No.

Ministry of Water Resources and Irrigation
Irrigation Department
Irrigation Improvement Sector
The Arab Republic of Egypt

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR REHABILITATION OF MONSHAT EL DAHAB REGULATOR
ON
BAHR YUSEF CANAL
IN
THE ARAB REPUBLIC OF EGYPT

SEPTEMBER 2007

JAPAN INTERNATIONAL COOPERATION AGENCY

SANYU CONSULTANTS INC.

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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 Rehabilitation and Improvement of Monshat El Dahab Regulator on Bahr Yusef Canal and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Egypt a study team from February 26th to March 24th, 2007.

The team held discussion 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 basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project 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 the Arab Republic of Egypt for their close cooperation extended to the teams.

September 2007

Masafumi Kuroki
Vice-President
Japan International Cooperation Agency

September 2007

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Rehabilitation of Monshat El Dahab Regulator on 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 from February to September 2007. 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.

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

Very truly yours,

Tomiji Shimoji
Project manager,
Basic Design Study Team on the Project for Rehabilitation of
Monshat El Dahab Regulator on Bahr Yusef Canal
Sanyu Consultants Inc.

Summary

1. Background of the Project

It is acknowledged that the Arab Republic of Egypt (hereinafter referred to as “Egypt”) depends on the River Nile for almost 100% of its water resources (National Water Resources Plan 2017: the Ministry of Water Resources and Irrigation). Hence the development of the country is directly influenced by the effective use of the available water resource limited to 55.5 billion m^3/year under the Nile Waters Agreement (1929) for the agriculture, mining and manufacturing, waterworks and so on through a rational system of water resource management.

According to the above plan, the country’s population of 63 million in 2000 is predicted to increase by 83 million in 2017, and the forecast of demand for water constitutes one of the urgent and serious problems to be solved. The plan also states that food self-sufficiency is the basis of the national development for Egypt like any other countries and thus, Egypt must cope with agriculture constraints for food security facing with the reality that the country is one of the leading food importing countries as the self-sufficiency rate of wheat, a staple food, remains 50%.

The Egyptian national territory is 100.1 km^2, which is as large as 2.7 times of Japan, but its arable land amounts to only 4%. For a sustainable agriculture to stably supply food to the increasing population under such severe conditions, a system for effective use of the water resources is essential to establish, namely effectively distributing the limited water into the Upper Egypt, Middle Egypt, and Nile Delta. Egypt has a long history of introducing to irrigation systems, but the most of the existing irrigation facilities are no longer adequate and the urgent necessity for their renewal has been recognized. Nowadays, the situation of modern agriculture and its supporting conditions has changed from the time the current irrigation systems were initially introduced. There is thus the necessity of reconstructing new irrigation systems, which are able to adapt to new changes including climate, agricultural methods, business requirements, and markets.

With this background, the Ministry of Water Resources and Irrigation of Egypt is facing the tasks to renew the superannuated water-use facilities, especially regulators and intake facilities throughout the country into modern ones for the effective use and rational management of the water resources. The ministry expects that the above tasks will secure a better balance in the demand and supply of water and thus contribute to increase in agricultural production as well as the productivity for the national food security as mentioned above and by the same token, income increase of farmers and poverty reduction.

Through the request from the Egyptian Government, the Japanese Government has given active assistance to the Egyptian Government since 1990 for the construction plan of the Bahr Yusef Canal which is the trunk irrigation system in the Middle Egypt Region. This has come out with the development study on “Rehabilitation and Improvement of Delivery Water System on Bahr Yusef Canal” in 1992 as an output of the development program for the entire irrigation canal. Based on this study, the Egyptian Government established the rehabilitation plan for 4 regulators installed over the entire Bahr Yusef Canal with a total length of 300 km. For three of them, the rehabilitation has been complete by the grant aid program, namely Lahoun Regulator (completed in 1997), Mazoura Regulator (in 2002), and Sakoula Regulator (in 2006) from the downstream site.

As for the Dahab Regulator built in 1900,located at the upper part of the Bahr Yusef Canal, a period of 100 years has elapsed since its construction and it has been heavily superannuated. Stable intake of water for the beneficiary areas cannot be achieved due to an unstable water level at the upstream reaches of the Regulator. Also, stable quantity of discharge cannot be supplied from the Dahab Regulator to the downstream reaches of the Bahr Yusef Canal. Evaluating the rehabilitation results of the three existing Regulators under the past grant aid program, the Egyptian Government requested the Japanese Government for another grant aid program for the rehabilitation project of the Dahab Regulator itself. The introduction of overflow type gates using the most advanced gate design and manufacture technology available in Japan would allow the easy control of water levels and flow rates, securing thus stable supply of irrigation water to the beneficiary area in the upstream reaches of the Dahab Regulator and also sustainable supply of the required discharge to the Bahr Yusef Canal downstream from the Dahab Regulator. The contents of the request are as follows:

- Renewal of the existing Dahab Regulator
- Renewal of the main gates into an electric overflow type gates
- Construction of the Control House
- Renewal of the regulator bridge

