JICA BASIC DESIGN STUDY REPORT ON THE PROJECT FOR THE REHABILITATION AND IMPROVEMENT OF LAHOUN REGULATOR OF BAHR YUSEF CANAL IN THE ARAB REPUBLIC OF EGYPT NOVEMBER 1994 SANYU CONSULT

No. 1

JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF PUBLIC WORKS AND WATER RESOURCES

ARAB REPUBLIC OF EGYPT

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PREFACE

In response to a request from the Government of the Arab Republic of Egypt, the Government of Japan decided to conduct a basic design study on the Project for the Rehabilitation and Improvement of Lahoun Regulator of Bahr Yusef Canal and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Egypt a study team headed by Dr. Kazuhiro Yoshii, Development Specialist, JICA and constituted by members of Sanyu Consultants Inc., from May 26 to June 26, 1994.

The team held discussions with the officials concerned of the Government of Egypt, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Egypt in order to discuss a draft report, and as this result, the present report was finalized.

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

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

November, 1994

Kimio Fujita
President
Japan International Cooperation agency

November, 1994

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for the Rehabilitation and Improvement of Lahoun Regulator of Bahr Yusef Canal in the Arab Republic of Egypt.

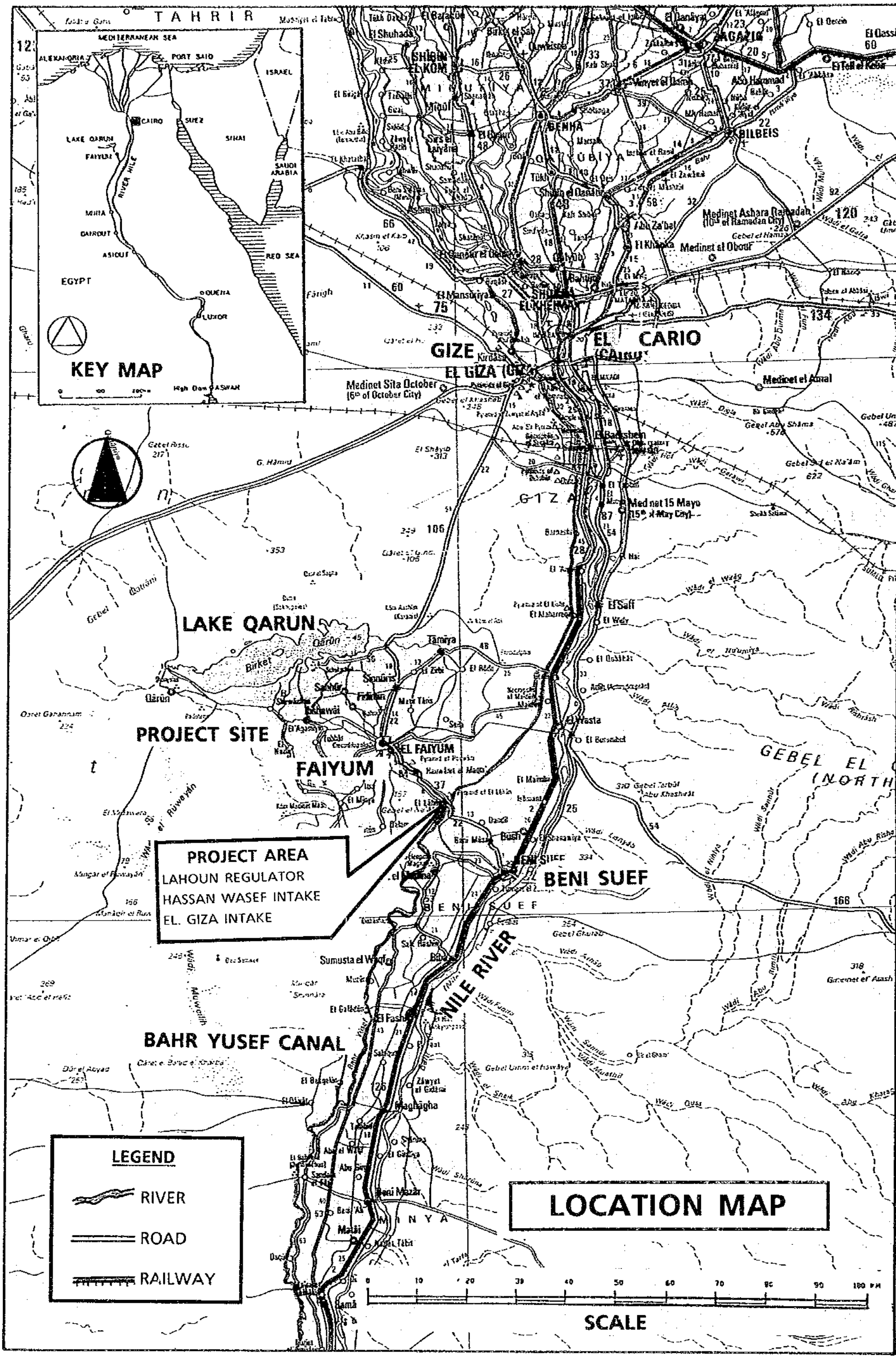
This study was conducted by Sanyu Consultants Inc., under a contract to JICA, during the period May 20, 1994 to November 21, 1994. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Egypt and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

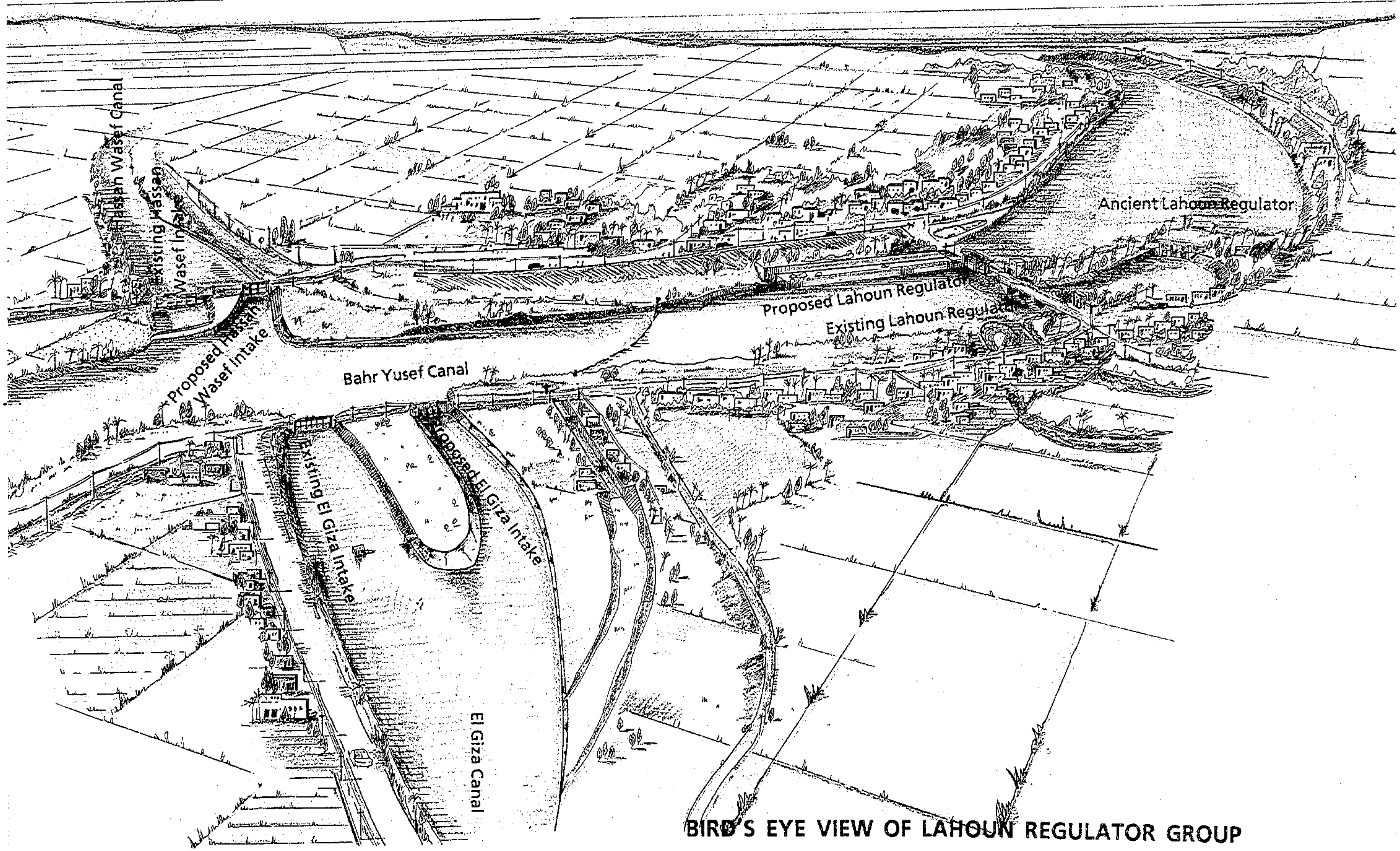
We wish to take this opportunity our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, and the Ministry of Agriculture, Forestry and Fisheries. We would also like to express our gratitude to the officials concerned of the Irrigation Department, Ministry of Public Works and Water Resources, the JICA Egypt office, the Embassy of Japan in Egypt for their cooperation and assistance through our field survey.

Finally, we hope that this report will contribute to further promotion of the project.

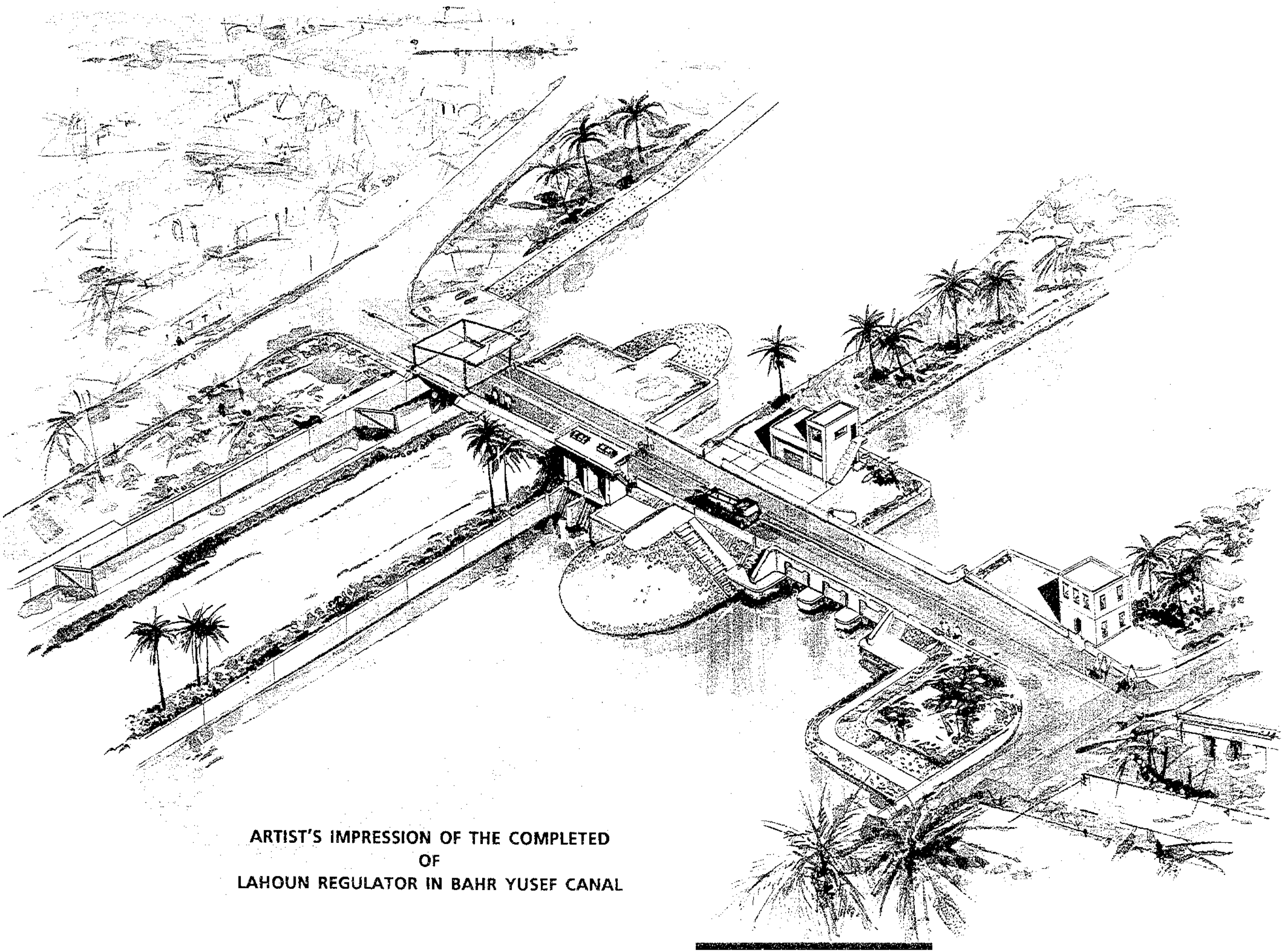
Very truly yours,

Yasuo Teramura
Project Manager,
Basic Design Study Team on the Project for the
Rehabilitation and Improvement of
Lahoun Regulator of Bahr Yusef Canal,
Sanyu Consultants Inc.

