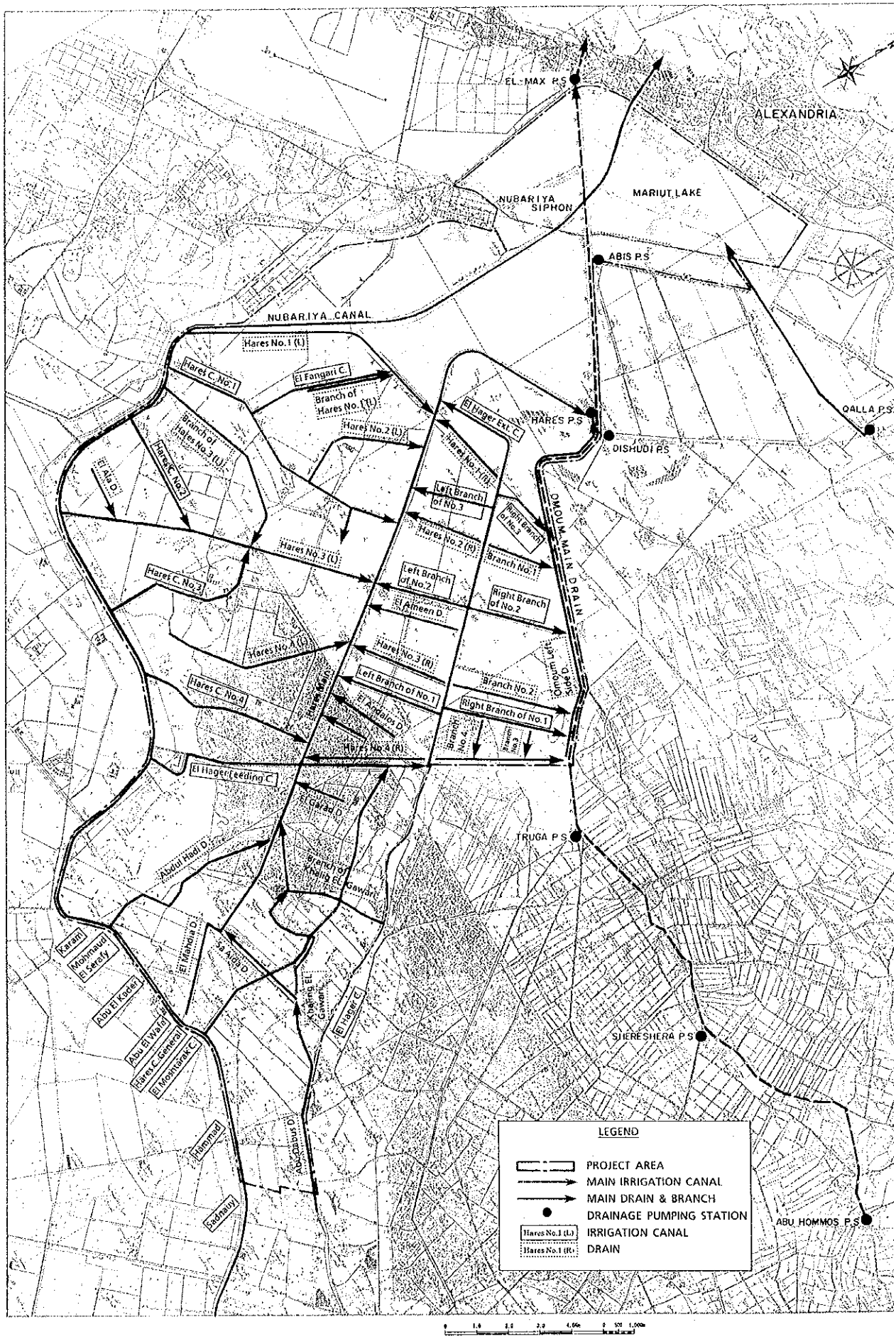
LANDSAT Image of the Lower Part of the Western Delta



GENERAL MAP FOR FARMLAND ENVIRONMENTAL IMPROVEMENT PROJECT IN OMOUM AREA



GENERAL PLAN OF PROJECT AREA



GENERAL PLAN OF PROJECT AREA

CONTENTS

PART - II FEASIBILITY STUDY

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEX

ABBREVIATION AND GLOSSARY

1) Agencies

ARC	Agricultural Research Center
DOI	Department of Irrigation, MPWWR
DOS	Department of Statistics, MALRF
DRI	Drainage Research Institute, MPWWR
EEAA	Egyptian Environmental Affairs Agency
EALIP	Executive Authority for Land Improvement Project, MOALR
EPADP	Egyptian Public Authority for Drainage Projects
ERI	Environmental Research Institute
ETP	East Treatment Plant
FAO	Food and Agricultural Organization of the United Nation
FIDD	Field Investigation and Design Department
HAD	High Aswan Dam
IBRD	International Bank for Reconstruction and Development
IMF	International Monetary Fund
IIP	Irrigation Improvement Project
JICA	Japan International Cooperation Agency
LIA	Land Improvement Authority
MED	Mechanical and ElectricalDepartment, MPWWR
MALRF	Ministry of Agriculture, Land Reclamation and Fishery
MOIC	Ministry of International Cooperation
MPWWR	Ministry of Public Works and Water Resources
NID	Nubariya Irrigation Directorate
PPD	Project Preparation Department
SWRI	Soil and Water Research Institute
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WPT	West Treatment Plant
WRC	Water Research Center
WUA	Water User's Association

2) Others

BOD	Biological Oxygen Demand
CIF	Cost, Insurance and Freight
COD	Chemical Oxygen Demand
EC	Electrical Conductivity
ECe	Electrical Conductivity of Saturated Soil Extract
EIRR	Economical Internal Rate of Return
ESP	Exchangeable Sodium Percentage
FIRR	Financial Internal Rate of Return

F/S	Feasibility Study
GNP	Gross National Product
GDP	Gross Domestic Product
LE	Egyptian Pound
M	Million
M/P	Master Plan
MPN	Most Probable Number
MSL	Mean Sea Level
O & M	Operation and Maintenance
SAR	Sodium Absorption Ratio
S/W	Scope of Work
TDS	Total Dissolved Salts
WMP	Water Master Plan

Study Area	Objective area for Master Plan Study on Farmland Environmental Improvement Project in Omoum Area covering drainage area of 180,710 ha (430,260 feddan)
Project Area	Prioritized development areas, which have been selected through the Master Plan Study mentioned in the above, and Feasibility Study on the areas has been conducted. The Project Area consists of two types of areas, Priority Development Area and Priority Development Project. The former corresponds to Hares Area with drainage area of 26,600 ha (63,330 feddan), and the latter consists of improvement works of Omoum main drain, discharge-channel and El-Max pumping station.