2. Contents of the Project

For this request, Japan International Cooperation Agency (JICA) dispatched a basic design study team to Egypt from February to March 2007. A series of discussions have been held with the Egyptian counterparts, in order to confirm the contents of the request and undertake the field study on the actual conditions of the Dahab Regulator and the secondary canals to the Bahr Yusef Canal, the present status of the canal system to end waterways, farming conditions, and the maintenance conditions of the irrigation facilities. The field study concluded that the main body of the Regulator and 20 gate facilities had been heavily superannuated and the water level in the upstream reaches of the Regulator was unstable. The study team also confirmed the necessity of solving the problems that the supply of irrigation water to the irrigation areas upstream from the regulator and the discharge to the downstream reaches of the Bahr Yusef Canal from the regulator were both unstable. The basic design of the contents for the assistance program was made in Japan and the study team for explaining the draft basic design was dispatched to Egypt in August 2007 to discuss and confirm with the Egyptian counterparts regarding the contents of the project. The details of this project are described below.

(1) Renewal of the Existing Dahab Regulator and Gates

The renewal will concern the main body of the Dahab Regulator, which has been heavily superannuated after 100 years of its service and 20 manually-driven gates whose stable water control function could not be demonstrated due to water leaks. The Regulator will be rebuilt from the existing brick block structure into a concrete structure, and the existing gates will be renewed by introducing the electric motor-driven overflow type gates provided with an excellent flow control function for controlling low to high flow rates with high accuracy. This will fulfill the required task of the Regulator, which is to secure a stable water level upstream the regulator and a stable discharge to the downstream reaches of the Bahr Yusef Canal.

(2) Construction of the Control House

For a high accuracy of the water-level and flow control functions of the renewed Dahab Regulator, the gate operation and maintenance equipment and machinery, including a gate remote control board, electrical and communications equipment, and a standby electric generator, has to be installed, and it is required to construct a control house to protect these equipment and machinery against sand storms that occur in every March. Also the control house has to have a function of the gate control station to carry out the daily operation of the Dahab Regulator, namely the gate operators work on maintaining the water level upstream from the regulator and discharge water to the canal at the downstream reaches under the commands from the Water Management Center Office located at Assuit. To this end, the foundation work for the construction of the control house and the installation of necessary equipment and machinery will be implemented under the grant aid program.

(3) Renewal of the Regulator Bridge

The Dahab Regulator is found in Minia, the central city of Minia Governorate located approximately 330 km away from the south of the Metropolitan City of Cairo. The villages around the Regulator are formed along the left and right banks of the Bahr Yusef Canal and the existing Dahab Regulator, with a width of 4 m, plays a central role of means of distributing people and goods in this area. The field study concluded that people, bicycles, horse carriages, vehicles, and large vehicles always cross the bridge so disorderly that they disturb the smooth traffic on the bridge in the daytime. The traffic survey undertaken in the basic design study recorded an average traffic of 2,500 vehicles/day, 1,400 bicycles and carts/day and 600 persons/day. To improve the traffic situation, a 10m-wide paved regulator bridge with 2 two-way lanes and a sidewalk will be constructed.

(4) Outline and Scale of the Project

The equipment and scale of the Dahab Regulator determined in the basic design study are shown in the table below.

Item	Design Specifications
1. Design water flow/ design water level	･ Maximum water flow: 210.15m^3/sec ･ Minimum water flow: 38.42m^3/sec ･ Maximum controlled upstream water level: 40.40m ･ Minimum controlled downstream water level: 36.23m
2. Regulator body	･ Reinforced concrete structure
3. Gate drive system	･ Electric motor-driven wire rope winch ･ Upper door: 1.5kW ･ Lower door: 5.5kW
4. Gate span	･ 8.0mW x 5.9mH x 4 spans ･ Gate height: 34.6m
5. Gate type	･ Overflow type gate ･ Forward three-way rubber watertight ･ Opening/closing speed: 0.3m/min or more ･ Sliding two-stage roller gate ･ Upper door height: 2.8m; Lower door height: 3.1m
6. Apron	･ Upstream apron length: 6.0m ･ Middle/downstream apron length: 41.5m ･ Upstream apron foundation height: 34.10m ･ Downstream apron foundation height: 34.05m
7. Bed protection work	･ Concrete block work ･ Downstream length: 52m Width: 38m
8. Cofferdam	･ Steel sheet pile IIIw and IVw type L=12.0 ~ 14.0m ･ Stone dyke slope protection work Total length L=135m
9. Revetment work	･ Steel sheet pile IIIw and IVw type L=13.0 ~ 14.5m ･ Stone dyke slope protection work Total length L=213m
10. Regulator bridge	･ Reinforced concrete T-girder ･ Bridge length: 40.8m ･ One-way lane width: 10.0m
11. Control House	･ Work by Japanese side: Control house foundation, and equipment and materials ･ Work by Egyptian side: Control house works upper than foundation
12. Operation panel/ (remote operation) / (local operation)	･ Upper/lower gate operation button ･ Buzzer stop button ･ Lamp test button ･ Upper/lower gate opening angle gauge ･ Up-/downstream water level gauge ･ Gate discharge integration meter ･ Water-level, gate opening angle and discharge quantity self-recording gauge ･ Emergency stop button ･ Telephone sets, etc.
13. Standby generator	･ 65kVA, 380V 1 unit
14. Spare gate	･ The spare gate for the Lahoun Regulator provided under the grant aid will be diverted.