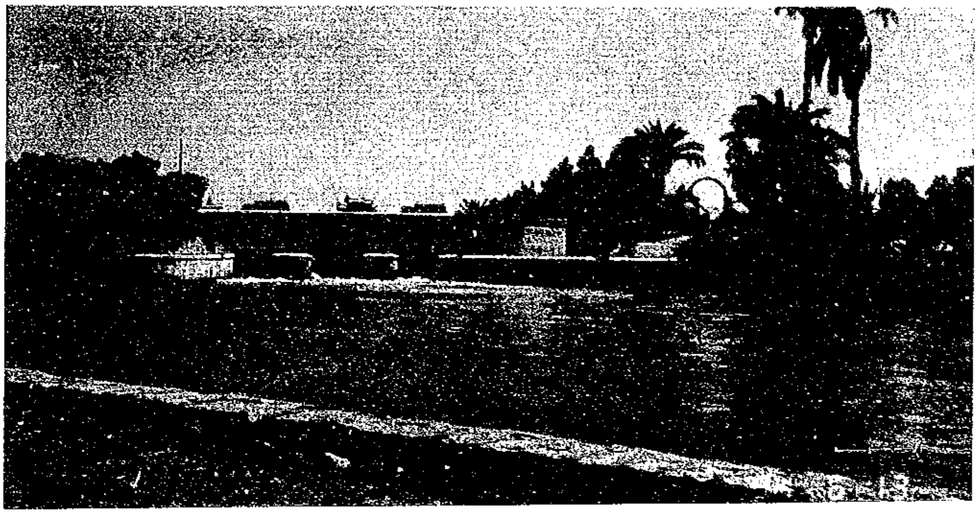

KEY MAP
LAKE QARUN
PROJECT SITE
FAIYUM
PROJECT AREA
LAHOUN REGULATOR
HASSAN WASEF INTAKE
EL. GIZA INTAKE
BAHR YUSEF CANAL
NILE RIVER
BENI SUEF
GIZE
EL CARIO
LEGEND
RIVER
ROAD
RAILWAY
LOCATION MAP
SCALE



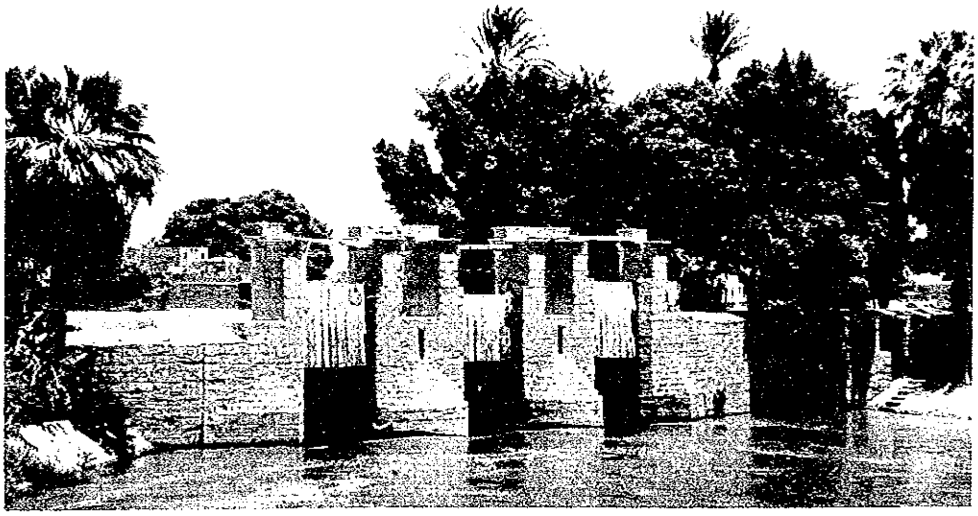
BIRD'S EYE VIEW OF LAHOUN REGULATOR GROUP



ARTIST'S IMPRESSION OF THE COMPLETED
OF
LAHOUN REGULATOR IN BAHR YUSEF CANAL

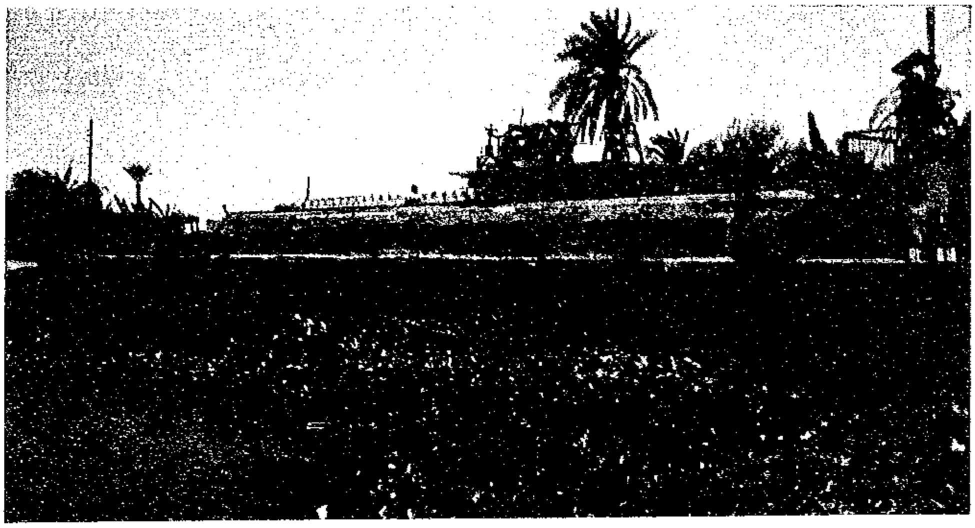


Front view of existing Lahoun
Regulator and Bahr Yusef Canal



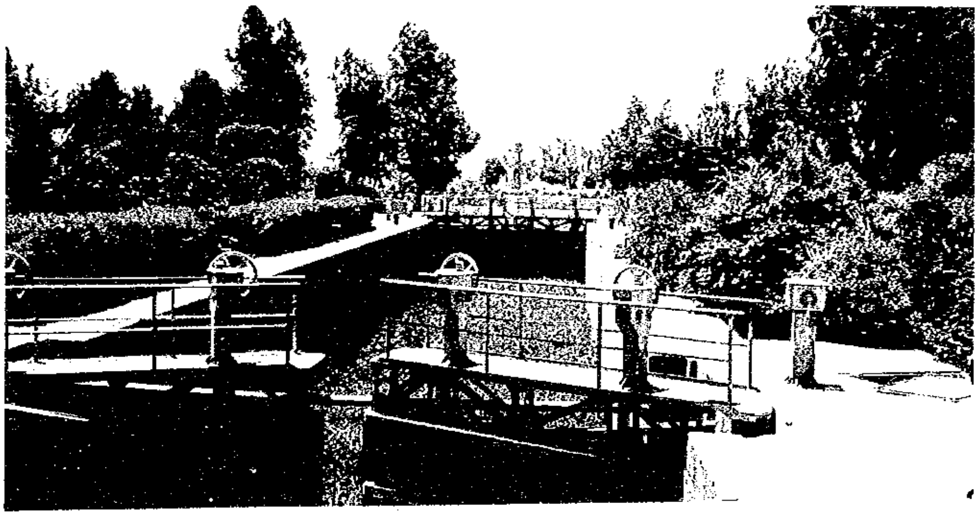
Front view of ancient Lahoun Regulator

Heavy loading mounted on the
bridge at existing Lahoun Regulator



Inlet view of Hassan Wasef Intake,
covered with water hyacinth

Outlet view of Giza Intake and
Giza branch canal



Plugged with water weeds and
sidement, existing Lahoun Lock

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ABBREVIATION AND GLOSSARY

Abbreviation

ARE	Arab Republic of Egypt
DAC	Development Assistance Committee
EC	European Community
FAO	Food and Agriculture Organization
F/S	Feasibility Study
GNP	Gross National Product
GDP	Gross Domestic Product
HAD	High Aswan Dam
ID	Irrigation Department
ID	Irrigation Directorate
IIP	Irrigation Improvement Project
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
MED	Mechanical and Electrical Department
MFA	Ministry of Foreign Affairs
M/P	Master Plan
MPWWR	Ministry of Public Works and Water Resources
O & M	Operation and Maintenance
S/W	Scope of Work

Conversion

cm	centimeter
°C	centigrade
cu.m	cubic meter
m^3/sec (cms)	cubic meter per second
fed.	feddan = 0.42 ha
ha	hectare = 2.38 fed.
hr	hour
kg	kilogram = 1,000 g
km	kilometer = 1,000 m
km^2	square kilometer
lit./sec	liter per second
m	meter
MCM	million cubic meter
m/sec	meter per second

%	percent
t	ton = 1,000 kg

Currency

LE	Egyptian Pound
Pt	Egyptian Piaster
Yen (¥)	Japanese Yen
US$	US Dollar(s)

Exchange Rate (1991)

LE	= 100 Pt
LE	= ¥29.63
LE	= US$0.30
US$	= LE3.37
US$	= ¥99.80

SUMMARY

SUMMARY

The agricultural sector plays a significant role in Egypt, supplying not only foods but also employment opportunity to 35 percent of the labour force (1986/87) and also contributes to earning foreign currency by export. However, small agricultural lands, occupying 3.4 percent of the national lands, or 6.12 million feddans, is the major limiting factor for agriculture in Egypt. To support the high population growth rate of 2.7 percent, and to improve the trading balance by increasing agricultural production, the Egyptian government has strived to develop new lands by horizontal expansion and to increase productivity by vertical expansion.

Aside from a new development of water resources like groundwater exploitation, improvement of irrigation efficiency by the rehabilitation of the existing water distribution systems is one of the most effective countermeasures. The government aims at rapid implementation of such rehabilitation and improvement in some 6.12 million feddans of old lands. Approximately one million feddans are scheduled to be improved by the present five-year plan "Egypt's Second Five year Plan for Socio-Economic Development (1987/88-1991/92)". Therefore, it will need some 30 years to improve all irrigation systems of old lands if the rehabilitation proceeds at the present rate.

In response to the request of the Egyptian government, the Japanese government extended the technical assistance for the feasibility study on rehabilitation and improvement of the water delivery system in the Bahr Yusef Canal. Depending on the recommendation, the Egyptian Government requested the construction of the Lahoun Regulator, Hassan Wasef and Giza Intakes to be implemented under the aid of the Japanese Government. The Government of Japan, in answering the request from the Government of Egypt, decided to carry out the Basic Design of the Bahar Yusef Area Irrigation Improvement Project, and JICA, given instructions by the Government of Japan, dispatched the Basic Design Study Team and the Draft Report Explanation Team to the field in a period from 25 May, to 26 June, 1994 and from 30 September to 11 October, 1994, respectively, so as to carry out the field investigation on rehabilitation and improvement of the existing facilities and to have consultative discussion with the Egyptian authorities and agencies concerned.

The procurement of the construction equipment and materials for the preparatory works are included in the components of the Project requested from the Government of the Arab Republic of Egypt. However, after series of discussion it was judged that the procurement shall not be an independent component of the Project but included in the construction cost.

MPWWR proposed a temporary bridge which cross the Bahr Yusef Canal at the upstream of the Lahoun Regulator as a detour for the national route. However, the results of site survey and mapping show that a temporary road is able to be constructed beside the construction site of the new Lahoun Regulator. Therefore, no temporary bridge is provided and the construction cost of a detour will be included in the direct construction cost as a temporary work.

MPWWR also strongly requested the construction of a control building in the meeting with the Basic Study team. The control building will furnish a remote control system of gates at the three facilities and the system will become a model for telemetric control systems in future. The Beni Suef office of ID has technology and technical staff who will operate the monitoring system. MPWWR will assign necessary staff for operation and maintenance of the proposed control building. Furthermore as they have enough ability and budget to maintain the control system, it is feasible for the system to be included as a component of the Project.