3) Glossary

Governorate	Province
District	District
Local Unit	Local Unit
Sheyakha	Village
Ezba	Small Village

4) Unit of Measurements

mm	millimeter
cm	centimeter
m	meter
km	kilometer
sq.cm	square centimeter
sq. m	square meter
sq. km	square kilometer

feddan	unit of land measurement
l, lit	liter
me	milliequivalent per litter
cu.m	cubic meter
MCM	million cubic meter
BCM	billion cubic meter
lit/sec	liters per second
m/sec	meters per second
ppm	parts per million
pH	potential of hydrogen
EC	electric conductivity
mS	milli siemen
mg	milligram
g	gram
kg	kilogram
ton, t	metric ton
m. MSL	meter. mean sea level
sec	second
min	minute
hr.	hour
min.	minimum
max.	maximum
%	percent
No.	number
°C	degree centigrade
Cl	chlorine
HP	horse power
ET	evapotranspiration
N	nitrogen
P	phosphate
K	potassium
LE	unit of Egyptian currency
US$	US Dollar = 3.374 LE (July 1994)

SUMMARY AND RECOMMENDATION

OUTLINE OF FARMLAND ENVIRONMENTAL IMPROVEMENT PROJECT IN OMOUM AREA

	Master Plan Study	Feasibility Study
1. Study Area/Project Area		
Location	: Behera and Alexandria Governorate	Dist. of Abu El-Matameer and Kafr El-Dawar (Behera Gov.) and Ameriya Square (Alexandria Gov.)
No. of Village	: 96*	15*
No. of Household	: 218,590 households	16,900 households
No. of Farm Household	: 79,070	11,000
Population (total)	: 1,138,000 person (664 persons/sq.km)	95,840 person (360 persons/sq.km)
* including ten unestablished villages		
2. Area		
Drainage Area	: 180,710 ha (430,260 fed)	26,600 ha (63,330 fed)
Cultivation Area	: 171,300 ha (407,860 fed)	22,650 ha (53,920 fed)
3. Major Crops		
Winter Crops	: Wheat, Berseem, Veget.	Wheat, Berseem, Veget.
Summer Crops	: Maize, Cotton, Rice	Maize, Cotton
4. Irrigation Water Source		
Irrigation Canal	: Mahmoudia Main Canal Nubariya Main Canal	Nubariya Main Canal
5. Drainage Plan		
Drainage Block	: 7 drainage blocks	Hares block and Mariut Lake
Design Rainfall (mm)	: 67 (3-day)	67 (3-day)
Design Unit Discharge at El-Max P.S. (cu.m/fed/day)	: 41	41
Ave. Annual Discharge (MCM)		
Before Reuse	: 2,707	2,707
After Reuse	: 1,750	1,750

6. Proposed Drainage Facilities

Drainage Block	P.S	Main Drain	Tile Drain	P.S	Main Drain	Tile Drain
	(cu.m/s)	(km)	(ha)	(cu.m/s)	(km)	(ha)
Qalla Block	8.8		5,000	-	-	-
Abis Block	5.6		3,210	-	-	-
Hares Block	30.0	24.0	22,440	30.0	24.0	22,440
Dishudi Block	16.0		13,030	-	-	-
Truga Block	36.0		26,440	-	-	-
Shereshera Block	40.0		4,510	-	-	-
Abu Hommos Block	16.0		-	-	-	-
El-Max Pump Sta.	150.0	-	-	150.0	-	-
Omoum Main Drain	-	10.0	-	-	10.0	-
Discharage-Channel	-	0.6	-	-	0.6	-

	Master Plan Study	Feasibility Study
7. Project Costs (million Pound)		
Study Area (Omoum Area)	1,649.0	-
Priority Development Area (Hares Area)	-	271.1
Priority Development Project (Improvement of El-Max pumping station, Omoum main drain and discharge-channel)	-	198.2
8. Project Implementation		
Study Area	1996-2006	-
Priority Development Area and Project	-	1996-2002
9. Project Evaluation (EIRR, %)		
Priority Development Area	-	19
Priority Development Project	17	-

SUMMARY

I. Master Plan Study

1. Introduction

1.1 Background of the Study

The completion of Aswan High Dam in 1970 opened the door for Egyptian agriculture to have a year-round water supply for all irrigated land, and as a result, the cultivable area with double cropping has increased sharply. On the other hand, intensified irrigation and ineffectiveness of drainage facilities have caused the groundwater table to be high and increased the problems of water-logging and salinity in the area, which in turn, has resulted in the deterioration of both soils and crop production.

In particular, the north-western part of the Nile Delta, where the Study Area of Omoum is located, has been encountering severe problems such as periodical inundation, water-logging and salinization due to high groundwater table. The other reasons for this situation could be outlined as ineffectiveness or absence of water management organizations and timeworn drainage facilities such as pumps and drains.

Under these conditions, the Government of Egypt has requested the Government of Japan to extend technical assistance in order to improve the situations.

In response to the request, the Government of Japan has decided to render technical assistance for the Study on Farmland Environmental Improvement Project in the Omoum Area. And the Japan International Cooperation Agency (JICA) dispatched a Study Team from July 1994 for carrying out the Study, according to the Scope of Work with the close cooperation of the Egyptian Public Authority for Drainage Projects (EPADP).

All data and study results obtained in the course of field and home office works are reflected in this report.

1.2 Purpose of the Study

The purpose of this Study is to prepare a Master Plan for Omoum Area, which is located in Behera and Alexandria Governorates in north-western Delta covering an area of about 430 thousand feddan (about 180 thousand hectares), focusing on the improvement of farmland environment in the area by amelioration of drainage systems and facilities, and identification of Priority Development Area and Project for Feasibility Study.

1.3 Scope of the Study

The Study has been set for a period of three years as shown below;

1st year :	Preparatory works at home office (preparation of Inception Report)	
2nd year:	Phase-I	Field works and home office works (Master Plan Study)
	Phase-II	Field works (Feasibility Study)
3rd year:	Phase-III	Home office works, preparation and presentation of Final Report

During Phase-I Study of the period, formulation of the Basic Development Plan for drainage improvement in Omoum area and selection of Priority Development Area and Project for Feasibility Study have been carried out successfully.