(5) Implementation Schedule

This project will be implemented in a period of 5 months for the detailed design and 22 months for the construction works.

3. Project Effects

(1) Direct Effect

① Recovery of the available irrigation water

The table below shows the result of the analysis on the effect of the increase in the volume of irrigation water with project implementation using actual data of water intake from the 13 secondary canals, which receive water from the existing Dahab Regulator, in 2005.

Comparison between the monthly water requirement for crops and actual water intake in the beneficiary area irrigated by gravity from the secondary canals in 2005 revealed that the actual volume of irrigation water was estimated at $437,445 \times 10^3$ m^3/year based on the daily record of the upstream water level at the Dahab Regulator against the required irrigation water volume of $489,650 \times 10^3$ m^3/year.

The rehabilitation and improvement of the Dahab Regulator is expected to have the direct effect of supplying the required water volume of $489,650 \times 10^3$ m^3/year to the beneficiary area by the result of creating a stabilized water level upstream from the regulator and steady irrigation water supply to the secondary canals after the completion of the project.

②Improvement in traffic condition by increasing the width of the regulator bridge

The regulator bridge is expected to be an important point of regional traffic. The total width of the bridge is expanded to 10 m with 2 lanes, so that smooth passing of the traffic through the bridge will be possible throughout the day without causing traffic jam. Additionally a large-sized car will be available to pass through the bridge, though the present decrepit bridge does not allow the one to pass. Expansion of the width of the bridge will also resolve the waiting time of around 5 minutes for vehicle passengers when one has to wait for the opposite to pass the bridge ahead during traffic jam

(2) Indirect Effects

①Increase in crop production in the beneficiary areas

The rehabilitation and improvement of the Dahab Regulator is expected to have the indirect effect to increase in crop production as shown in the table bellow, by realizing the supply of the required water volume of $489,650 \times 10^3$ m^3/year to the beneficiary area.

As a result, crop yields are estimated to increase by 2 to 11 % from the current level. The crop production in the irrigation area as a whole is expected to increase from $1,189 \times 10^3$t to $1,278 \times 10^3$t, or by 89×10^3t, which means an expected improvement of productivity by approximately 8%.

②Increase in agricultural production

The table below shows the results of the evaluation of the change in agricultural production (output) with and without project implementation using the unit prices of crops in 2005. It is estimated that the agricultural output in the entire irrigation beneficiary area will increase from the current level of $926{,}940 \times 10^3$ LE/year to $986{,}160 \times 10^3$ LE/year. This increase of approximately 59,220 million LE $\times 10^3$ LE/year is translated into an increase of approximately 6.3% from the current level.

4. Conclusion

A water quantity of 5 billion m^3 per year flows down from the River Nile to the Bahr Yusef Canal where the Dahab Regulator is located. The quantity accounts for 9% of the usable volume of water limited to 55.5 billion m^3 per year from the River Nile. The irrigated area accounts for 11% of the national irrigation area in Egypt. As described above, the rehabilitation project for the irrigation canal and 4 regulators will comply with the requirement of the national policy of food production increase for higher food self-sufficiency in Egypt. This will also generate higher income for the rural residents through the agricultural revitalization and production increase to be achieved through the stabilized irrigation water supply in the Middle Egypt Region. Therefore, the project is appropriate to meet the aim of the grant aid program.

The environmental impacts on this project have been evaluated as Category B in the screening of the environmental impact risks by the Egyptian Environmental Affairs Agency (EEAA). The necessary procedure under the Egyptian law was conducted and a formal notice on the approval of this project was issued in July 2007 to the Ministry of Water Resources and Irrigation, which is the implementing agency of this project.

Upon implementing this project, we recommend the Egyptian Government to undertake the inspection and repair works for the 13 secondary canals located in the upstream reaches of the Dahab Regulator before the completion of its rehabilitation works and to take all possible measures to realize the stable supply of irrigation water.