Project Components, therefore, are following four items :

① Construction of the Lahoun Regulator
② Construction of the Giza Intake
③ Construction of the Hassan Wasef Intake
④ Construction of the Control Building

Detailed specific information of the section and structures for each facility is given as follows:

1) Lahoun Regulator

Structure	
Spans	5.5m×2sps
Hight (Depth)	5.62m
Length	12.6m
Body	Direct foundation concrete structure
Bridge	8.0m width with 1.0 m width of pedestrian walk at both sides
Gate	Double leaf slide type roller gate 5.5m spans×3.15m hight × 2 leaves, 2units

2) Giza Intake

Structure	
Spans	4.0m × 4 sps
Hight (Depth)	4.1m
Length	20.5m
Body	Direct foundation concrete structure
Bridge	8.0m width with 1.0 m width of pedestrian walk at both sides
Gate	Double leaf slide type roller gate 4.0m spans × 2.4m hight × 2 leaves, 4 units

3) Hassan Wasef Intake

Structure	
Spans	4.0m × 3 sps
Hight (Depth)	4.6m
Length	15.0m
Body	Direct foundation concrete structure
Bridge	6.0m width
Gate	Double leaf slide type roller gate 4.0m × 2.65m × 2 leaves, 3 units

4) Control Building

First floor	Storage of stop logs and a generator room.
Second floor	Control room
Area	132.6m^2

Implementation period is estimated at 5 months for the detailed design and 18 months for construction.

The Project will bring the following results and benefits to the area of 223 thousand hectars, about 70 percent of that commanded by the Bahr Yusef Canal or about 8 percent of the national total arable land.

- About 530 thousand feddans (223 thousand has equivalent to 8 % of the national total arable land) of the beneficial area and 215 thousand farm households can be efficiently irrigated and directly benefited.
- Efficient irrigation will benefit to about 4 million of agricultural population in the provinces of Beni Suef, Faiyum and Giza through expansion of arable land (horizontal development) and unit yield increase (vertical development).
- The Project can contribute to food production increase of the Country and to development of the national economy.

And the following effects will be contributed on the long term basis.

- Establishment of the water management system.
- Improvement of the water management technology such as gate operation by introducing remote control.
- Improvement of the road function of the attached bridge.

For O and M services of the Project after completion, ID of MPWWR will take responsibility for carrying out the work with sufficient manpower, technology, and enough budget for the purpose. And the ministry has an experience of the necessary procedures and rules of the Japanese grant aid. Under this situation, it is considered reasonable and no problem for MPWWR to carry out the Project.

With the opportunity for the rehabilitation and improvement of the facilities of the Lahoun Regulator group, the following improvement will contribute not only to the improvement of the subject facilities of the Project, but also the total irrigation system of the Bahr Yusef, or even further, the national irrigation system.

1) An efficient water management plan shall be created. Then, the organizational application of the said water management will result in the more effective use of irrigation water. For successful realization, ID should give appropriate guidance to the local farmers in close cooperation with the Ministry of Agriculture.

2) Rehabilitation and improvement works should be executed for the heavily deteriorated Mazoura and Sakoula Regulators in the upstream of the canal following the Lahoun Regulator.

3) As part of the resident staff for the control building of the Lahoun Regulator, an engineer with sufficient knowledge and well experienced in water management should be assigned to show a model operation of modern irrigation facilities.

4) The total water control system and facilities maintenance plan shall be established, thus the rehabilitation and improvement of the facilities in the Bahr Yusef Canal shall be executed for the purpose of consistent water management. Then the effective use of water resources will be achieved.

Furthermore, for the purpose of adequate distribution and efficient use of the irrigation water, the followings are recommended.

- Promotion of water management engineers
- Establishment of a water management manual
- Reinforcement of the water management cooperative

CHAPTER 1 BACKGROUND OF THE PROJECT

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1.1 BACKGROUND OF THE PROJECT

The agricultural sector plays a significant role in Egypt, supplying not only foods but also employment opportunity to 35 percent of the labour force (1986/87) and also contributes to earning foreign currency by export. However, small agricultural lands, occupying 3.4 percent of the national lands, or 6.12 million feddans, is the major limiting factor for agriculture in Egypt.

Egypt reached a population of about 55.9 million in 1992 with an annual growth rate of 2.7 percent since 1992. To support the high growth rate of population, and to improve the trading balance by increasing agricultural production, the Egyptian government has strived to develop new lands by horizontal expansion and to increase productivity by vertical expansion. In addition, there is a limited availability of water resources for irrigation, which is the primary constraint to long term agricultural growth.

Agriculture in Egypt depends on irrigation due to a lack of precipitation. The water resource available for irrigation is solely the Nile River water released through the High Aswan Dam (HAD). Egypt receives 55.5 billion cubic meters of water according to the Nile Water Agreement. Continuous drought in the last 20 years, which caused desertification in Africa, also attacked the riverhead of the Nile, resulting in reducing the water reserved in the HAD. If prolonged Sahelian drought persists and the inflow of HAD's reservoir is reduced, the quota to Egypt will probably be cut to some 49 billion cubic meters from the allocated 55.5 billion cubic meters, which will seriously affect the water resources available for irrigation.

The Egyptian government initiated a development programme for increasing agricultural production by horizontal expansion, i. e. increasing the area under cultivation, also by vertical expansion, i. e. increasing the productivity of the cultivated area in order to keep self sufficiency of food and to improve the trading balance. Securing the water for irrigation is a must for implementing the development programme. However, the water resources available for irrigation are trending downward.

Aside from a new development of water resources like groundwater exploitation, improvement of irrigation efficiency by the rehabilitation of the existing water distribution systems is one of the most effective countermeasures. The government aims at rapid implementation of such rehabilitation and improvement in some 6.12 million feddans of old lands. Approximately one million feddans are scheduled to be improved by the present five-year plan "Egypt's Second Five year Plan for Socio-Economic Dvelopment (1987/88-1991/92)". Therefore, it will need some 30 years to improve all irrigation systems of old lands if the rehabilitation proceeds at the present rate.

The government desires to increase the speed of execution of such rehabilitation and improvement projects, through the cooperation of the Japanese government and other developed countries. In response to the request of the Egyptian government, the Japanese government extended the technical assistance for the feasibility study on rehabilitation and improvement of the water delivery system in the Bahr Yusef Canal. The study recommended the implementation of the rehabilitation of the Lahoun Regulator with top priority.

Out of the 6.12 million feddans of the total farm lands, the Bahr Yusef Canal serves for the command area of about 770,000 feddans or about 13 percent of the total farm lands, which is one of the biggest water delivery systems in Egypt. The rehabilitation and improvement of the Bahr Yusef Canal will, therefore, give significant impact on the recent status of water resources of irrigation.

The Lahoun Regulator is located at 288.7 km in the Bahr Yusef Canal and controls the water distribution to a command area of about 530,000 feddans or about 69 percent of the total command area of the Canal. Major branch canals to be controlled by the Lahoun Regulator are the Giza branch with 153,000 feddans, the Hassan Wasef branch with 118,000 feddans and 10 more branch canals with 22,000 feddans upstream. Downstream of the Lahoun, there are several branch canals with a total command area of 238,000 feddans, including the Wahabi branch with 71,000 feddans, the Senories branch with 27,000 feddans, and 15 more branch canals with 140,000 feddans.

Among several facilities of the water delivery system of the Bahr Yusef Canal, the Lahoun Regulator is considered the most important facility for improving irrigation efficiency.

Barrage/regulators of the Bahr Yusef Canal are large scale canal structures, control a discharge of about 20 million cubic meters per day (about 230 m^3/sec), and are comprised of bricks which were constructed more than a hundred years ago. These over aged structures are deteriorated and hardly operable. Therefore, it is urgent to modernize such structures and facilities, replacing the old ones for effective control of the irrigation water distribution.

Introduction to Egypt of design technics and construction of modern large scale structures and facilities of the water delivery system shall be considered to be necessary and to contribute greatly to future development of engineering in Egypt.

1.2 OUTLINE OF THE REQUEST AND MAIN COMPONENTS

The Rehabilitation of the Lahoun Regulator, Giza and Hassan Wasef Intakes will benefit an area of 223,000 hectares and has the following short-term objectives:

- to control the irrigation water distribution effectively to the command area of about 530,000 feddans (about 223,000 hectares),
- to cope with additional irrigation demand by improving the cropping patterns, and
- to secure more farm income by expanding production in vertical as well as horizontal development.

Long-term objectives:

- to contribute to the country's food supply,
- to contribute to the national economy.

The rehabilitation of the Lahoun Regulator will make irrigation water distribution effective and stable and thus will promise stable agricultural production and more farm income by expanding production in vertical development and horizontal development. The improvement and increase of production will contribute to the country's food supply and the national economy by improving the balance of trade. In addition, the project would contribute to the future development of engineering in Egypt on design and construction of the modernized structures and facilities of the water delivery system.

The executing agency of the Project is the Irrigation Improvement Project (IIP) sector of the Irrigation Department (ID) under the administration of the Ministry of Public Works and Water Resources (MPWWR). Irrigation facilities are maintained and controlled by the ID, Mechanical and Electrical Department (MED), and other organizations within the MPWWR. The ID controls dams, barrages, main irrigation canals including regulators, main drains, and auxiliary facilities. The MED controls drainage and irrigation pump stations. IIP sector of the ID is in charge of the rehabilitation and improvement of the irrigation facilities.

Main Components of the Project requested by Egyptian Government are described as follows:

1. Preparatory Works for Construction

   1.1 Procurement of Construction Equipment
   1.2 Procurement of Construction Materials

2. Construction of Irrigation Facilities

   2.1 Lahoun Regulator
   2.2 Intake of Giza Branch Canal
   2.3 Intake of Hassan Wasef Branch Canal

1.3 PROJECT AND/OR PROGRAM OF OTHER DONORS

1) Project proposed by international organizations and foreign countries

Taking into account that Egypt has been playing a vitally important role in securing the Mid- and Near-East Peace as well as providing a large potential for the development, advanced nations have been increasing aid and assistance on a bilateral basis since Egypt left the Soviet group in 1974.

The United States has been the top donor to Egypt since resuming the aid in 1974. During the Gulf War in 1990 the bilateral aids by the DAC counties to Egypt amounted to 1,970 million dollars, of which the United States offered 1,150 million dollars, representing about 53 present of the total bilateral aid received.

The United States resumed financial aid to Egypt in 1974 and currently provides the largest amount of all donor countries. The U.S. aid to Egypt has been mainly in the commodities import programme and the food supply programme by PL 480. Besides the above, some other project aid made money available through sales of military goods, although the fund was small in its amount. The on-going agri-infrastructure projects are being carried out in the form of the model project for on-farm irrigation facilities consolidation and the national irrigation control monitoring system through telemeter networks.

MPWWR has a plan to develop the water control monitoring system to the level of a telemetric-control system in the future, but it is impossible to up-grade the present control system unless the manually operated old- fashioned regulating facilities, like regulators and intake structures of the canal system for water control, are improved.

Germany has been cooperating at almost the same level as Japan, about 85 percent of the aid has been made on the loan basis and the rest on the grant basis. German financial aid has been mainly in the fields of transportation, traffic, industry, and energy, while the grant has been given mainly to projects in the fields of education and agriculture as technical assistance.

The French aid has been fluctuating in amount for years, and about 60 percent of the total has been given on a loan basis to the fields of large scale projects such as agriculture, human resources development, health, and sanitation, etc.

International organizations have not emphasized the agricultural sector. The World Bank has mainly cooperated in the macro economy but less in the project aids. The European Community (EC) has concentrated on the three fields; environment, chemistry, and trade promotion.

2) Present aid by Japan to Egypt

As far as loan projects are concerned, new ones have been interrupted since 1988 due to a long suspended Yen-credit problem, and due to link of the financial assistance to the Persian Gulf countries in the Gulf Crisis. A total amount of 66.9 billion Yen was given as emergency aid in commodities and credit in 1990 and 1991. In 1991, however, cooperation was extended to the Beni Suef Cement Manufacturing Plant Construction Project.

For grant aid, the food production increase was aimed at in the Rice Storage Center Improvement Project (fiscal 1991 to 1992) in the field of food production and agriculture, improvement of the Facilities of the Nursery Faculty of Cairo University (fiscal 1990 to 1993) in the field of the foundation of daily life, and the New Training Ship Building Project for Arab Naval University (fiscal 1989 to 1991), and Ahmed Hamdi Tunnel Improvement Project (4 terms from fiscal 1992) in the fields of transportation and traffic. Thus, several large-scale and long-term projects were included in the Japanese aid programme.

Technical assistance has been positively extended as well in the fields of agriculture, health, sanitation and medicine, industry and in many other fields.

In the agricultural sector, aid for food production promotion varied from 5.0 to 100.0 million Yen per year, and an irrigation plan with floating pumps was carried out in 1992, which has a good reputation. The feasibility study for the Rehabilitation and Improvement of the Water Delivery System on the Bahr Yusef canal was carried out during 1991 and 1992 as technical assistance and it was recommended that repair and improvement works of the regulators and intakes along the Bahr Yusef Canal should be executed as urgently as possible.