On the other hand, during the Phase-II Study period, the Feasibility Study on the selected Priority Development Area and Project was undertaken, which was commenced by the end of January, 1995.

2. Background of the Project

2.1 Agricultural Policy in National Development Plan

Agriculture is one of the most important industrial sector in the Egyptian economy and shares 15 percent of GDP, 33 percent of the employment, 39 percent of agriculture related industrial output and employs a

substantial share of the work force. Before 1990, agricultural policy was controlled by the central Government in which farmers were only allowed to produce crops according to the allocated quotas. Recently, however, farming has been made free in the cases of major crops like paddy, cotton and maize.

2. 2 Agriculture Policy for the Western Delta

The Western Delta including the Study Area has been playing an important role in agricultural production increase. Therefore, the Egyptian Government has been advocating its development through irrigation expansion, drainage improvement and agricultural development. The contents are as follows;

- Irrigation Expansion	:	Effective water management and reuse of drained water for the newly reclaimed area in the Western Desert.
- Drainage Improvement	:	Implementation of tile drains to lower the groundwater table that is causing water-logging and salinity in the farmland.
- Agricultural Development	:	Diversification and introduction of high yielding crops. Strengthening of supporting service, extension service and research activities.

2. 3 Problems in the Study Area and Necessity of Development

The problems that are encountered in the Study Area are stated below;

- Negative effects on crop production, due to raised water level in open drains and groundwater table,
- Improper irrigation water management,
- Deterioration of drainage facilities,
- Deterioration of Mariut Lake water quality, and
- Inadequate rural environment.

On the basis of the above, an early improvement of the farmland environment in the Area by improving drainage systems is most essential.

3. Present Conditions of the Study Area

3.1 Location and Geography

The Study Area is located about 220 km north of Cairo in the western Delta within the Governorates of Behera and Alexandria. The area is formed by the deposition of fertile silts brought by the Nile river and has a land slope of between 1/10,000 - 1/30,000 extending 70 km in a north-southerly direction and 30 km east-westerly. The Area has an elevation of six meters above the mean sea level in the south and 3.5 m below the mean sea level in the north. About 41 percent of the area lies below the mean sea level.

3.2 Land Acreage of the Study Area

About 70 percent of the Area is farmland where paddy, cotton and maize and etc. are grown. The Study Area consists of Mariut Lake and seven other drainage blocks, totaling an area of 430,260 feddan (180,710 ha) .

3.3 Geology

Geologically, the Area is mostly composed of sediment rocks developed in the Quarternary era with a thickness of about 700 m. But the thickness of the surface layer hardly exceeds 50 cm. The geological structure of the surface and layer beneath is rather simple.

3.4 General Climate

The climate around the Area is classified into the Mediterranean type with an average temperature fluctuating from 14°C in January and 27 °C from July to August. Humidity is comparatively high ranging from 49 - 83 percent.

Average annual rainfall is about 200 mm in Alexandria and 110 mm in Damanhur, concentrating between November and February.

3.5 Population

The population of the area is about 1,138 thousand and the number of households is about 219 thousands. Average family size is 5.2 persons per family. Annual rate of population increase is 3.8 percent and the density is estimated as 664 persons/sq.km, where the number of farm households is about 79 thousand.

3.6 Hydrology

The hydrology of the Area is controlled by Mahmoudia and Nubariya canals, Omoum main drain, Mariut Lake and the Mediterranean Sea. Omoum main drain crosses the Lake and Nubariya navigation canal, and at present it is a source of fresh-water for fish culture and conservation of the Lake water quality.

Annual drainage discharge from the whole drainage area of 407,860 feddan (171,300 ha) exclusive of Mariut Lake area is estimated at about 2,443 MCM, which is equivalent to 1,426 mm/sq.m.

3.7 Reuse of Drainage Discharge

Not only farmland drainage improvement but also reuse of drainage discharge is taking place in the area. At present, annually about 570 MCM of water is pumped into the irrigation canals by five pumping stations at different locations in the Study Area. It is envisaged that this plan will be expanded more in the future due to increasing water demand and limited water sources. However, it is considered that some restrictions on both quantity and quality of drainage discharge have been set.

3.8 Groundwater

A survey of groundwater at 100 points in the Study Area was carried out during the phase-I and phase-II study periods. The survey results show that the areas like Hares, Abis and Dishudi where subsurface drainage have not yet been provided is very high. The range is 0.2 m - 1.2 m below the ground surface. Also in the areas, namely, Shereshera, Abu Hommos etc. with the provision of tile drain, the groundwater table was found high, only about 1.1 m below the ground surface. The salinity ranges from 1.0 - 7.5 mS/cm in general, but there are many areas which have a salinity as high as 4.0 mS/cm.

3.9 Soils and Land-Use

The soils of most of the Study Area are formed by the deposits in the Mariut Lake and alluvial deposits of the Nile. The area close to the Western desert is formed by old sea-floor and wind-blown sandy soils. Except wind-blown soils, the top soil is a kind of clayey textured containing 40 percent of clay. According to the result of soil survey in 1960s about 62 percent of the total area is covered by cultivable land of first to fourth classes, of which class one and two have salinity less than 8 mS/cm shares only 18 percent. It is necessary to improve the conditions of the groundwater table and soil salinity, because they are considered as the main factors in classifying soils.

The present land-use is that the cultivated land occupies about 124,210 ha (73%), culturable waste and non-farmland respectively about 35,580 ha (22%), and of the total cultivated land, 97,310 ha(78%) is cropped with annual crops, 15,820 ha (13%) by orchard and 11,080 ha (19%) is left as short-term fallow area.

3.10 Present Irrigation Conditions

There are three irrigation networks in the Area. The source of water for these systems is the Nile river. The systems are the Nubariya canal which forms the western boundary of the Area, the Mahmoudia canal which forms the eastern boundary and the Kandak canal. The total area covered by them is 171,300 ha and their shares are 92,880 ha (54%), 61,550 ha (36%) and 16,870 ha (10%) respectively.

The maximum irrigation demand occurs in the summer month of June, about 7.1 mm. The rotation of the Nubariya canal network is five days on and ten days pause, whereas in the case of Mahmoudia canal network, the rotation is five days on and five days pause. Due to low water level in the canals, irrigation is performed by lifting water from the secondary canals by traditional Saqias or portable pumps. A comparison between water requirement and actual intake for two main networks, that is, Nubariya and Mahmoudia, shows that the intake amount of Nubariya canal covers only 81 percent of the requirement and relating to the requirement, Mahmoudia canal has a 105 percent intake rate. From which it can be said that the Nubariya system has a shortage of water through out the year.