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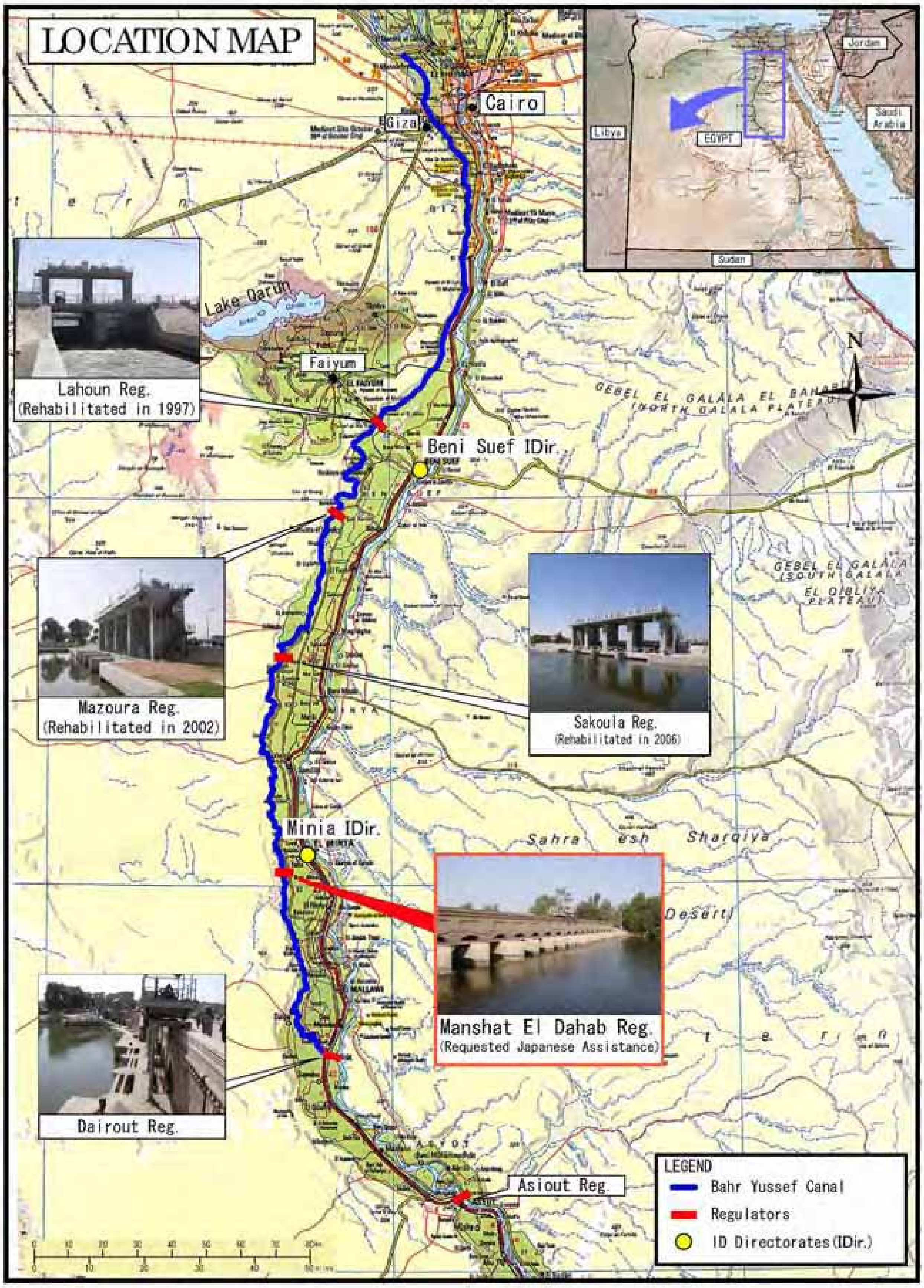
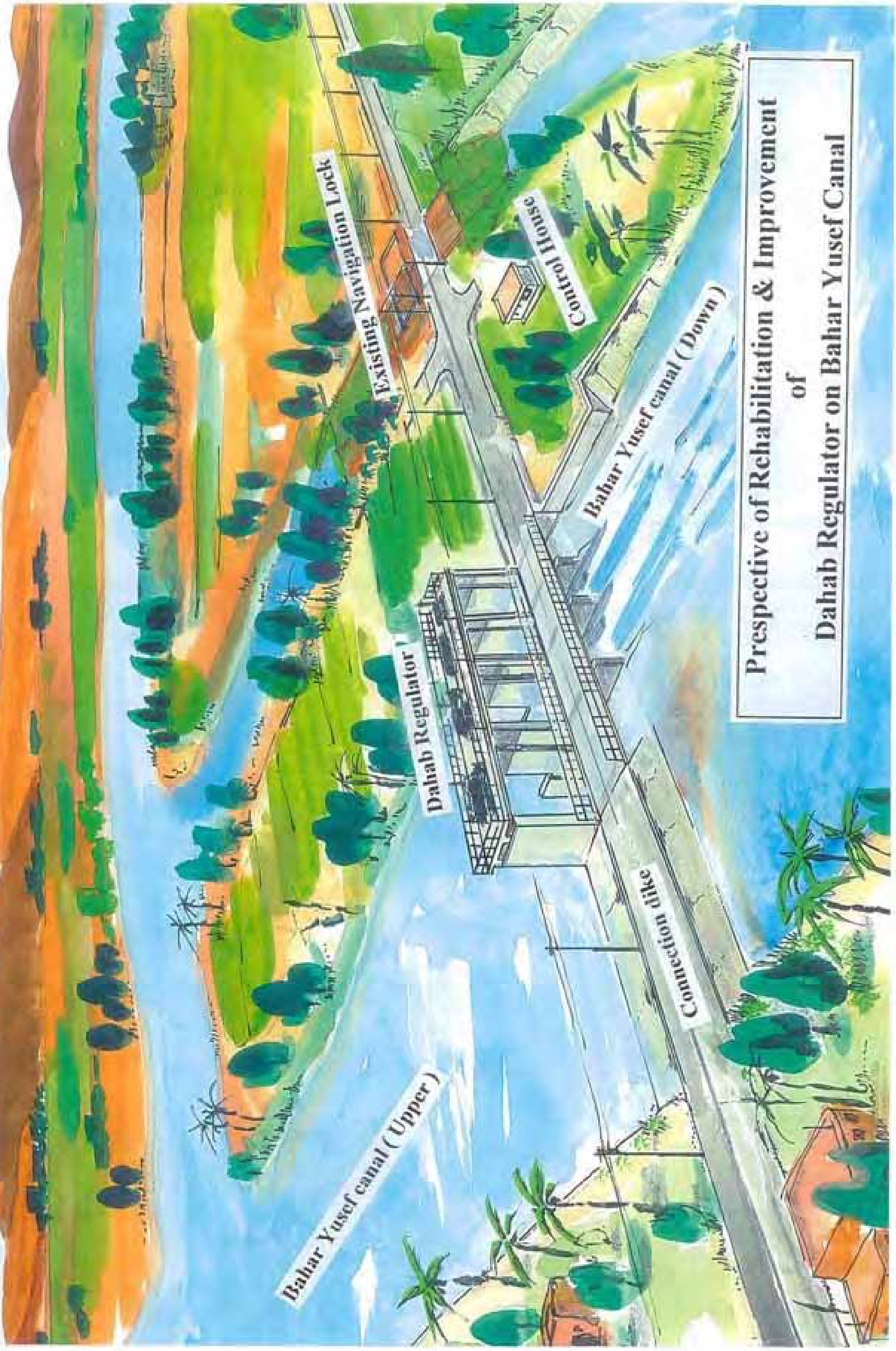
[Appendixes]