CHAPTER 2 OUTLINE OF THE PROJECT

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2.1 OBJECTIVES OF THE PROJECT

The Bahr Yusef Canal serves irrigation water to its command area through regulators and intakes, now aged more than 90 years and already deteriorated enough so that efficient water control can not be expected due to the outdated facilities.

In response to such unfavorable conditions, various studies or rehabilitation and improvement projects have been carried out for effective use of the water resources available, repairing of the related facilities, O and M improvement of the existing irrigation facilities, etc., under the aid and assistance by international organizations and various countries on a bilateral basis.

In answering the requests from the Egyptian Government, the Government of Japan executed the feasibility study in 1992 for the rehabilitation and improvement of the distribution system of the Bahr Yusef Irrigation Canal under technical assistance. As a result, it has been recommended that the reconstruction of those facilities is the urgent subject for the rehabilitation and improvement of the water delivery system of the Bahr Yusef Canal. Among them, the first priority should be given to the repair and improvement works of the Lahoun Regulator, Giza and Hassan Wasef Intakes.

According to the recommendation suggested by the Japanese Government, the Egyptian Government requested the rehabilitation and improvement works of the Lahoun regulator group facilities to be undertaken under the grant aid of the Japanese Government.

The objectives of the Project are to raise irrigation efficiency and to contribute agricultural productivity for the Bahr Yusef Canal through the rehabilitation and improvement of the Lahoun Regulator, Giza and Hassan Wasef Intakes.

2.2 STUDY AND EXAMINATION ON THE REQUEST

The objective plan under the Japanese grant aid, which is requested by the Egyptian Government, is the reconstruction of the Lahoun Regulator, Giza and Hassan Wasef Intakes commanding about 70 % of the total beneficial area of the Bahr Yusef Irrigation system. The components of the Project are:

(1) Preparatory works for construction
(2) Construction of irrigation facilities

The procurement of the construction preparatory works is divided into:

① procurement of construction equipment
② procurement of construction materials

And the objectives for the construction of irrigation facilities are:

① Lahoun Regulator
② Intake of Giza Branch Canal
③ Intake of Hassan Wasef Branch Canal

These facilities are located on the Bahr Yusef Canal at the town of Lahoun where is situated between Faiyum and Seni Suef. The Lahoun Regulator is a facility to control the water level of the Bahr Yusef Canal for distributing the water to the Giza and Hassan Wasef branch canals. The Giza Intake is located on the right bank of the Bahr Yusef Canal about 300 meters upstream of the Lahoun Regulator. The Hassan Wasef Intake is on the left bank opposite side of the Giza Intake.

The following are the examination on the request and the basic concept.

1) Preparatory works for construction

(1) Procurement of construction equipment

For the construction of the above mentioned three structures, the following construction equipment:

① Bulldozer
② Crawler crane
③ Vibro hummer
④ Diesel generator, etc.

should be procured. This equipment will be used for the construction of other deteriorated regulators installed along the Bahr Yusef Canal, i. e. the Sakoula, Mazoura, Dirout Regulators and etc.

However, it was judged that the procurement could not be included as a component of the Project because of the following reasons:

① MPWWR does not rent construction equipment which is used for the construction works ordered.
② MPWWR has no organization to maintain this construction equipment.
③ Necessary equipment cost for construction is estimated as depreciation cost for the equipment in the construction.
④ They are able to procure general construction equipment in Egypt except for special machines or equipment.
⑤ There is no fixed time schedule to reconstruct other irrigation facilities in the Bahr Yusef Canal.
⑥ The management of the procured equipment after completion of the Lahoun Regulator is not clear.

(2) Procurement of construction materials

The necessary materials for the preparatory works of the construction such as steel sheet pile for water proof or retaining and H shape steel beam or channel beam for the temporary bridge, are difficult to procure in Egypt. Therefore, they shall be procured in Japan or other countries and they will be used for the materials of preparatory works for the construction of other deteriorated regulators installed along the Bahr Yusef Canal such as the Sakoula, Mazora, Dirout Regulators etc.

The above mentioned materials are used for the preparatory works of construction. The detailed time schedule for the construction plan of the Sakoula, Mazoura, Dirout Regulators, etc. is not established yet, and the construction of them is not included in the request. Accordingly, the plan for reusing of those materials can not be established. Those materials are necessary in the beginning stage of the Project and from the following reasons:

① Construction schedule is too short for the owner to procure and rent construction materials to the contractor.

② MPWWR does not applied rental method for construction materials.

③ Therefore, MPWWR has no facilities, organization or any plans for maintaining construction materials.

The procurement of construction materials is not included as a component of the Project. It will be included in the direct construction cost as depreciation cost for those materials.

2) Construction of irrigation facilities

(1) Construction of irrigation facilities

The existing Lahoun Regulator is deteriorated extremely due to its age of more than 100 years. On the other hand MPWWR repaired the Lahoun Regulator with surface stone about one and a half years ago as periodic rehabilitation. However, the main structure of the facilities is not in as good a condition as it looks since the bridge on the Lahoun Regulator is a main route having a fairly heavy traffic, the deterioration of the facilities are accelerated. Accordingly urgent countermeasure shall be taken. The Giza and Hassan Wasef Intakes shall also be reconstructed because of their deteriorated structure and gates.

Both the Hassan Wasef and Giza branch canals, which branch off at the immediate upstream side of the Lahoun Regulator, are considerably large canals commanding about one third of the irrigation areas in the Bahr Yusef Irrigation System, and the rehabilitation and improvement of the Intake structures of these canals along with the Lahoun Regulator is expected to have an impact.

In adding the irrigable area of the two branches and the controlled area of the Lahoun Regulator, the total irrigable area will become about two thirds of the command area in the Bahr Yusef canal (about. 200,000 hectares).

Faiyum Province, located in the downstream area of the Lahoun Regulator, has topography in a basin with rather steep slope between 1/300-1/500 from EL 30 m to EL-42 m at Lake Qarun. Since Lake Qarun, in the desert, has no outlet the water level of the lake is balanced by inflow from drainage in the surrounding area and evaporation from the water surface. The lake surface water level fluctuates only by the amount of inflow of drainage water from the arable land in the arid area.

By timely and appropriate irrigation water control, the Lahoun Regulator plays an important role not only for farm production increase but also for keeping socio-environmental conditions favorable.

The gate spans of the existing Lahoun Regulator range from 3.0 m to 3.5 m with the Fahmy Henen type, which has a very simple structure with multi-use mechanism. A gate of this type, however, cannot be applied to modern large scale irrigation facilities due to its manual operation. Therefore, the gates to be used in the future should be of a type with a remote control mechanism and which can be linked with the Total Nile River Water Control System that MPWWR has now promoted to provide.

The technology to introduce the regulators with new type gates should be introduced and extended so as to accelerate smooth rehabilitation and improvement of older irrigation facilities throughout the country.

(2) Temporary Bridge

MPWWR proposed a temporary bridge which would cross the Bahr Yusef Canal at the upstream of the Lahoun Regulator as a detour for national route crossing on the Regulator. However, the result of site survey and mapping shows that a temporary road is able to be constructed beside the construction site of the new Lahoun Regulator. Therefore, no temporary bridge is provided and the construction cost of a detour will be included in the direct construction cost as a temporary work.

(3) Control Building

The control building was not requested as a component in the MPWWR's proposal. However, MPWWR strongly requested the construction of a control building in the meeting with the Basic Study team. The control building will furnish a remote control system of gates at the three facilities and the systems will become a model of telemetric control system in future.

The Beni Suef office of ID has technology and technical staff who will operate the monitoring system. MPWWR will assign necessary staff for operation and maintenance to the proposed control building. Furthermore as they have enough ability and budget to maintain the control system, it is feasible for the system to be included as a component of the Project.

(4) Procurement of O&M Equipment

The existing operation and maintenance works in the Bahr Yusef Canal extend to a wide area and there are only a few equipment items and little budget to maintain important facilities along the Canal. The Lahoun Regulator is the important facility commanding about 70 % of the total beneficial area or 8 % of total arable area in Egypt.

MPWWR requested the following O&M equipment to the Japanese Government to maintain those important facilities in the Bahr Yusef Canal in good condition, especially to execute operation and maintenance works of the Lahoun Regulator on force account basis.

①	Crawler crane (30 ton class)	1 unit
②	Clam shell (Back hoe type, Boom length over 10 meter)	1 unit
③	Dump truck (10 ton class)	2 units
④	Loader (0.7 m^3 class)	1 unit

However, from the reasons that ① the total operation and maintenance plan for the Bahr Yusef Canal is not clear, ② the operation and maintenance plan for this equipment is not clear, the request is judged infeasible. Accordingly, the procurement of O&M equipment is not included as a component of the Project.

3) Contents of the Project

The executing agency is the Irrigation Department of the MPWWR who have responsibilities to execute their own project for the construction of irrigation facilities, and have enough ability and technology for construction. The new facilities will be maintained and operated under the organization of O&M system in the Bahr Yusef Canal. MPWWR also has sufficient ability for operation and maintenance for these new facilities.

As a result of the above studies, realization of the Project under the grant aid by the Government of Japan is judged reasonable and agreeable in due consideration that the Project impacts, realizability, and Egyptian capability for implementation can be fairly evaluated and the Project effects can meet the requirements in the rules of the grant aid projects provided by the Government of Japan. The Project, therefore, is judged to be executed under the grant aid by Japan.

Project Component, therefore, are following four items :

① Construction of the Lahoun Regulator
② Construction of the Giza Intake
③ Construction of the Hassan Wasef Intake
④ Construction of the Control Building

2.3 PROJECT DESCRIPTION

2.3.1 Executing Agency and Operational structure

1) Executing Agency

The responsible agency for planning and implementation of the Project is the Ministry of Public Works and Water Resources (MPWWR) and the Irrigation Improvement Project sector of the Irrigation Department is in charge of the implementation of the Project. The Ministry of International Cooperation is in charge of the coordination for international cooperation of the Project.

2) Organization

The organization diagram for implementation of the Project is shown in Appendix 8. The Beni Suef office of Irrigation Department will be assigned to supervise site works of the Project.

3) Budgetary Plan

As the Irrigation Department has enough staff to implement the Project, no special budget is requested. However, a budget for land acquisition and other expenses is prepared for implementation of the Project.

2.3.2 Plan of Operation

JICA will submit the basic design study report to the Ministry of Foreign Affairs (MFA) and the MFA will appraise whether or not the Project is suitable for grant aid of the Japanese Government.

If the Project is deemed appropriate for the Japanese Grant Aid Program, the MFA will present it to the Ministry of Finance.

The Ministry of Finance will finalize the draft budget for the Project and the MFA will proceed to get approval for its implementation from the Cabinet. Following agreement on the Draft, Notes will be exchanged by both governments.

The Notes will be signed and exchanged by both sides either in Cairo, the capital of the Arab Republic of Egypt, or in Tokyo.

After the Notes are exchanged, the Egyptian Party should select a consultant among Japanese firms to execute the Project according to the Japanese Grant Aid procedure. The selected consultant will prepare the detailed design and the bidding documents, and will submit them to the Japanese Government for approval.

The Egyptian Party will then select a general contractor through tender by the assistance of the Consultant to implement the Project.

2.3.3 Location and Condition of Project Site

1) Location

The land of Egypt can be roughly divided into three areas; the Delta extending north from Cairo (Lower Egypt), four provinces including Faiyum province, extending north of Minia province (Middle Egypt) and four provinces extending south of Asiout province to Aswan province (Upper Egypt).

The Project Area is located almost in the center of farm land, which extends in long strip on the left bank of the Nile in the Middle Egypt, and in a small town of Lahoun along the Bahr Yusef Canal, which is located at the middle of Faiyum and Beni Suef, about 100 km south of Cairo.

The Nile water, after being diverted at the Asiout barrage, runs down about 60 km through the Ibrahimia main canal to reach the Dairout barrage, the starting point of the Bahr Yusef Canal.

The Bahr Yusef Canal, which was a natural river to convey water to the Faiyum basin in the ancient times, was constructed as the main irrigation canal and is about 313 km long from the Dairout Barrage at the starting point to the Qarun Lake in Faiyum city, as the terminating point. The Lahoun Regulator, located at 288.7 km point of this main canal, is an important irrigation facility, commanding about 69 percent of the beneficial area of the Bahr Yusef Canal.

2) Topography and Soil Conditions

The Project Area extends topographically in the river terrace of the left bank of the Nile. The river terrace of the Nile valley has a width of 15 km to 20 km with undulation by about 10 m on the left bank, whereas it is 3 km to 5 km wide on the right bank. At the west side of the Project Area, the Faiyum basin extends a slope of 1/500 towards East from the Lahoun Regulator to the Qarun Lake, i. e. with a water level of elevation (-) 42.0 m.