3.11 Present Drainage Systems

The Study Area can be divided into eight blocks, consisting of seven drainage blocks and the Mariut Lake. Every block is equipped with a pumping station enabling drainage to keep the field groundwater table as low as possible. There is another pumping station (the El-Max pumping station) at the downstream of Omoum main drain which drains all the water coming from the seven upstream blocks to the Mediterranean Sea. According to the original plan, Omoum main drain used to divide the Mariut Lake but recently, as the water quality of the Lake has deteriorated substantially, the embankments of the Omoum main drain and Nubariya canal have been cut in order to supply fresh water to the Lake. Therefore, present water levels of the Lake and Omoum main drain are the same.

Owing to the above circumstances, the water level of Omoum main drain has become higher than the designed water level and caused problems such as water-logging, salinity etc. in the Area. Therefore, from the viewpoint of agriculture, water level of the Omoum main drain is requested to lower up to the design level as shown below;

Present Mariut Lake level	:	(-) 2.70 m ~ (-) 2.80 m. MSL
Proposed Omoum main drain level	:	(-) 3.25 m. MSL
Proposed Mariut Lake level	:	(-) 2.40 m. MSL

The maximum drainage discharge for the El-Max pumping station is observed in winter, which is due to the excess rainfall runoff. In case of other pumping stations, it happens during the end of summer season from August to October, before or after the harvest of cotton, rice etc.

Owing to the heavy rainfall occurred in December 1991, of which maximum daily rainfall is observed at 167 mm, agricultural crops in the lower areas of Abis, Hares, Dishudi and Truga blocks were severely damaged with inundation periods of one to two weeks and inundation depth of more than 40 cm in some area.

It was reported that in December, 1991, the water level of Mariut Lake increased to (-)1.86 m. MSL. This happened due to the overflow in the downstream part of the Omoum main drain. During that flood a large quantity of trashes, aquatic plants etc. that came with the flood flow disturbed the El-Max pumping station and prevented it from reaching its full operational capacity. The other reasons for this flood may be mentioned as the insufficient cross-section of Omoum main drain caused by the sedimentation in the bed and obstacles such as aquatic plants.

3. 12 Present Drainage Facilities

In order to reduce the groundwater level, implementation of subsurface drainage in 44 percent of the Study Area, mainly in the upstream has been completed. But it has been reported that some areas have not yet derived the anticipated benefits. It is thought that the low density of the laterals may be one of the reasons. The water level of Omoum main drain is maintained at a level which is higher than the designed one, which is also affecting the subsurface drainage in the upstream adversely.

Drains in the individual blocks are also of unlined earthen type with mild slopes. Due to this, sedimentation and growth of aquatic plants have been hampering the flow and there are some places where the capacity of the drains cannot cope with the capacity of the pumps. Especially, in Hares block, where subsurface drainage is yet to be implemented, the situation is worse. Also the continuous flow of primarily treated muddy sewage water may cause overflowing in the delivery side of Qalla pumping station.

The capacity of Omoum main drain has decreased due to sedimentation and deterioration of side slopes. The Nubariya Siphon has also lost its capacity due to the cuts in the embankments and sedimentation in the siphon. The cross-section at the railway bridge point has become very shallow with inadequate capacity. The discharge-channel from the El-Max pumping station to the Mediterranean Sea also does not have enough capacity. Although some improvement works have been done, it is still dangerous for the settlers on the both banks due to high velocity flows.

From the operation records it was learnt that the capacity of Hares and Dishudi pumping stations indicate a shortage. All operations such as pumps, recording of delivery and suction heads, operation of gates etc. are done manually. Although the facilities are well maintained, 24 hours-operation loads have been causing wear on the parts and the difficulty in importing foreign-made spare-parts worsens the problem. Except Hares, replacement of pumps in most of the pumping stations has taken place during the last four to five years. The age of the Hares pumping station is about 27 years and has become a timeworn facility. Over the last four to five years, the quality and quantity of electricity has improved considerably and no interruption in pumping operations has been recorded.

The capacity of the El-Max pumping station is smaller than the total drainage discharge from seven pumping stations, and is not able to cope with discharge, if Mariut Lake does not function as a reservoir. Moreover, the No.1 pumping station (old) is too old, having been installed 31 years ago. The maintenance costs have become a burden.

3.13 Operation and Maintenance of Drainage Facilities

1) Operation and Maintenance Organization

Responsible Organization of drainage Facilities

Major drainage facilities in the Study Area are Omoum main drain, drain, operation and maintenance roads along drains, subsurface tile drains, and drainage pumps. Operation and maintenance (O&M) works of these

facilities except drainage pumps are under the responsibility of EPADP, while those of drainage pumps are under MED, respectively.

Operation and Maintenance Conditions

The principal and periodical O&M works of the drains are excavation of deposited soils and reshaping of drain section inclusive of grass cutting of the side slopes. The excavated soils, which are usually placed on the one side of roads provided along the drains, are causing a obstruction for transportation in the areas, due to heavy rain during the winter season.

The other O&M works of the drains are elimination of aquatic plants such as water hyacinth, of which works are undertaken by clamshell type heavy equipment for drains with relatively wide width, and by back hoe type equipment for narrow drain in width.

Regarding O&M works of drainage pumps at seven stations, both the Directorate of El-Max and Mahmoudia are undertaking those works. Since El-Max pump (No.1) and Hares pumps have been installed at the years of more than 31 and 27 years ago, respectively, pump operation efficiencies of both the pumps are lowered, and maintenance costs by means of replacement of necessary parts become large in recent years. But pump itself are relatively well-maintained by the staffs of MED. Pump houses are remarkably deteriorated because of timeworn facilities as well as insufficient maintenance due to shortages of budget.

Design and construction of subsurface tile drains at field level are basically made by EPADP, and O & M works of these facilities are used to be carried out by farmers' group themselves. However, it is reported that groundwater table at field dose not reach to the targeted level at many places, even after the installation of subsurface tile drains. Under the circumstance, it deems to be vital important for related farmers to give the opportunity for participation of planning subsurface tile drains, grasping the outline of tile drain systems to be installed and necessity of operation and maintenance of the tile drain facilities.