Location Map



Perspective



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Abbreviations

Abbreviations

MWRI	Ministry of Water Resources and Irrigation
MFT	Ministry of Foreign Trade
ID	Irrigation Department
MED	Mechanical and Electrical Department
IIS	Irrigation Improvement Sector
IS	Irrigation Sector
Minia IIP	Minia Irrigation Improvement Project
Beni Suef IIP	Beni Suef Irrigation Improvement Project
IDir.	Irrigation Directorate
West Minia IDir.	West Minia Irrigation Directorate
Beni Suef IDir.	Beni Suef Irrigation Directorate
IIP	Irrigation Improvement Project
IAS	Irrigation Advisory Service
JICA	Japan International Cooperation Agency
O/M or O&M	Operation and Maintenance
WUA	Water User's Association
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product

Units

cm	centimeter	℃	centigrade
cu.m	cubic meter	cms (m^3/sec)	cubic meter per second
fed.	feddan (= 0.42ha)	ha	hectare (=2.38 fed.)
hr	hour	kg	kilogram (=1,000 gram)
km	kilometer	km^2	square kilometer
lit.	liter	lit/sec	liter per second
m	meter	MCM	million cubic meter
mg/lit.	milligram per liter	meq/lit.	milliequivalent per liter
m/s	meter per second	ppm	parts per million
t	ton (1,000 kg)	%	percent
Aldap	Weight unit for agricultural products (differing by products) 1 ardap = wheat(150kg), beans(155kg), maize(140kg), sesame(120kg)		
Cantar	1 Cantar=Cotton(100kg)		

Currency

LE	Egyptian Pond
Pt	Egyptian Piaster (1 LE = 100 Pt)
Yen or J¥	Japanese Yen
US$	US Dollar

Exchange Rate （March 2007）

LE	= ¥ 20.94
LE	= US$5.71
US$	= ¥119.59

Glossary

Sakia	Water wheel to lift water by animal to field ditch from lateral canal
Mesqa	Small irrigation field canal constructed by the farmers themselves

Chapter 1 Background of the Project

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1-1 Present Status and Problems of this Sector

1-1-1 Present Status and Problems

(1) Outline of the Country

The Arab Republic of Egypt (hereinafter referred to as "Egypt") is a country with a powerful influence in geopolitics on the Middle East and African Region under the historical and contemporary aspects. Egypt faces the Mediterranean Sea on its northern side and the Red Sea on the eastern side and its national land area is approximately 1,000,000 km^2 (about 2.6 times the national land of Japan) in the northeast region of the African Continent. However, 96% of its national land is occupied by the desert region and the habitable and arable land area is only 4% and concentrated on the Canyon of the River Nile and Delta. The River Nile has its source in Ethiopia,Uganda,Sudan,etc flows down through the national land from the south to the north and forms riverbank plains and terraces which are made of alluvial soil. The riverbank terraces in the Nile Canyon are gradually lower from the south to the north and their height is 400 m in the vicinity of Luxor in the north of Egypt, 200 m in the vicinity of Minia where the site of this project is located, and about 150 m in the Metropolitan City of Cairo. Broad deserts are distributed between these terraces.