The Area consists of the Nile alluvium soils as mother materials, and fertile since it contains organic matter. The soil is of clay (C) or of clay loam (CL). The soil color becomes bright yellowish gray and it gets hard with cracks in dry conditions. It softens and allows ploughing in wet conditions. The bricks for house walls and fences are made from those soils in the Area.

3) Meteorology

The Project Area belongs in the semi-tropical zone meteorologically with annual mean temperature of 21 °C. Annual rainfall is only 9-25 mm, so plants hardly survive but evapotranspiration is as much as 3,000 mm per year such harsh dry conditions.

Meteorological Data in Faiyum

	Jan.	Feb.	Mar.	Apl.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Temperature (°C)	12.8	14.3	17.6	21.6	25.6	28.0	29.6	30.0	27.5	24.6	20.0	14.6
Humidity (%)	68	65	59	55	52	53	55	56	61	63	67	70
Precipitation (mm)	0	2	1	1	1	0	0	0	0	0	1	3

4) Hydrology

The discharge of the Bahr Yusef canal is estimated at 20 million m^3 per day in summer, and 10 million m^3 per day in winter. The actual intake water in summer, however, has been below the amount quoted above.

In the Upper Egypt, the interruption of water starts on January 9 and ends on February 1, and the Bahr Yusef canal has been interrupted to coincide with this period. Such interruption is planned so as to carry out the repair and maintenance works of the related canals and irrigation facilities.

5) Irrigation and drainage system of the Bahr Yusef Canal

The water source of the Bahr Yusef canal depends upon the Asiout Barrage which was constructed in 1902, and the water taken therefrom is conveyed by the Ibrahimia canal (290 km in total length) along the left bank of the Middle Nile. At the Dairout Barrage, 60 km from the beginning point, water is diverted to the Bahr Yusef Canal.

The Ibrahimia Canal, situated on the natural embankment of the Nile, mainly irrigates the farm land which extends between the Ibrahimia canal and the Bahr Yusef Canal.

The Bahr Yusef Canal was originally a natural river and, was transformed into an introductory canal of the flood water of the Nile River to the ancient Faiyum basin for agricultural use. After being diverted at the Dairout Barrage, the water flows down about 300 km on the quite gently slope of 1/40,000, going through four regulators on the way.

The longest branch canal is the Giza Canal which runs about 100 km from the Lahoun Regulator, included in the Project structures, to Giza city. The benefited area is about 320,000 hectares and covers some parts of the following four provinces; Minia, Beni Suef, Faiyum, and Giza.

Beneficial Area of Bahr Yusef Canal

(Unit: ha)

	Minia	Beni Suef	Giza	Faiyum	Total
Nile Valley	47,922	24,064	57,666	151,867	281,519
Reclaimed Area	13,860	4,557	-	-	18,417
Proposed R.A*	-	2,100	4,620	16,800	23,520
Total	61,782	30,721	62,286	168,667	323,456

* Proposed Reclamation Area

The Bahar Yusef Canal receives water drained from the farm land between the Bahr Yusef and Ibrahimia Canals and between Bahr Yusef and the desert land on the west bank. Since the Bahr Yusef Canal was originally a natural river, there is much meandering which stagnates the flow considerably. Therefore, in some farms around the canal, there is a need to use pumps to prevent flooding from excessive drainage water.

6) Main and Branch Canals

Since the main canal, a total length of about 300 km, was a natural river, there are many meanderings on the course which have caused such problems as heavy erosion and sediment on its curves. Moreover, with a gentle canal slope, the flow becomes so slow as to allow aquatic weeds, particularly water hyacinth, to thickly grow which prevents the water from flowing smoothly and distributing normally.

The branch canals have a total length of as long as 1,500 km, which are mainly distributed on the left side area of the main canal.

7) Regulator

From the Dairout Barrage to the Lahoun Regulator, there are five barrage/regulators in total, including the above two. All of these structures were constructed with brick materials around 1870, and their structure is of old design with a manual operating system which is now rather difficult to operate.

Four regulators, except the Dairout Barrage above mentioned, are tabulated below.

Name	Distance from Dairout
E1-Abeed Regulator	77.6 km
Sakoula Regulator	177.7 km
Mazoura Regulator	230.3 km
Lahoun Regulator < Objective of Basic Design >	288.7 km

These regulators have two staged sluices with 3 to 25 gates (One gate is as wide as 5.0 m maximum). The gates are operated manually, one by one, with chain blocks, which are mounted on a trolley. The trolley slides on the regulator. However the gates are in quite poor condition. The gate opening degrees are confirmed by the number of the links of winding chain.

The crests of those regulators are used as major roads for local traffic. Such a load by heavy traffic has brought much trouble to the functions of those gates. Several gates are found inoperative as a result.

Since the Nile discharge has been well controlled throughout year, since completion of the Aswan High Dam, those regulators do not need to make frequent water control operations. The old and malfunctioning regulators, however, are still utilized as major irrigation facilities for the existing farms.

8) Lahoun Regulator

(1) Old Lahoun Regulator

The regulator was constructed in 1800s in arch structure with stone masonry on the surface. The materials used are sandy stones, of which the exposed parts have been heavily weathered and the bridge on the crest is not used. The regulator body is extremely deteriorated.

The regulator created a 100m×100m square-shaped pond downstream. The canal is 15m deep at about 70 m downstream from the regulator, and the pond may seriously affect the regulator.

(2) Present Lahoun regulator

Judging from extent of deterioration of the structure, this regulator was estimated to be constructed in the latter half of the 1800s and more than 120 years have probably passed after completion. The surface has an arch structure with masonry works, and the materials are of sandy stone. The deterioration has extremely advanced by weathering at exposed parts, falling of joint materials, breakage of brick piers, etc.

MPWWR repaired the regulator by grouting about 40 tons of cement milk into 176 holes. The bridge on the crest has been used as an important road for heavy traffic but deterioration is heavily advanced. The canal bed immediately downstream has been protected from scouring by the elevated sill of the old Lahoun Regulator to secure the stability of the present Lahoun Regulator.

Fahmy Henen gates (The gates of this type have been used for many small scale regulators/intakes in Egypt) are used for the Lahoun Regulator, of which the gear is put out over the pier and leaning when in operation, and this will cause easy breakage of gears at the base. Furthermore, the gate height is so high (5.2 m) that the operability of the gate is unfavorable and the O and M of such large size gates are difficult. Furthermore, the gate leaves themselves have been quite damaged.

On the left bank of the present Lahoun Regulator there is a navigation lock, which is 8.0 m wide and about 100 m long and is parallel with the canal. This lock, probably constructed in the 1960s, is relatively new but is not actually used at present. The lock gate provides a draw bridge, which has not been used recently. The Ministry of Transportation has an authority to carry out O and M of the lock, but the Ministry will not give up the actual right to use it.

Little trash has been trapped by the screen placed upstream of the Regulator and there is no trouble found in the gate operation.

Dimension of Present Lahoun Regulator

Description		Present Lahoun Regulator
Distance from Dairout Barrage		288.7 km
Scale	Total Length	15.8 m
	Gate	Gate Span 3.0 m× 2 gates 3.2 m×1 gate
Body	Constructed	Presumed in the latter half of 1800s
	Repaired	1988 Reinforced by grouting
	Structure	Stone made
	Apron	Riprap, Raised gate sill
	Bridge	Arch structure with brick 6.0 m width.
Gate	Gate type	Worm gear gate (Fahmy Henen type)
	Winding mechanic	Wheel rack
Navigation Lock		Provided apart from regulator body on the left bank (constructed in 1960s) 8.0 m width.
Special Descriptions		Old Lahoun Regulator exists about 85 m downstream (Bent width 2.75 m×3 spans without leaves)

9) Intake

The chain winding type for the double leaf gates used at the intakes of the Giza and Hassan Wasef branch canals, are the same ones as used at the other intakes and regulators on the Bahr Yusef Canal, and there have been many troubles such as chain breakage, clogging in the leaf guide, and imbalance of the leaf by one point hanging. These troubles have caused several leaves to be left intact in the closed position. Brick-made weir body is as well badly deteriorated.

The navigation lock is provided at the Giza intake but it has been not functioning at all at present. The gate leaf at the lock outlet has been broken with holes, and the entrance has been totally closed artificially and not to be used.

At the upstream side of these intakes along the Bahr Yusef canal, trash screens are provided to trap trash, and much water hyacinth and trash is trapped there, which is removed regularly.

10) Infrastructure at Site

(1) Villages

The Town of Lahoun has been a base of irrigation activities since the ancient times and, as an old saying says that those who can succeed in river training can succeed in dominating a country, the Lahoun administration was very prosperous in the old times. The road networks ran along the irrigation canals and the bridges were provided with the weirs or regulators. Navigation was an important means of transportation and the irrigation canals played the role of the navigation canals.

In the area around the Lahoun Regulator, the Bahr Yusef Canal is a boundary between Faiyum province and Beni Suef province. At the right side of the Lahoun Regulator, the town of Lahoun extends, while at the left side, Hawaret extends.

(2) Roads

Road networks had been provided along the canal system when the Lahoun Regulator, Giza and Hassan Wasef Intakes were constructed. Then, Lahoun became an important point of transportation. The national highway between Beni Suef and Faiyum has never failed to pass through Lahoun Regulator, and there are several ways from Cairo such as the road to Lahoun from Faiyum via desert road, the one via the farm road from Beni Suef, and the one proceeding southwards along the Giza branch canal.

For transportation of construction materials, both the ways via Faiyum or Beni Suef are available. The national highway from Faiyum to Beni Suef provides two lanes for up and down traffic so as to allow large size vehicles to run through.

(3) Electric Supply

Electric power is transmitted in 11,000 volts from Beni Suef and distributed to the consumers after being reduced by a transformer in Lahoun.

(4) Municipal Water Supply

Municipal water to the Project Area is distributed to the local consumers after being conveyed from Beni Suef and stored in elevated tanks

11) Environmental Issues

The older brick intake structure has resulted in difficulty in operation and the trash clogged in the intake has pollution possibilities. Reconstruction of the old facilities is required for easy and efficient operation and for conservation of a good environment. Water is quite precious to the nation, and the water front should be conserved carefully and reclamation of water areas should be avoided as much as possible.

Since the Bahr Yusef Canal, originally a natural river, has heavy meandering and a very gentle slope to cause quite a slow flow velocity, aquatic weeds are prone to grow thickly. Those weeds are carried down from the upstream side of canal by flow velocity fluctuation to be piled up at the upstream side of the Regulator. Those accumulated weeds have not only been obstacles to smooth flow of water but a pollutant of water in its quality. Recently, there have been many plastic wrapping materials carried down, which are unpleasant to people.

As mentioned before, the Lahoun Regulator is the important facility for traffic and there are a great number of people who gather around the area. The ancient structures are kept as remains, and there is a water pool between the ancient and present structures, which presents a beautiful scene with thickly growing greens. At the downstream of the ancient structures, there is a large regulating pond where the local inhabitants practice washing as well as rest. Great care should be taken in construction of the proposed new regulator and water intake so as not to downgrade the environment.

2. 3. 4 Outline of Facilities and Equipment

1) Purpose of the Project

The project aim is to raise the agricultural productivity through improving the irrigation efficiency by rehabilitation and improvement of delivery water facilities provided along the Bahr Yusef Canal.

2) Project Area

The Project Area is located partly over the Beni Suef and the Faiyum provinces, and around the Lahoun Regulator along the Bahr Yusef Canal.

3) Executing Body

The Ministry of Public Works and Water Resources is the executing body with full responsibility to implement the Project and total coordination. The Irrigation Department of MPWWR is in charge of implementation of the Projects works.

4) Specific Items of the Project Works

The Project will be implemented based on the following objectives.

- The three facilities of the Lahoun Regulator, Giza and Hassan Wasef Intakes are the objectives of the Project.
- The necessary land for the construction works of the above facilities (stock yard of the construction materials and equipment, including other land required temporarily used for the works, etc.) shall be obtained by the executing agency.
- In principle, the facilities should be constructed on the government-owned land, and the Egyptian Authorities concerned should follow the necessary procedures for acquirement of the land for the facilities if necessary to use private land.
- The Government of Egypt requested a control building for the three facilities of the Lahoun Regulator's group to operate gates remotely.

The specific works contained in the Project are as follows:

(a) Reconstruction of the old facilities as below:

- Lahoun Regulator
- Giza Intake
- Hassan Wasef Intake

(b) Construction of the control building

- Construction of the control building

The procurement of construction equipment and machinery which was required by Egyptian Authorities was judged to be unnecessary because of the following consideration:

① The construction works shall be on contract basis.

② MPWWR, which is executing body, does not take rental method of construction equipment and machinery.

③ The necessary equipment and machinery for the construction can be procured on lease or rental basis in Egypt.