Operation and Maintenance Costs

Operation and maintenance costs for drains and pumping facilities in 1993, from July 1993 to June 1994, are reported to be 3,898 thousand LE for EPADP and 10,917 thousand LE for MED, totaling 14,815 thousand LE. which is equivalent to 31 LE/feddan (73 LE/ha).

These required O & M costs are burden by the government without charge of farmers.

3.14 Agricultural Conditions

An increasing trend in owner-farmers is observed in Egypt due to various land reform programs undertaken by the Government. The total number of farm households in the Study Area is 79,070, of which about 59,450 (75%) are owner farmers and land holding size is 3.7 feddan (1.6 ha) per farmer. A rotational cropping of two to three years is practiced for the main crops such as cotton, paddy, oranges etc. The main crops that are grown in the winter season are wheat (28% of total cultivated area), berseem (40%), beans (5%) and vegetables (8%) and in the summer season, cotton (22%), paddy (20%), maize (28%) and vegetable (11%) are grown.

The amount of production is slightly lower than the national and provincial level. Especially, in Hares and Truga areas the situation is worse. High groundwater table and soil salinity may be cited as reasons. The benefits from subsurface drainage in production increase could not be achieved as estimated, and however, increased ratio for cotton, rice and maize are ten, three and four percent only, respectively.

It seems that mechanized cultivation in the Area is in progress. Land preparation and planting of most of the crops and threshing of wheat and paddy are done by machines. Ownership of the machines is shared. Usually, one tractor is owned by about 12 households, while in the case of thresher it is six.

3.15 Agricultural Economy

Net income from cotton cultivation is more than paddy and maize. Average annual income of all rural families in Egypt was LE.3,500. On the other hand, annual farm income in Omoum Area was LE 2,535 without project. Should project be implemented, farm income would become LE 6,922. Usually, farmers sell their products to the cooperatives or local markets, however, the overall marketing process is not well organized.

3.16 Agricultural Supporting Services

Agricultural supporting services such as farmland improvement, seeds for improved varieties, new farming techniques and services for machineries are rendered by different organizations. However, the provision of agricultural experiments and research facilities is absent. There are village-level agricultural cooperatives and their activities include distribution of seeds, fertilizers and chemicals at subsidized rates and facilitates help to the farmers obtain loans. There are also other organizations such as Farmland Improvement Organization, Water Users' Association and Drainage Associations, but at present their functions are very limited.

3.17 Inland Fisheries

The number of fishermen who are engaged in inland fisheries in Mariut Lake is about 5,600 and the total annual catch is about 3,400 tons. Telapia constitutes 74 percent of the total catch. Deterioration of Lake water quality has adversely affected the fish production in the Lake, however, since 1992 it has shown an increasing trend which may be caused by the supply of Omoum main drainage water into the Lake.

3.18 Rural Infrastructure

Potable water for the Area is supplied through the pipeline systems connected to three treatment plants installed in Damanhur, Abu Hommos and Nubariya. About 90 percent of the people of the Study Area can obtain fresh

drinking water from the community taps installed in the villages. Average consumption rate is 150 lit/day/person, in the rural area it is low, only 50 - 70 lit/day person. This water supply is managed by the Behera Water Supply Company.

Construction and maintenance of the roads are the responsibility of Road and Transportation Directorate of Behera Governorate. The total length of roads in Behera Governorate is about 1,588 km of which only 48 percent is paved. The farm roads which are used as connecting roads among the village are narrow and the density is low. The present farm-road network is not able to cope with the future trend of farm mechanization.

3.19 Environment

In order to understand the existing environmental conditions of the Study Area focusing on water quality, 20 samples from Mariut Lake and Omoum main drain were collected and analyzed. The results show that the quality of Omoum main drain and Nubariya canals is comparatively better, on the other hand, the water quality of Qalla drain and drain for carrying western portion of sewage water and sludge is very poor.

The reclamation activities have reduced the water surface area of Mariut Lake to about 24 percent from the area of 40 years ago. At present, inflow of primarily treated sewage water with malodor and sludge from Alexandria city is worsening the natural landscape as well as water quality of the Lake. And for conservation of Lake water quality, supply of water from Omoum main drain is taking place. Under the circumstances, the water from Omoum main drain is playing a vital role not only for fish culture in the Lake but also for its water quality.

From the analyses and discussions on Initial Environmental Examination (IEE) for the subject project, the anticipated impacts may be summarized as follows.

Social Environment:

In case of changes in the present condition of Mariut Lake or its water level, changes in economic activities, loss of jobs in fisheries sector are envisaged, necessity of settlement of water right and fishing right is important.

Natural Environment:

Changes in surface and groundwater hydrology, adverse effects on inland fisheries, water pollution and degradation of water quality and eutrophication may also occur.

3. 20 Related Projects and Studies in the Study Area

The projects and studies that have been implemented in the Study Area are listed below;

Project/Study Name	Implementing Agency
Subsurface Drainage Development Project	EPADP, MPWWR
Behera Rural Development Project	Ministry of Agriculture
Main System Management Project	EPADP, MPWWR
Hares Pilot Project for Subsurface Drainage Design	DRI, MPWWR
Reuse Monitoring Program	DRI, MPWWR
Omoum Drain Project	EPADP, MPWWR
Balaqter Irrigation Project	Irrigation Dept., MPWWR
Mahmoudia Irrigation Improvement Project	Irrigation Dept., MPWWR
West Nubariya Agricultural Intensification Project	Irrigation Dept., MPWWR

4. Development Potential and Its Restrictive Factors

Development potentials and at the same time restrictive factors related to the 430,260 feddan (180,710 ha) of Study Area are described below;

4. 1 Land and Water Resources

- In the Study Area, only 62 percent of farmland falls under the categories from one to fourth classes according to the result of soil survey in 1960s. Presence of fifth class cultivable land is mostly observed in Hares and Truga areas and they are left fallow due to high groundwater table and salinity. It seems that these soils conditions have not change adequately.

- High salinity and high groundwater table are affecting the farming efficiency and crop yields. For efficient land-use, improvement of drainage systems including subsurface drainage is very important.

- Discharge of an annual amount of 2,500 MCM through the El-Max pumping station to Mediterranean Sea has limitations as a reuse water source from the view point of amount and quality.

4. 2 Irrigation and Drainage

- A large amount of irrigation water loss in connection with the increased drainage discharge is taking place due to inefficient water management and facilities.

- Lack of knowledge and experience regarding water use, over-use by the upstream inhabitants are causing problems for the downstream farmers.