The Minia District that includes the study area is a central city of Middle Egypt and its development is based on the agricultural activity depending upon the water resources of the Nile. The climate in this region changes seasonally. For example, in 2005, the maximum daily temperature was 20.7°C in January in the winter season and 36.9°C in July in the summer season, while the minimum daily temperature was 5.7°C in January and 23.3°C in August. There was little rainfall during the whole year and only a rainfall of 2.8 mm was observed in February. The relative humidity was low, changing between 40% and 70% during the whole year. The people cannot depend upon rain water, but they rely on River Nile for the water resources related to their agricultural activities and household-use.

(2) Present Status and Problems of Water Resources

In May 2005, the Ministry of Water Resources and Irrigation established the National Water Resources Plan 2017 (hereinafter referred to as "NWRP") under the title of "Water for the Future" in cooperation with the Government of the Netherlands. This Plan stated that "water" will be an impeding factor for the socioeconomic development of the country, but for the appropriate water resources management. Acknowledging this situation, the Ministry declared that the Government was committed to the "Integrated

Water Resources Management (IWRM)" and that the Ministry itself would have the responsibility to play a central role in the development of a water management system and in the management field.

The Egyptian agricultural sector accounted for 40% of the national GDP in 1960, and though it has decreased to 17%, a high rate of 40% could be achieved for employment in the entire country. On the other hand, regarding the consumption of water resources, almost 100% of the agricultural production activity depends upon irrigation. For this reason, the consumption of water resources in the agriculture sector accounts for 95% in the entire country, while 4% is used for city and industrial water and the remaining 1% for aquaculture.

In the NWRP, it is stated that the agricultural land will increase by 35% in 2017 according to the horizontal expansion policy (agricultural land expansion), ensuring 20% of the population increase to be covered. It is also stated that the available water resources and cultivation rate per unit area have already been decreasing, and that the development and promotion of a water resources management system remains an urgent solution.

As said, the water resources in Egypt basically depend upon the Nile. The Nile is an international river with a total length of 6,700 km providing water to a wide area of 3,000,000 km^2 and 10 countries. However, Egypt is restricted to the annual usable water volume of 55.5 billion m3 in accordance with the Treaty concluded with Sudan in 1959. The water flowing down from the Nile is contained in the Lake Nasser (Aswan High Dam), but 85% of the water resource is found in the Blue Nile which flows down from the highland of Ethiopia, with its source in Lake Tana of the Amhara Region, in Ethiopia. The precious water resources of the Aswan High Dam flows down through the Delta region to the secondary canals and finally irrigates through the meskas (on-firm canal) into the end fields under the water resources management that is made by the main canal network and a number of regulators as shown in Table 1-1-1.1.

The water resources for the Bahr Yusef Canal under this project are ensured through the water resources management system which takes in and conveys the irrigation water of 9.6 billion m^3 per year from the Asyut Regulator located at about 470 km up the Nile from Cairo (Giza) into the Ibrahimia trunk canal, and further conveys 51.53% of that irrigation water through one of the 8 diversion channel facilities at the Dairout diversion work group located at about 60 km downstream from the Asyut Regulator. (See Fig. 1-1-1.1.)

The success in the irrigation system in Egypt depends upon the effective and efficient use of the limited water resources as described above (55.5 billion m^3 per year). It depends also upon the appropriate timing for supply of the required water volume for fields, avoiding the ineffective discharge due to oversupply of water and the shortage of water due to undersupply, and it is the only way to realize the horizontal expansion (agricultural land expansion) and the vertical expansion (increase of production volume and productivity). It is thus necessary to stabilize the water levels in the irrigation canals with sustainability and the means which exist to support the stable water levels are the Regulators that are distributed over the trunk canal. Because of the importance of irrigation, the Ministry of Water Resources and Irrigation has a detailed program to build regularly and rehabilitate the main large-scale Regulators throughout the country. Furthermore, it is important to construct a network of secondary canals extending from the trunk canal in various ways, the pumping stations to stably distribute water to the beneficiary areas located at heights, and the drainage (pumping) stations to feed back the water ineffectively discharged into the drains to the waterways for the reuse of precious water resources. It is also indispensable to provide the water management and maintenance technology (software) for the appropriate and integrated operation of these water utilization facilities.

Table 1-1-1.1 Main regulators, Main canals and Irrigation Directorate

Name of Regulator	Trunk Canal	Irrigation Directorate
Esna	Asfoun	Qena
	Kelabia	
Nag-Hammadi	East Naga Hamadi	Sohaq
	West Naga Hamadi	Asyut
Asyut	Ibrahimia	Asyut(small area), Ismailia,Salhia
	Bahr Yusef	East Minia, West Minia
		Beni Suef, Fayoum and Giza
Delta (Damietta)	Ismailia	Sharkia
	Sharkawia	Kalubia
	Tawfiki	Kalubia,Sharkia and East Dakahlia
	Basusia	Kalubia
	Darawa	Menufia
Delta (Rosetta)	Menufi Rayah	Menufa, Gharbia, West Dakahlia and Kafr El
	Nagail	Sheikh
	Beheira Rayah	Menufia
	Nasiri Rayah	Beheira, West Beheira, Nubaria and Nasr
Zifta	Mansouria	East Dakahlia and Damietta
	Zaglula	East Dakahlia
	Abbasi Rayah	Gharbia, West Dakahlia and Kafr El Sheikh
	Omar bey	Gharbia
	Dahtura	
Edfina	El-Mahmodia	El-Behera
	El-Rashidia East	Kafr El-Sheikh
	El-Rashidia West	
Farascour	El-Shakrawia	Damietta
	El-Salam canal	West Dakahlia