For the temporary bridge, the field investigation and surveying have revealed that there will be no need to provide a temporary bridge, but a temporary road. It was agreed that the cost of the temporary road, consequently, shall be included in the direct construction costs.

The procurement of the construction materials requested separately shall be included in the direct construction costs in consideration that the contractors can procure those materials for their own works.

2. 3. 5 Operation and Maintenance Plan

For Operation and Maintenance works of the facilities after their completion, the following matters should be taken into consideration. Since the new control building is to be provided for controlling three major facilities, one technical staff with sufficient knowledge of irrigation and gate operation shall be assigned as permanent staff for controlling those facilities. A mechanic and workman under the above technical staff shall be the present gate keeper and his workman.

1) O&M works of the Control Building at the Lahoun Regulator

The usual O&M works at the Lahoun Regulator Control Building will be as follows.

- to control the gate operation to meet the discharge designated by the inspector, which is the demand from the beneficiaries.
- to inspect the facilities, and
- to prepare the daily report.

As a staff plan to execute the above mentioned daily works, the following staff shall be assigned:

Permanent staff (Engineer)	1
Mechanic (Present Gate Keeper)	1
Workman	2
Labour	1

2) Periodic Maintenance

Periodic maintenance for the new facilities and the canal is as follows:

(1) Removal of water weeds and trash

Removal of water weeds and trash in the canal is executed once every three months.

(2) Removal of sedimented sand

Removal of sedimented sand in the canal is executed once a year by contract basis.

(3) Check and repair of facilities

Check of facilities is usual work of the control office and a check report shall be prepared by the staff. Repainting is made once five years, usually, and necessary repair work shall be done when and if required. Annual O&M cost born from the above plan is as follows:

Personnel expenses	47,000 LE	(1,387 thousand yen)
O&M for facilities	171,400 LE	(5,056 thousand yen)
Total	218,400 LE	(6,443 thousand yen)

Detail of the above expenses is shown in Appendix II.

2.4 TECHNICAL COOPERATION

Regarding the Project, there have been no particular requests for Technical Cooperation from the Government of Egypt. As the water management, for which the habitual rules are firmly established and Egypt has its own method and will not be changed easily, technical cooperation will not be required in this field.

However, for the purpose of establishment of the consistent water management, it is considered to provide the "Water Management Center" (temporally name) and to prepare the "Water Management Criteria" by the Japanese Technical Cooperation.

The total radio monitoring system for water level and discharge for the main and lateral canals throughout the country will be completed in 1995 under the technical assistance of the United States of America.

CHAPTER 3 BASIC DESIGN

CHAPTER 3 BASIC DESIGN

3.1 DESIGN POLICY

1) Locations of the Regulator and Intakes

The Bahr Yusef Canal is the year-round servicing canal to cover almost 320,000 hectares, except for about three weeks of annual interruption for checking and repairing of the related irrigation facilities.

The construction work for improvement of the irrigation facilities shall be carried out without any interruption in irrigation services of the Bahr Yusef Canal and the branches of the Hassan Wasef and Giza.

In general, it is difficult to execute construction of the irrigation facilities with water kept flowing in the related canals, and the cost becomes higher. New structures shall be constructed on the land a little apart from the existing facilities and water shall be led to the new facilities by switching from the old ones after completion of the work.

In this Project as well, it is highly recommended that the switching method, after completion, should be adopted in view of the construction costs and schedule.

(1) Location of Lahoun Regulator

Since the Lahoun Regulator is surrounded by residential areas and it is difficult to find a suitable construction site with sufficient space, there is no site available for new construction, although the above conditions were taken into consideration. The study was made on the location within the area of the existing facilities in reference to the results of the feasibility study.

If the existing navigation lock could be taken away to construct new facilities, it would be most suitable. The Egyptian Authorities concerned wish to have the lock remain intact and it has been mutually confirmed that the construction site should be at the area in the middle of the Regulator and the Navigation Lock, and in accordance with the wishes of the Egyptian counterparts. Both the ancient and the existing regulators shall be preserved as the remains.

(2) Location of Hassan Wasef Intake

The new water intake shall be constructed at the public land area owned by ID on the right bank, as there are no suitable land areas available on the left bank due to the fact that private land extends anywhere suitable.

A bridge runs on the crest of the facilities. But, since traffic through that bridge is found to be very little, vehicles shall pass the bridge about 300 m downstream therefrom. During the construction period, a pedestrian walk shall be reserved.

(3) Giza Intake

The following four plans were taken into consideration on the location of the Giza Intake as follows.

① at the site of the existing intake.
② at the downstream site of the above ①,
③ at the site of the Giza Navigation Lock
④ at the site in the middle of the existing intake and the navigation lock.

The filed investigation and detailed surveying have resulted in taking the plan ④ as most economical and suitable in hydraulics, and plans ① and ② cannot be adopted because there are little land areas available for providing water protection works and retaining walls for construction works. The plan ③ is also difficult to implement because withdrawal of the navigation lock is the absolute condition for construction works and it is impossible to use the lock in the future and the construction will be costly.

2) Determination of Gate Types

In Egypt, the double leaf sluice gates have been used for regulating facilities for a considerable length of time. The gates of this type control the water level by operating the upper leaf with the lower leaf closed. The gates are small in scale and operated by movable chain block type winches. The gates, however, cannot be operated smoothly and efficiently due to worn out mechanism and gate deformation.

Recently, radial gates have been adopted for small scale regulators. Although radial gates are suited to small scale shallow water canals, the construction cost will become higher for large scale deep water canals like this Project because structures would become larger in scale by providing long arms and setting hinges over the water surface.

Furthermore, radial gates, the bottom release type, have some defects because of ① having difficulty in water level control at the upstream side and ② having larger discharge velocity prone to give damage to canal beds.

Single leaf slide gates of this kind have similar mechanism and functions, and the deeper depth the canals have, the higher piers the gates should provide for larger lift. To solve these problems, the double leaf slide gates are adopted as a safer method. Advantages of this type of gates are to enable water level control effectively with the upper leaf operated and lower leaf closed, and in case of having large differences in the water levels between up- and downstream, overflowing the upper leaf will bring a dissipation effect.

From such points of view, the double leaf slide type gates shall be employed for the Lahoun Regulator, and the same gate type shall be adopted to both the Hassan Wasef and Giza Intakes, judging from their purpose and scale.

Merit and demerit of double leaf type gates or radial gates is shown in Table 4-1.

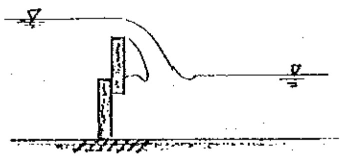
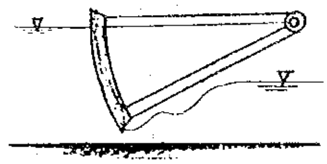
3) Operation Method of the Gates

An Electric power drive system is adopted for gate operation, considering the future systematic total control which MPWWR has planned. The manual operation devices shall be provided against blackout or any other emergencies.

A control building with a panel display of Lahoun group gates is constructed to operate not only the Lahoun Regulator gates but also Hassan

Wasef and Giza intake gates at the same location. It will be a model case which is the final goal of the total operation system by telecontrol and telemeter.

TABLE 3-1 COMPARATIVE TABLE FOR THE GATE SELECTION

Description	Double Life Roller Gate	Radial Gate
Plan		
Structure	. Water pressure is supported by side rollers distributed on the vertical side beams through skin plate, supporting horizontal and vertical beams. . Gates are operated up and down side. . Water release system is upside.	. Water pressure is supported by hinge fixed at anchor on the side wall through skin plate, supporting horizontal and vertical beams and arm beams. . Gate is operated rotationally. . Water release system is downside.
Merit	. Easy water level control . Gate operation is easier because of separated gate lives. Thus operation cost is cheaper. . Gate body maintenance is easier.	. No pier is provided. . Big volume of water can be released through small opening due to under gate release.
Demerit	. Mechanical system is little bit complex. . More steel material is required as compared with single lief gate.	. Dissipator for released water is necessary. . Big structure is provided. . Much steel material is required . Delicate level control is difficult. . Replacement of hinge is quite difficult.
Consideration	. Gate operation is easier due to separated gate lives and no dissipator is required. . This gate is recommendable from canal operation and maintenance.	. This type gate is not recommendable because of several demerit such as higher cost than double lief gate, difficult delicate level control or difficult maintenance.

4) Structure of Facilities

The structure body shall be of a reinforced concrete structure in view of ease in construction and durability. Particular attention will not be given to appearance but to colours of the steel gate leaves so as to harmonize the environment.

5) Trash Elimination

Presently, a floating net is provided at the upstream of the Lahoun Regulator so as to trap and collect trash and weeds for dumping. For the cases of the Hassan Wasef and Giza intakes, since no floating net is provided, trash and weeds are trapped directly by screens placed in front of the intake mouths. This trash is gathered manually to be dumped or flushed downstream at times.

Weeds and trash trapped at the Lahoun Regulator are taken away by a clamshell crane and carried by dump trucks for dumping at the designated spill dump sites.

6) Protection Works for Canal Bed and Embankment

Successful protection works for the canal bed and embankment are quite necessary since the downstream side of the Regulator and Intakes is prone to be scoured due to velocity change caused from gate operation. Length of the canal bed protection works will require that it is two times as long as that of the width of the structures. Gabions packing natural stones shall be used so as to secure the dissipation of water flow velocity.

The dike slopes shall be protected from scouring caused from large release velocity. The dike protection shall be made with stone masonry or gabion works, but when sufficient space cannot be secured on the slopes, concrete walls and/or steel sheet piles shall be used.

7) Bridges on Facilities

A bridge shall be constructed on the Lahoun Regulator, as the Regulator crosses the national highway. The bridge is designed to have a width of 8.0 m based on the Egyptian Standards. In response to the request from the

MPWWR, a 1.0 m pedestrian walk shall be provided at both sides of the bridge surface.

The bridge for the Giza Intake shall be designed in a similar way in view that the intake also crosses the national highway.

For the Hassan Wasef Intake, a bridge shall be designed with a 6.0 m width as presently used, in consideration that there will be little traffic on said bridge, which is used as a local community road and also will not become a major road in the future.

8) Navigation Lock

A navigation lock is provided at both the site of the Lahoun Regulator and the Giza Intake and neither have been used. These Locks are under the control of the Ministry of Transportation, and will remain intact because ID does not wish to touch this matter, in taking into account that the Ministry of Transportation does not have any plan to take away the Lahoun Navigation Lock.

Although the Giza Lock can be taken away, this Lock shall remain intact as well because there will be no merits to be utilized by doing this as well as having to provide a new intake facility after its withdrawal.

9) Temporary Bridges

The Egyptian counterparts have requested construction of a temporary bridge during construction work at about 300 m upstream of the Regulator for securing means of traffic for vehicles.

As the results of field investigation, surveyings, and discussion meetings, since a temporary road will be able to be constructed for the better use of the mid island between the Regulator and the Navigation Lock, the costly plan of the temporary bridge shall be canceled.

10) Closing Works

For temporary closing work for the Lahoun Regulator and the intakes construction, sheet piles and/or H-shape steel shall be used indispensably because of the work in the narrow land areas. Vibrationless pile drivers should be adopted so that adverse effects shall not be given to the ancient cultural remains of the ancient Lahoun Regulator during the construction work.

11) Design Criteria

The design criteria shall be based on the criteria prepared as "Headworks" in the Standards for Land Consolidation Works in Japan. The basic conditions of load and hydraulical conditions, however, shall be based on the Egyptian Standards. For the design of steel gates, the "Standards for Pipes and Gates" shall be applied and JIS (Japan Industrial Standard) shall be for machines and materials.

3.2 DESIGN CONDITION

1) Design Capacity

The feasibility study report reveals, as follows, on the design capacity of the Lahoun Regulator, Hassan Wasef and Giza Intakes:

- Lahoun Regulator
  - $Q\,max = 80.07\ m^3/sec$
  - $Q\,min = 15.73\ m^3/sec$
- Giza Intake
  - $Q\,max = 52.69\ m^3/sec$
  - $Q\,min = 10.21\ m^3/sec$
- Hassan Wasef Intake
  - $Q\,max = 39.77\ m^3/sec$
  - $Q\,min = 7.71\ m^3/sec$

Note: Qmax, is presumed to happen in July, while Qmin, in October.

2) Design Water Level

The water level in the proposed irrigation canal should be judged from that in the existing canals. The following table shows the results obtained from the detail survey in the fields.