- Unification of Mariut Lake and Omoum main drain has raised the water level of the drain from its design level which may be considered as the main reason for poor drainage in the upstream blocks.

- Insufficient implementation and lack of proper management of subsurface drainage.

4. 3 Agricultural Aspects

- Owing to the suitable climate for crop cultivation and marketing conditions, the project has a considerably high potential to develop intensive farming with a wide range of crop diversification.

- In the case of Hares and Truga areas where subsurface drainage facilities yet to be provided have very low productivity due to the high groundwater table.

- Selection of appropriate crops and their diversification, strengthening of supporting services and enhancing farmer's knowledge of O&M of irrigation and drainage facilities are necessary.

4.4 Drainage Facilities

- Sedimentation and growth of aquatic plants in Omoum main drain and blocked drains due to improper management

- Insufficient capacity of Omoum main drain and discherge-channel at downstream from the El-Max pumping station

- Weakening of Omoum main drain embankments

- Non-functional presence of Nubariya Siphon and insufficient cross-section around the railway bridge

- Timeworn facilities of El-Max and Hares pumping stations

- Insufficient capacity of El-Max, Hares and Dishudi pumping stations.

4.5 Environment

- Deteriorating of water quality of Mariut Lake owing to Alexandria sewage water, industrial effluence from factories around the Lake, agricultural chemical, livestock sewage, etc.

- Maintaining suitable water level of Mariut Lake from the viewpoints of fisheries, water conservation, preservation body for birds and small animals, landscape of the Lake, and etc.

- Plan formulation for utilizing Mariut Lake, taking into account improvement plan of Omoum main drain and operation plan of El-Max pumps.

5. Formulation of Basic Development Plan for Drainage Improvement

5. 1 Fundamental Policy for Development Plan

Purpose, Strategy and Target

On the basis of Third-Five Year Plan of the Republic of Egypt, the following development plans have been formulated in order to eliminate the above mentioned restrictive factors. Field-wise strategies are as follows;

- Drainage Improvement Plan
  After a comparative study, a reasonable and suitable water level for Mariut Lake, Omoum main drain and block drains should be determined. And focusing on agriculture, improvement/ construction of Omoum main drain, block drains, pump facilities and subsurface drainage facilities should be taken place.

- Water Resource Development and Water Management Improvement Plan
  Conservation of ensured water source for the area and status/possibility of reuse water source for the newly developed area and proper water management for an efficient use of scarce water should be considered.

- Farm Management Improvement Plan
  In order to raise the crop yields, an appropriate and suitable land-use plan, cropping pattern, farming practices, supporting services and farmer's organization should be taken into consideration.

- Rural Environment Improvement Plan
  Improvement of village water supply systems and village roads should be considered.

- Mariut Lake Environment Improvement Plan
  Water quality of the Lake should be conserved at a suitable water level and water supply, with strict laws against polluters being enacted.

5. 2 Sectional Development Plans

Land and Water Resources Development

There are vast areas of uncultivated land in the Area, as a result of high salinity and high groundwater table. To bring this land under cultivation, leaching of saline substances and lowering of groundwater table is necessary. Improvement of drainage up to on-farm level, land leveling, deep plowing and application of gypsum are also required.

Currently, there is a project called Omoum Drain Project for water resources development which will deal with reuse of drain water from the Shereshera block. Installation of pump facilities is in progress and after the completion, reuse of maximum possible drain water, about 73 percent will be possible. The mixing ratio of drain water and Nubariya canal water has been fixed as 1 : 3.5, which would reduce the salinity from 2,000 ppm to 700 ppm. In the future, this resource may be increased to some extent by changing the mixing ratio, in other words using more saline water. But in that case selection of crops with high salinity tolerance has to be considered.

Irrigation and Drainage

For efficient irrigation, selection of an appropriate method for optimum use of water resources, introduction of canal lining for reducing conveyance losses or introduction of a pipeline system are necessary. Moreover, to control over-intake and unattended night time irrigation, construction of gates with strict operation rules should be considered.

In the case of drainage, increased drainage discharge due to development work in the Area and implementation of subsurface drainage is envisaged. Therefore, standardization of unit discharge is necessary. Besides, to attain optimum benefits from subsurface drainage, modification of design criteria such as interval and depth of laterals should be considered at an early date.

Improvement of Drainage Facilities

In Hares, Dishudi and Truga blocks, designed drainage discharges will be increased by 10 ~30 percent due to an increase in unit discharge. As a result, the designed capacity of Omoum main drain and the El-Max pumping station will also have to be increased to 150 cu.m/sec. In fact, these facilities do not have enough capacity. Therefore, improvement of Omoum main drain, the El-Max pumping station, block drains and pumps are necessary.

Current drainage situation should be improved through lowering water level in Omoum main drain as well as the drains in each block by the originally design level. And also, in order to improve the drainage conditions at field level, subsurface tile drains with appropriate density should be newly provided.

Agricultural Development Plan

To gain increased agricultural production, development of arable land and its optimum use are the prerequisites. The other important factors are drainage improvement up to on-farm level, land consolidation, improvement of water management system, establishment/strengthening of farmers' organizations for O & M of drainage systems, etc. Moreover, introduction and development of advance farming technology, research facilities for crop husbandry, and establishment/strengthening of supporting services are necessary.

With the implementation of the project, the cropping intensity of annual crop will be raised to 100 percent of the cultivation area, both in winter and summer seasons, with 200 percent of annual cropping area. The area coverages of both winter and summer season vegetables will be increased by 50 percent of the concerned area without/ project in the proposed cropping pattern.

It is estimated that average crop yields will increase in the range of 5 ~ 25 percent at project maturity. However, the average crop yields will be raised in the half range in the area, where the subsurface tile drain exist, taking account the groundwater table in the area. The crop production with project is estimated at 4,575 thousand tons, which will increase by about 37 percent of the production without project, where the annual cropping area will

increase by 23 percent of the area without project to 590 thousand feddan (248 thousands hectares).

5. 3 Alternative Plans for Drainage Improvement and Selection of Optimum Plan

Four technically suitable alternative plans for the downstream drainage system have been prepared with due consideration for Mariut Lake, Omoum main drain, Nubariya canal, agriculture, fishery and conservation of Mariut lake water quality. And a comparative study from the view point of technical, economical availability of O & M facilities and environment around the Mariut Lake was carried out.