(3) Role of Middle Egypt Region in the Water Resources Project

The 55.5 billion m^3 of water that is taken in and discharged from the Aswan High Dam flows down in the main stream of the River Nile and reaches the Asyut Regulator, which is capable of taking in and making available the water resource volume of 10.0 billion m^3 as shown in the "Conceptual diagram of water distribution of the River Nile" above. The water resources of the River Nile that are taken in by the Asyut Regulator are conveyed into the Ibrahimia trunk canal to flow down through the trunk canal section of approximately 350km up to the start point of the Delta Area, through which section the agricultural land of $1{,}070 \times 10^3$feddan in the Middle Egypt Region is irrigated, making a large contribution to impelling the national policy of food production increase.

From the viewpoint of utilization of water resources, 18% of the water resource volume of 55.5 billion m^3 from the River Nile that Egypt can use under the International Treaty is utilized by the Middle Egypt Region.

(4) Role of Bahr Yusef Irrigation Canal in Egypt

All the water volume withdrawn from the River Nile into the Ibrahimia main canal is diverted by a group of 8 diversion works (intake regulators) (Dairut Group) into individual main canals. The diversion ratio is constant for the full year.

Name of Main Canal	Diversion Ratio
Sawahlia	4.93%
Dirotia	
Badama	
El Ebrahimia	36.84%
Bahr Yusef	51.53%
Abo Gabal	6.70%
Delgawi	
Bahr Asyut	

As shown in the table above, the Bahr Yusef Canal is given half the water flow volume diverted from the Ibrahimia trunk canal and plays a very important role in the utilization of water resources in this region.