TABLE 3-2 MONTHLY AVERAGE WATER LEVEL UP/DOWNSTREAM FACILITIES

(unit: m)

Month	Lahoun Regulator			Giza Intake			Hassan Wasef Intake		
	Up-stream	Down-stream	Deference	Up-stream	Down-stream	Deference	Up-stream	Down-stream	Deference
Jan.	-	-	-	-	-	-	-	-	-
Feb.	26.65	24.90	1.75	26.67	25.90	0.77	26.65	25.45	1.20
Mar.	26.23	24.70	1.53	26.29	25.80	0.49	26.23	25.45	0.78
Apl.	26.40	24.60	1.80	26.42	25.70	0.72	26.40	25.42	0.98
May	26.45	24.55	1.90	26.47	25.80	0.67	26.45	25.40	1.05
Jun.	26.40	24.95	1.50	26.42	26.05	0.37	26.40	25.61	0.79
Jul.	26.38	24.95	1.43	26.40	26.00	0.40	26.38	25.64	0.74
Aug.	26.52	25.00	1.52	26.54	25.85	0.69	26.55	25.64	0.91
Sep.	26.50	24.90	1.60	26.54	25.80	0.74	26.52	25.60	0.92
Oct.	26.28	24.55	1.73	26.30	25.55	0.75	26.28	25.44	0.84
Nov.	26.50	24.55	1.95	26.52	25.40	1.12	26.50	25.40	1.10
Dec.	26.60	24.30	2.30	26.62	25.75	0.87	26.60	25.36	1.24

3. 3 BASIC PLAN

3. 3. 1 Scale of Facilities

The scale of the regulator and intakes is basically of a size determined to keep the present size of the facilities. In other respects, since the flow velocity is around 0.6m/sec at both up and downstream of the facilities, the design velocity in the structures should not exceed 1.5 - 2.0 times the present canal flow velocity.

In the case of the Lahoun Regulator, the width of the structure will be a little narrower toward the discharge since the construction site is comparatively narrow and the structures cannot be constructed as large. Under the conditions, the dissipator shall be provided at the downstream of the structures so as to release water to the wider part of the canal. The width of the other structures shall be kept almost the same size as of that at present.

Detail specific information of the section and structures for each regulator and gate is given as follows:

1) Lahoun Regulator

Structure	
Spans	5.5m×2sps
Hight (Depth)	5.62m
Length	12.6m
Body	Direct foundation concrete structure
Bridge	8.0m width with 1.0 m width of pedestrian walk at both sides
Gate	Double leaf slide type roller gate 5.5m spans×3.15m hight × 2 leaves, 2units

2) Giza Intake

Structure	
Spans	4.0m × 4 sps
Hight (Depth)	4.1m
Length	20.5m
Body	Direct foundation concrete structure
Bridge	8.0m width with 1.0 m width of pedestrian walk at both sides
Gate	Double leaf slide type roller gate 4.0m spans × 2.4m hight × 2 leaves, 4 units

3) Hassan Wasef Intake

Structure	
Spans	4.0m × 3 sps
Hight (Depth)	4.6m
Length	15.0m
Body	Direct foundation concrete structure
Bridge	6.0m width
Gate	Double leaf slide type roller gate 4.0m × 2.65m × 2 leaves, 3 units

3.3.2 Discharge Capacity

Since a double leaf gate is applied, the maximum capacity with upper leaf fully opened and the maximum capacity with lower leaf fully opened are examined as follows:

1) Applied Formula

- For upper leaf moving.

$$Q = CLH^{3/2}$$

Where,

Q	:	Discharge (m^3/sec)
C	:	Coefficient 1.8
H	:	Energy height on the crest (m)
L	:	Available length of gate (m)

- For lower leaf moving

$$Q = CA\sqrt{2gH}$$

Where,

Q	:	Discharge (m^3/sec)
A	:	Area of orifice(m^2)
H	:	Water head (m)
g	:	Acceleration of gravity (9.8m/sec^2)
C	:	Coefficient 0.6

2) Lahoun Regulator

- Upper leaf fully opened

  Water head (maximum) = 2.3m

  $L = 5.50 \times 2 = 11.0m$

  $Q = 1.8 \times 11.0 \times 2.3^{3/2} = 69.06 m^3/s < 80.0 m^3/s$

- Lower leaf fully opened

  Water head (minimum) = 1.43m

  Gate opening degree 2.8m

$$Q = 0.6 \times 11.0 \times 2.8\sqrt{2 \times 9.8 \times 1.43}$$
$$= 97.83 m^3/s > 80.0 m^3/s$$

3) Giza Intake

- Upper leaf fully opened
  Water head (maximum) = 1.12m
  $L = 4.0m \times 4 = 16.0m$

  $$Q = 1.8 \times 16.0 \times 1.12^{3/2} = 34.13 m^3/s < 53.69 m^3/s$$

- Lower leaf fully opened
  Water head (minimum) = 0.37m
  Gate opening degree 2.2m

$$Q = 0.6 \times 16.0 \times 2.2\sqrt{2 \times 9.8 \times 0.37}$$
$$= 56.88 m^3/s > 53.69 m^3/s$$

4) Hassan Wasef Intake

- Upper leaf fully opened
  Water head (maximum) = 1.24m
  $L = 4.0m \times 3 = 12.0m$

  $$Q = 1.8 \times 12.0 \times 1.24^{3/2} = 29.83 m^3/s < 39.77 m^3/s$$

- Lower leaf fully opened
  Water head (minimum) = 0.74m
  Gate opening degree 2.20m

$$Q = 0.6 \times 12.0 \times 2.2\sqrt{2 \times 9.8 \times 0.74}$$
$$= 44.88 m^3/s > 39.77 m^3/s$$

3.3.3 Apron Length

The apron length of the regulator and intakes is calculated from Bligh's Formula to prevent piping or scouring.

Apron Length (La)

$$La = 0.6\, C \sqrt{H} \cdot f$$

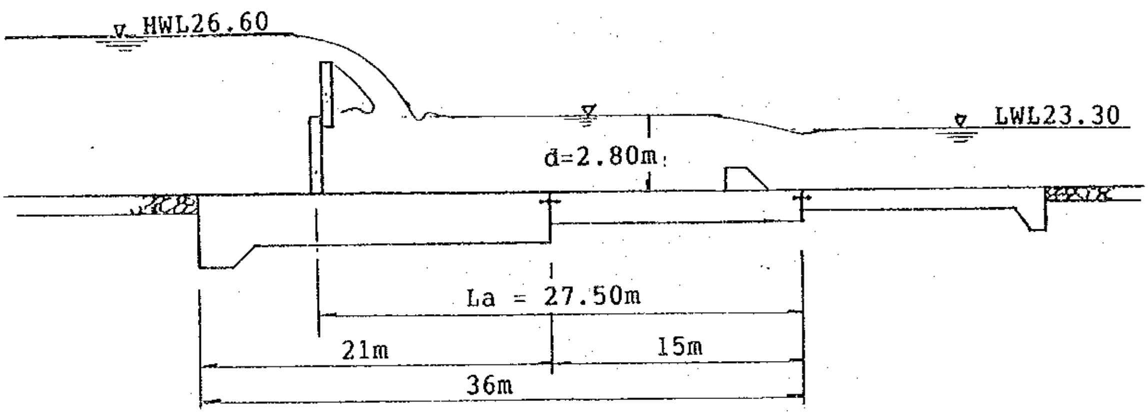
Where, La : Creep length (m)

C : Bligh's coefficient 15, soil grain is judged as above fine sand from the result of soil mechanical test.

H : Water head (m)

f : Safety factor 1.5, by Japanese Design Criteria

1) Lahoun Regulator



- Upstream water level

  WL = 26.60m

- Downstream water level

  Observed minimum water level
  LWL = 24.30m

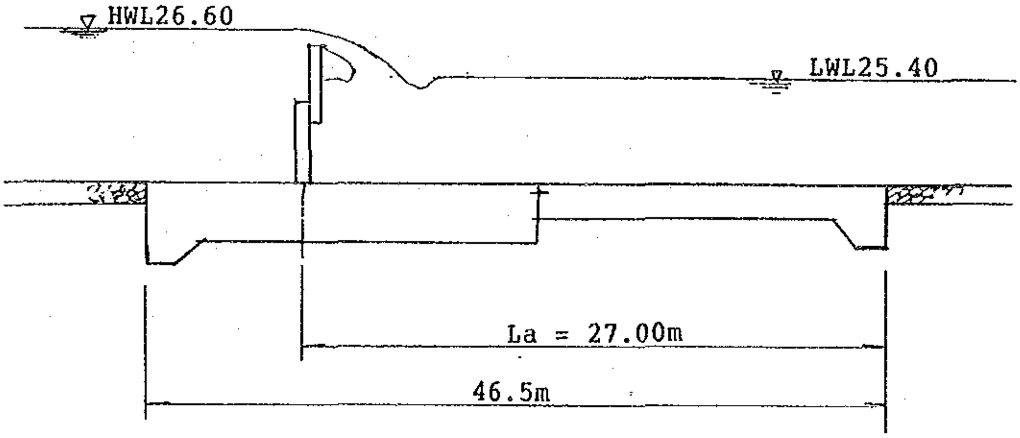
  However, downstream water level of the new regulator is estimated about 1.0 meter lower than the above observed level which is observed at the pool between existing and old regulator. Thus, the water level is estimated :

  WL = 24.30-1.00 = 23.30m

- Apron Length

  H = 26.6m - 23.30m = 3.30m
  $La = 0.6 \times 15 \times \sqrt{3.3} \times 1.5 = 24.5m < 27.5m$

2) Giza Intake



- Upstream water level

  WL = 26.60m

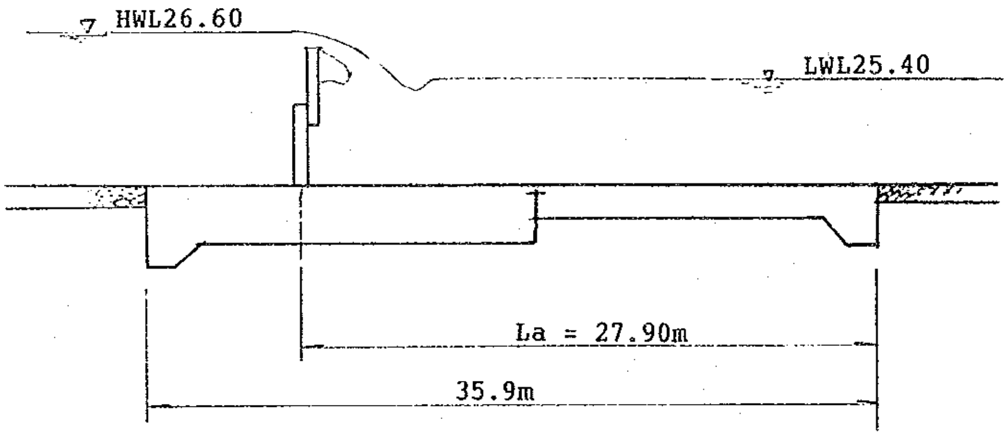
- Downstream water level

  Observed minimum water level
  LWL = 25.40m

- Apron Length

  $H = 26.60 - 25.40m = 1.2m$
  $La = 0.6 \times 15 \times \sqrt{1.2} \times 1.5 = 14.8m < 27.0m$

3) Hassan Wasef Intake



- Upstream water level

  WL = 26.60m

- Downstream water level

  Observed minimum water level
  LWL = 25.40m

- Apron Length

  $H = 26.60 - 25.40m = 1.2m$
  $La = 0.6 \times 15 \times \sqrt{1.2} \times 1.5 = 14.8m < 27.9m$

3.3.4 Creep Length

According to the result of boring test or soil test executed on the previous field survey, the coefficient of permeability (K) varies between $(2 \sim 2.5) \times 10^{-4}$ cm/sec in sandy layer and reached to $(1 \sim 2) \times 10^{-5}$ cm/sec in clayey layers. Judging from the result, the foundation layer is not so permeable. When the weir were constructed on the permeable layer, a sufficient creep length shall be required to control percolation water velocity and to prevent destruction of the foundation due to permeability. When the footing length is not sufficient to prevent piping, a cutoff by concrete or steel sheet pile shall be provided.