On the basis of the study results, Case-3 (separation of Omoum main drain from Mariut Lake) has been selected as the optimum drainage system plan which will satisfy all the above mentioned conditions. However, any change in Mariut Lake environment should be considered separately.

Outlines of the alternative plans are presented below;

Case	Lake Water Level	Omoum Water Level	Agriculture	Fishery	Navigation	Lake Environment	Economy	Remark
1	(-)2.70	(-)2.70	no good	moderate	moderate	moderate	unfavorable	Present condition
2	(-)2.40	(-)3.25	good	good	good	good	unfavorable	Improvement Plan
3	(-)2.40	(-)3.25	good	good	good	unfavorable	moderate	Improvement Plan
4	(-)2.40	(-)3.25	good	good	good	unfavorable	unfavorable	Improvement Plan

According to the results, the proposed water level at the El-Max pumping station and Mariut Lake was decided as shown below;

- Suction water level of the El-Max pumping station : (-) 3.25 m. MSL
- Normal water level of Mariut Lake : (-) 2.40 m. MSL

5. 4 Drainage Facility Plan

The necessary work on the basis of the selected drainage system is described below;

- Replacement / improvement of pumping station

Improvement of El-Max pumping station (No.1)	: Discharges 14.6 cu.m/sec×7 units
Improvement of Hares pumping station	: Discharges 7.5 cu.m/sec×5 units
Inclusion of pump for Dishudi pumping station	: Discharges 4.0 cu.m/sec×1 unit
Inclusion of pump for Truga pumping station	: Discharges 4.0 cu.m/sec×1 unit

Note: Discharges of the El-Max and Hares pumping stations include the capacity of stand-by pumps

- Improvement of Omoum main drain
  (Separation related facilities)
  : Discharges 150.0 cu.m/sec
  : Length 10 km
  : Bed width 55 m

- Improvement of dishcarge-channel
  : Discharges 150.0 cu.m/sec
  : Length 1 km
  : Bed width 20 m

- Improvement of block drains
  : Length 700 km

- Provision of subsurface tile drain
  : Area 177,620 feddan (74,600 ha)

5. 5 Selection of Priority Development Area and Project

The priority area for development has been selected after a detailed discussion with the study related personnel and concerned Government officials. The selection criteria has also focused on their consistency with Government policy, local people's demand, farmer's income increase, creation of job opportunities and project evaluation results.

An in-depth study shows that i) improvement of Hares pump facility including implementation of subsurface drainage in area and improvement of El-Max pumping station (No.1) have also been given high priority by EPADP, ii) inadequate infrastructure, poor living conditions compared to other areas and keen interest of the local people in subsurface drainage installation, and iii) from the result of economic analysis which showed 17 percent of internal rate of return (EIRR), Hares area has been selected as the Priority Development Area.

On the other hand, in order to obtain the fruitful results from the Farmland Environmental Improvement Project in Omoum Area, the improvement of pumping stations, Omoum main drain and drains in the blocks, on-farm drainage facilities and improvement of subsurface tile drains are prerequisite from the viewpoint of hardware, along with the improvement of water management technology from viewpoint of software. Especially, Omoum main drain and discharge-channel are recommended for urgent improvement work. Under the situations, these three major drainage facilities are selected as the Priority Development Project.

In Phase-II field works, a Feasibility Study was carried out on these selected Priority Development Area and Project.

5. 6 Stage Development for Basic Development Plan (Master Plan)

For the Implementation of the Farmland Environmental Improvement Project in the Omoum Area, the following three Phases have been planned, with each Phase requiring seven years.

First Phase : Short-term Development (1996-2002)
Second Phase : Middle-term Development (2003-2009)
Third Phase : Long-term Development (2010-2016)

The contents for the Short-term Development will include the projects with highest priority, listed as follows;

- Provision of open and subsurface drainage mainly in the lower reaches.

- Construction of a suitable drainage systems in Mariut Lake area, taking into consideration agriculture, fisheries, environment and navigation,
- Improvement/replacement of decrepit facilities/structures in the El-Max and Hares pumping stations,
- Improvement of Omoum main drain (cross-section, O&M roads),
- Partial utilization of Omoum drain water as reuse water sources,
- Establishment/strengthening of farmer's organization and water and drainage users' association for an efficient water management, and
- Establishment of water quality monitoring program and legislation against polluters in order to conserve Mariut Lake water quality.

6. Environment

6. 1 Study Objectives and Impact Assessment

The results of Initial Environment Examination (IEE) are summarized as follows;

- Separation of Omoum main drain will affect fisheries and navigation.
- Quantitative change in Omoum main drain.
- Lowering of groundwater table with installation of subsurface drainage.
- Qualitative and quantitative changes in Lake.
- Effects on the Lake water due to Eutrophication.
- Effects on local inhabitants.

6. 2 Forecast and Evaluation of Impact

- Affect on Fisheries and Navigation Activities

The separation dike of Omoum main drain in the Lake will have the following impact on fisheries and navigation, and the countermeasures or mitigation plans to be considered.

- Freshwater from the Omoum main drain and Nubariya canal cannot easily flow into the Lake without the gate facility
- Obstacles to inland navigation will occur

- Impact on Surface Water

The impact on water flow to the Mariut Lake can be characterized as twofold. One assumes that discharge from Omoum main drain will increase after the project, while inflow of Mariut Lake will decrease due to reuse of water at Truga pump site. But, it is considered that the effects of increment and reduction in discharge are not serious apart from water salinization.

- Impact on Groundwater

The level of groundwater in the Study Area's farmland is maintained at about (-) 1.2 m below the ground surface with tile drain and drainage pumps. Therefore, it is considered that negative impacts will not take place.

- Affect on Lake Water

The water sources affect the lake both in quality and quantity, The main inlets and it's average discharge in 1994 are;

-	Omoum main drain	: $4,849 \times 10^3$ cu.m/day	(72%)
-	Nubariya navigation canal	: 625×10^3 cu.m/day	(9%)
-	Qalla drain	: $1,000 \times 10^3$ cu.m/day	(15%)
-	West Treatment Plant (WTP), etc	: 298×10^3 cu.m/day	(4%)
	Total	: $6,772 \times 10^3$ cu.m/day	(100.0%)

Namely, the inflow of Mariut Lake is seven million cubic meter per day on average and almost the same amount of Lake water is discharged into the Mediterranean sea through the El-Max pump every day.