The creep length is estimated from the following formula:

$Lp = C \cdot H$

Where,
- Lp : Creep Length (m)
- C : Bligh's coefficient 15, for fine sand.
- H : Water head (difference between maximum water level upstream and bed surface downstream : m)

1) Lahoun Regulator

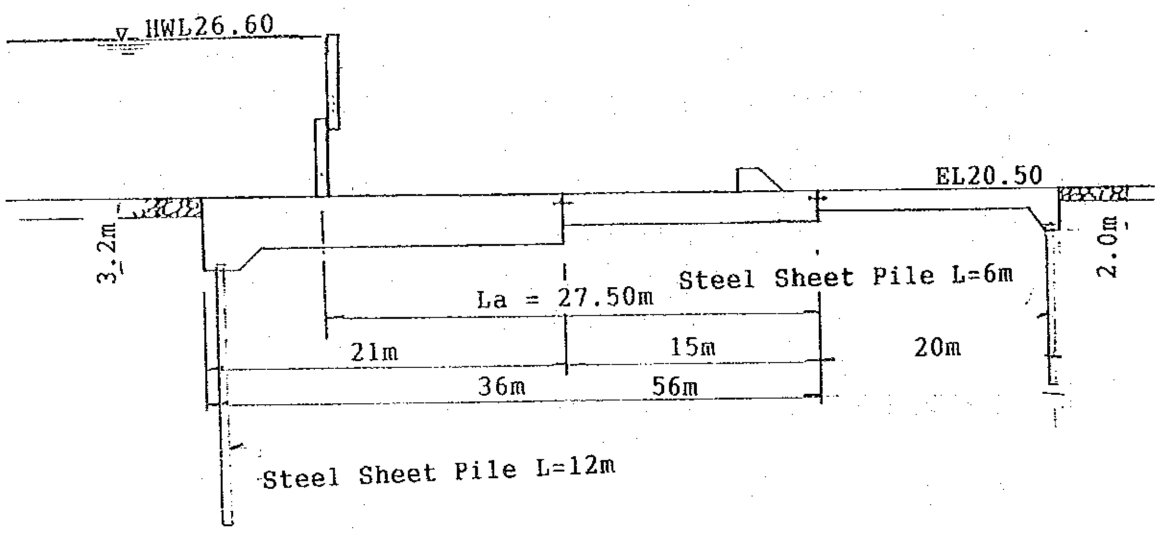
Water head (H) = 26.6-20.5 = 6.1m

Lp = 15 × 6.1 = 91.5m

The design length of apron is 56m, if 12 meters long steel cheep pile were applied for the upstream cutoff, the downstream cutoff length is estimated as follows:

Downstream Cutoff Length = (91.5m-56m-2 × 12m) ÷ 2 = 5.75m ≒ 6m

Accordingly, cutoff are provided at two stations with the length of 12m long for upstream side and 6m long for downstream side.



2) Giza Intake

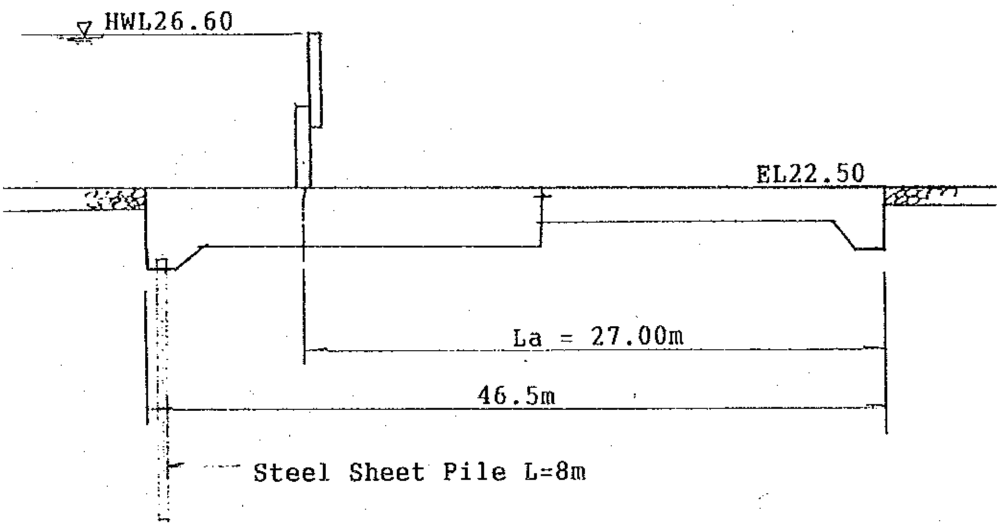
Water head (H) = 26.6-22.5 = 4.1m

Lp = 15 × 4.1 = 61.5m

The design length of apron is 46.5m, if one cutoff is applied, the cutoff length is estimated as follows :

$$\text{Cutoff Length} = \frac{61.5\,\text{m} - 46.5\,\text{m}}{1 \times 2} = 7.5\,\text{m} \doteqdot 8\,\text{m}$$

Accordingly, one cutoff is provided with the length of 8m long.



3) Hassan Wasef Intake

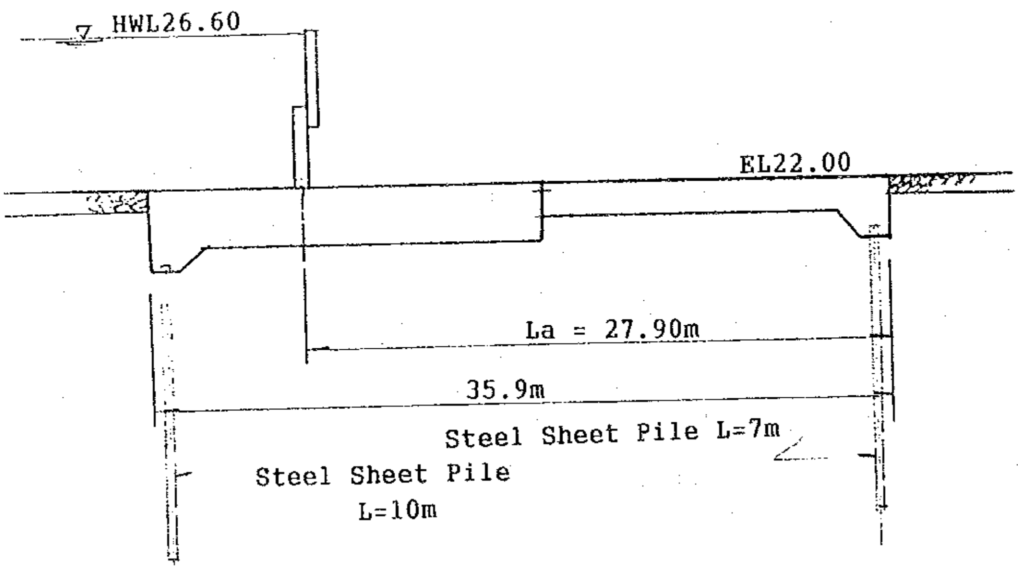
Water head (H) = 26.6-22.0 = 4.6m

Lp = 15 × 4.6 = 69m

The design length of apron is 35.9m, if 10 meters long steel sheet pile were applied for the upstream cutoff, the downstream cutoff length is estimated as follows:

Downstream Cutoff Length = (69m-35.9m-2×10m) ÷ 2 = 6.55m ≒ 7m

Accordingly, cutoffs are provided at two stations with the length of 10m long for upstream side and 7m long for downstream side.



3.3.5 Bed Protection

1) Bed Protection Length

For prevention of the canal bed from scouring, the bed protection shall be provided. The length of the bed protection is determined from the following formula:

$$L = Lb - La$$
$$Lb = 0.67C\sqrt{H \cdot q} \cdot f$$

Where,	L	:	Length of total protection (m)
	Lb	:	Length of bed protection (m)
	La	:	Length of apron (m)
	H	:	Water head (adopted present water head of maximum discharge) (m)
	f	:	Safety factor 1.5
	C	:	Bligh's coefficient 15

- Lahoun Regulator

$$Lb = 0.67 \times 15 \times \sqrt{2.3 \times 6.35} \times 1.5 = 57.6$$
$$q = 80.07m^3/s / 12.6m = 6.35m^3/s / m$$
$$L = 57.6 - 45 = 12.6m$$

- Giza Intake

$$Lb = 0.67 \times 15 \times \sqrt{1.12 \times 3.29} \times 1.5 = 28.9m$$
$$q = 52.69m^3/s / 16.0m = 3.29m^3/s / m$$
$$L = 28.9 - 26 = 2.9m$$

- Hassan Wasef Intake

$$Lb = 0.67 \times 15 \times \sqrt{1.24 \times 3.31} \times 1.5 = 30.5m$$
$$q = 39.77m^3/s / 12.0m = 3.31m^3/s / m$$
$$L = 30.5 - 26 = 4.5m$$

Actually, the length of the bed protection is designed as longer than the calculated one in consideration with site condition.

2) Bed Protection Structure

The bed protection shall be designed to not only be stable against canal flow but also stable against canal bed scouring. For stability against flow velocity, it shall have enough weight. Natural stones or concrete blocks are adopted for the protection materials, however, a gabion generally used is adopted in this Project in view of the fact that no large size natural stones are obtained easily at this site and for easy construction.

The weight of gabion per unit shall be larger than the weight calculated by the following formula:

$$W > 3.75A \cdot \frac{V^2}{2g}$$

Where,

W	:	Weight of gabion (t)
A	:	Area against flow (m^2)
V	:	Flow velocity on the gabion (m/s)
g	:	Acceleration of gravity (m/s^2)

When assumed the gabion size as 0.5m×1.2m×2.0m and unit weight of stone used for gabion as $1.8t/m^3$,

$$W = 0.5 \times 1.2 \times 2.0 \times 1.8 = 2.16t$$

$$A = 0.5 \times 1.2 = 0.6m^2$$

V = 4.0m/s (Maximum velocity)

$$3.75A \cdot \frac{V^2}{2g} = 3.75 \times 0.6 \times \frac{4.0^2}{2 \times 9.8}$$

$$= 1.84t < W$$

3.3.6 Sill Block of Lahoun Regulator

A sill block at the downstream of the Lahoun Regulator is necessary to prevent scouring from critical flow from causing initial operation of gates. The height of the sill is determined from the following formula;

$$D = 0.2H_2$$

Where, D : Height of sill (m)

H_2 : Downstream water depth 5.0 m

$$D = 0.2 \times 5.0 = 1.0m$$

3.3.7 Foundation

The weight per unit area of the facilities is small due to its flat foundation of bottom concrete. The direct foundation is used, because those design weights are smaller than the allowable bearing capacity estimated from the Terzagi's formula at each point of the facilities.

The following formula is applied for calculating the allowable bearing capacity. The results of the said calculation are shown in Table 3-3.

$$qc = 1/3 \times qd$$

$$qd = \alpha \cdot c \cdot Nc + \beta \cdot \gamma 1 \cdot B \cdot Nr + \gamma 2 \cdot Df \cdot Nq$$

qc	:	Allowable bearing capacity (t/m^2)
qd	:	Ultimate bearing capacity (t/m^2)
c	:	Cohesion under foundation
$\gamma 1$	:	Wet unit weight under foundation (About soil below water table, submerged unit weight shall be adopted)
$\gamma 2$	:	Wet unit weight above foundation
α,β	:	Form factor
Nc, Nr, Nq	:	Bearing capacity factor (function of internal friction)

Df	:	Depth from lower ground level nearest foundation to foundation level
B	:	Smallest width of foundation (in case of circle shaped foundation, diameter shall be adopted)

Table 3 - 3 CALCULATION OF ALLOWABLE BEARING CAPACITY

Item	Number of Bore-hole					
	Bor. 1	Bor. 1-1	Bor. 2	Bor. 3	Bor. 4	Bor. 4-1
Average N-value	6	10	6	6	18	10
Internal Friction ϕ	20	20	20	20	21	20
Form Factor α	1.0	1.0	1.0	1.0	1.0	1.0
Shearing Strength (kg/cm^2)	1.6	1.1	1.6	1.4	1.1	1.1
Cohesion C (t/m^2)	5.6	3.8	5.6	4.9	3.8	3.8
Bearing Capacity Factor Nc	7.9	7.9	7.9	7.9	8.3	7.9
Form Factor β	0.5	0.5	0.5	0.5	0.5	0.5
Unit Weight $\gamma 1$ (t/m^3)	1.8	1.9	1.9	1.9	1.9	1.9
Smallest width of Foundation B (m)	23.7	23.7	18.2	15.8	15.8	15.8
Bearing Capacity Factor Nr	2.0	2.0	2.0	2.0	2.0	2.0
Unit Weight $\gamma 2$ (r/m^3)	1.9	1.9	1.9	1.9	1.9	1.9
Penetration Depth Dc (m)	10.2	10.2	8.5	8.1	8.1	8.1
Bearing Capacity Factor Np	3.9	3.9	3.9	3.9	4.2	3.9
Ultimate bearing Capacity qd (t/m^2)	164.8	150.8	141.7	128.7	125.9	120.2
Allowable Bearing Capacity qa (t/m^2)	54.9	50.3	47.2	42.9	42.0	40.1
Width of Structure (m)	23.7	23.7	18.2	15.8	15.8	15.8
Weight of Concrete Structure (t)	301.1	301.1	371.7	291.5	291.5	291.5
Weight of Water (t)	55.2	55.2	65.6	67.3	67.3	67.3
Weight of Gate and Equipment (t)	3.4	3.4	3.4	5.0	5.0	5.0
Total Weight (t)	359.7	359.7	440.7	363.8	363.8	363.8
Overburden Pressure (t/m^2)	15.2	15.2	24.2	23.0	23.0	23.0
Judgment	○	○	○	○	○	○