- Water Quality of Mariut Lake and Drains

The water quality of the Lake Mariut and drains of the outlet into the Lake Mariut are summarized as follows;

- Irrigation water quality at the upper reach at Nubariya canal is very clean with the Value of EC, DO, BOD, COD, Total Nitrogen and MPN of Coliform.
- The water quality of the Omoum main drain is complies with Egyptian Standards apart from high salinity (EC; 6,200 mS/cm).
- The water in the northeast and south side of the Mariut Lake are extremely polluted, so it can be called over-eutrophic lake, the value of COD, T-N and MPN of Coliform is 38.5, 40.0 mg/ℓ and 24 million MPN/100 cu. cm respectively. The water quality in the western Lake is comparatively clean apart from EC value of 13.3 mS/cm.
- The effluent of Qalla drain and W.T.P which are received the sewage from Alexandria city, cause the eutrophication of the Mariut Lake with high contents of BOD, COD and MPN of Coliform.

- Impact on Inhabitants

There are some inhabitants along the discharge channel to be improved by the project, it should be considered to make compensation for moving house.

6.3 Environmental Conservation Plan

- Environmental Conservation Policy

The separation embankment proposed in the Project is expected to give some adverse effects to the local fisheries, navigation and the Mariut Lake

water quality. In this connection, there will be effective countermeasures to be required so as to avoid or minimize such adverse effects. The proposed facilities shall be constructed to keep the following environment level and Mariut Lake water quality as the targets.

- The local fisheries and navigation should be maintained at the level as of 1982 when the old separation embankment would not be partially destructed.
- The Lake water quality should be almost equal to that of the water introduced of the Omoum Area.

- Environmental Conservation Plan

The necessary countermeasures for the local environment conservation shall be provided on the pollutants' cost basis, Mitigation plan is comprised of physical plan and the Mariut Lake water control plan, the former is construction of five gate facilities which allow fishing boats to pass and water to flow and discharge into the Lake. As a latter, the following plans are proposed for effective Lake water management.

- Introduction of drainage discharge of Omoum main drain into the Lake.
- Establishment of target Mariut Lake water level

  Following Water Level will maintain in average;

  Winter ; (-) 2.70 m. MSL

  Summer ; (-) 2.40 m. MSL

- Compensation for Local Inhabitants

EPADP has already started environment assessment for the area since January, 1994, and the necessary countermeasures for the movement to the objective inhabitants of 135 households have been determined.

- Water Quality Monitoring System

Monitoring in the Omoum main drain basins covers the whole major points of the irrigation canals and drains, It is, however, proposed to provide

remote monitoring systems at two points, additionally, for monitoring progressive Lake water pollution as well as quality of reuse water.

6. 4 Preparation of Environmental Impact Assessment

Environmental impact by the project implementation should be evaluated objectively and rightfully, and its study report on the Environmental Impact Assessment (EIA) should be presented, prior to the commencement of the project implementation. In this connection, Egyptian Public Authority for Drainage Projects (EPADP) and Mechanical and Electrical Department (MED), Ministry of Public Works and Water Resources, which will be main implementation organizations of the Project, should prepare the EIA report in cooperation with Environmental Research Institute (ERI), and submit it to Egyptian Environmental Affairs Agency (EEAA) and its related committee to get approval on it.

The EIA report should be carefully prepared in accordance with the direction described in this Feasibility Report, and the followings should be mentioned in the report; i) restoration measures of the Mariut Lake to be executed, ii) compensation plan and its progress to resettle the related houses living on both banks of the proposed discharge-channel, iii) mitigation measures for water contamination to be caused by the Project during the construction period of drains and pumping station, and iv) monitoring of water quality and quantity of Mariut Lake after operation of Omoum Drain Project.

RECOMMENDATIONS

1. Improvement of Water Management

The inefficient irrigation system along with inadequate drainage, causes many problems such as shortage of water, water-logging, increased salinization and increased O&M costs in the Study Area. Therefore, an urgent need to improve this situation is essential. In this regard, recommendations are made to work in close cooperation with the relevant Government agencies inclusive of farmers and to establish/strengthen the farmers' organizations even up to the on-farm level, and prepare technical guidelines for land-use, crop husbandry, water distribution and O&M of drainage facilities.

2. Reuse of Drainage Water

The present annual amount of reuse water is 570 MCM, however, after the completion of the Omoum Drain Project this amount will become 1,650 MCM, which will mean a 73 percent use of total available drain water. In this regard, in a situation of possible water scarcity in the future, the reuse of drain water must be managed paying close attention to quantity and quality.

3. Improvement of Subsurface Drainage Facilities and Their Design Criteria

In about 44 percent of the Study Area, mainly upstream, installation of subsurface drainage has been completed. But it was reported that some areas are still not getting the expected benefits due to the ineffectiveness of the drainage. At present, a Pilot Project has been taken up by DRI of MPWWR and research is being conducted on appropriate design criteria and their effectiveness, installation costs and suitable envelop materials etc. Based on the outcome of this research, improvement of subsurface drainage including existing facilities is recommended.

4. Selection of Salinity Tolerant Crops

From the viewpoint of efficient use of water sources, reuse of drain water is taking place, maintaining salinity level after mixing of 700 ppm (EC is 1.1 mS/cm). From which a conclusion may be drawn that this level has no adverse effects on the crops that are currently be grown. However, crops such as onion, carrot, etc. need an EC value less than 1.0 mS/cm for healthy growth. Therefore, selection should be made excluding the above mentioned crops.

5. Improvement of Farming Technology, Crop-husbandry and Supporting Services

From the viewpoint of more arable land and intensified agriculture followed by increased crop production, activities such as drainage improvement, farmland consolidation, an efficient water management system, training for O&M of drainage facilities and research through the establishment of farmers' organization are recommended.

6. Phased Development

The implantation of the Farmland Environmental Improvement Project in Omoum Area should take place in a phase-wise manner. The components of the Project should be categorized as Short-term, Middle-term and Long-term on the basis of their urgency, quantity and scale of works, economy etc.

7. Environment

At present, the major inflows to Mariut Lake are drainage water from surrounding farmland and primarily treated sewage and industrial waste water from Alexandria city. The major pollutant of the Lake is the sewage water from Alexandria city. To conserve the environment of Mariut Lake, eradication of pollution sources, elimination of accumulated sludge and some biochemical treatments are recommended. In this connection, the worst part of the Lake, especially the eastern part of the Lake, may be declared abandoned

and restrictions on eating fish from that part of the Lake should be imposed. It is also desirable for the Government to execute overall environmental countermeasures for the successful environmental conservation in the vicinity of the Study Area.