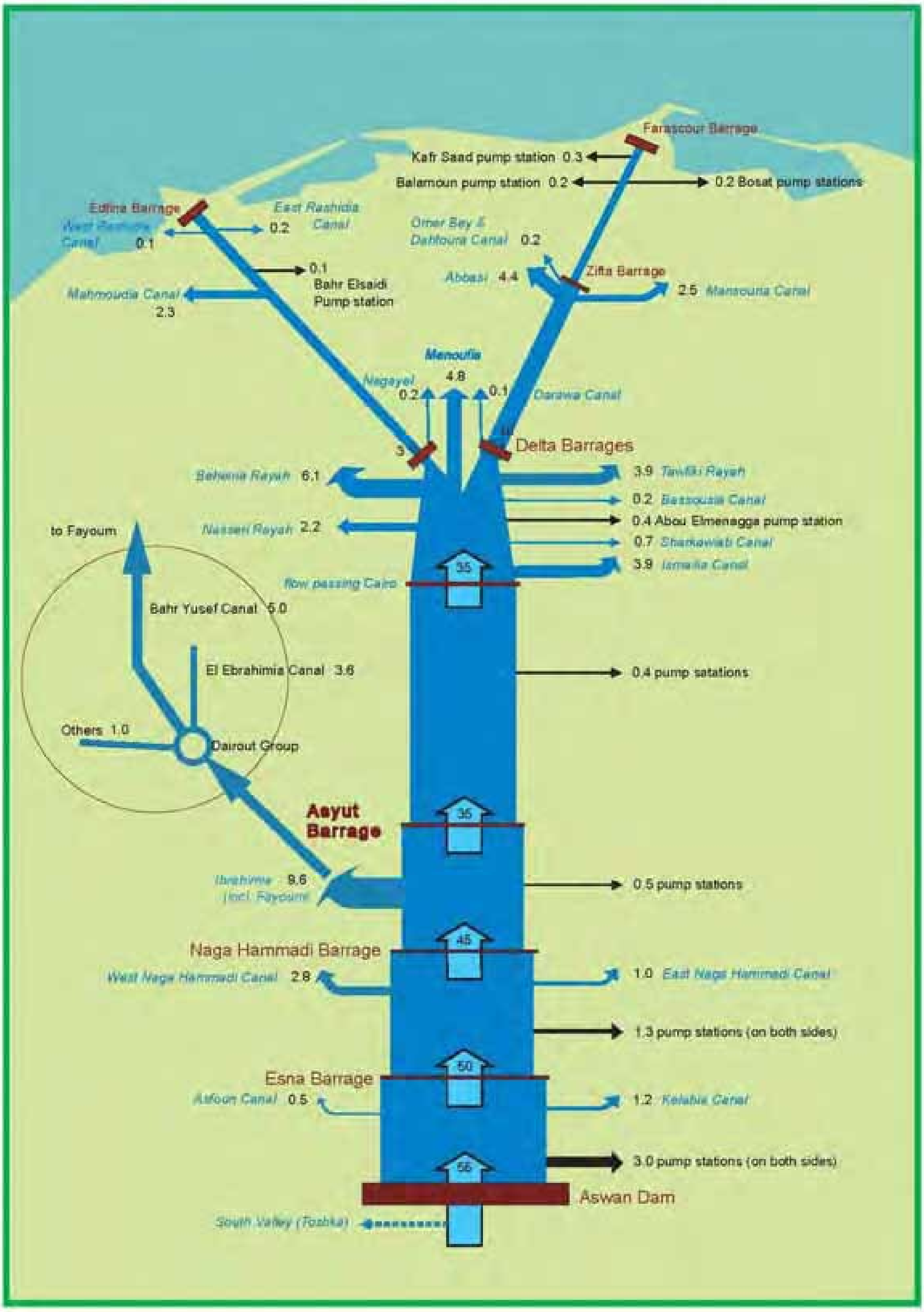


Fig. 1-1-1.1 Conceptual diagram of water distribution facilities in the River Nile

Source: National Water Resources Plan 2017 (The descriptions in the circle added by the Study team.)

1-1-2 Development Plan

(1) Functionality of this Sector in the National Plan

In the Fifth Five-Year Plan for Socio-Economic Development (2002 – 2007) and the First Year, April 2002 (hereinafter referred to as "National Plan"), the following 7 main objectives are included in the concept of the long-term socio-economic development plan:

① Conservation of natural resources and development of cities to desert areas
② Stable decrease of the current population increase rate
③ Attainment of high rate of GDP and its sustainable development
④ Slow escape from the national income and expenditure in the deficit
⑤ Poverty reduction and decrease in income unbalance
⑥ Development of human capital and realization of full employment
⑦ Improvement of social welfare

In considering the relations of the water resources, agriculture and irrigation fields in this sector in accordance with the National Five-Year Plan that is the most important national plan, the "Conservation of natural resources" in Item ① defines the conservation of the precious water resources available only from the Nile in Egypt, for which it is not expected to reserve water resources from rainfalls within the country for the whole year. Also, the "development of cities to desert areas" in the second phrase in Item ① implies the development of agricultural lands to desert areas. The policy in Item ① leads to the food security issue associated with the increasing population in Item ②, indicating clearly the importance of the agriculture and rural areas. The efforts to reduce the poverty in rural areas that are poorer compared to the urban areas, and the resulting serious income unbalance between rural and urban areas, remain the central issues of the National Plan, as well as the political issues related to the socio-economic development of the agriculture and rural areas.

The population of Egypt was 57 million in 1991, but exceeded 70 million in 2004, and it is expected to reach 86 million by 2022. As a result, many social problems listed herein-after are deemed national issues by the Government:

① Decrease of fertile agricultural lands due to the progress of urbanization under the horizontal expansion polity (30,000 feddan/year)
② Decline of food self-sufficiency due to the food production that cannot follow the population increase
③ Pressures from water resource situation
④ Employment problem
⑤ Poverty problem

Under these circumstances, the Government of Egypt deems the improvement in food self-sufficiency rate, from the viewpoint of food security, a concrete policy in the main objectives of the National Plan and it establishes a policy to positively cope with ① horizontal expansion (agricultural land expansion) and ②vertical expansion (increse of production volume and productivity).

The development plan for the agriculture and irrigation sector in the National Plan as mentioned above includes:

① Development of irrigation facilities for the additional agricultural land of $1,100\times10^3$ feddan (See Table 1-1-2.1)
② New development of $1,000\times10^3$ feddan in continuous agricultural land development
③ Distribution of new developed agricultural land of 168×10^3 feddan to new farmers
④ Project development for improvement of the integrated water resources development, irrigation and drainage system
⑤ Expansion of the agricultural land of 564×10^3 feddan to attain the total area of national agricultural land of $8,800\times10^3$ feddan for the initial 5 years
⑥ Increase of production of export-oriented high-price farm products and limitation of cultivation of high water-consumption farm products represented by rice and maize (See Table 1-1-2.2)
⑦ Increase of cattle and poultry, and marine product industry (See Table 1-1-2.3)
⑧ Increase of agricultural production at a year rate of 3.7% for five years (See Table 1-1-2.4)

To enforce the policies of horizontal expansion (agricultural land expansion) and vertical expansion (increse of production volume and productivity) as indicated in the above National Plan, it is urgent and mandatory to develop the water resources through the exploitation of unused water resources under the limited water resource volume. It is also urgent to develop the water resource management system through the effective use of the existing water resources, as described later on, and further to construct and rehabilitate the intake and irrigation facilities so as to relate the water resources to the agricultural production, and to develop and establish the operation and maintenance scheme for those facilities.

For the realization of the national policies adopted by Egypt and for a solution to various problems faced by the country, it is necessary to develop the policies strategically in order to develop the water resources, irrigation, agriculture, and rural sector as a total integrated unity.

Table 1-1-2.1 Area ($\times 10^3$ feddan) under the facilities development plan

	Five-Year Plan			Initial Year		
	State-own	Private	Total	State-own	Private	Total
East Delta	86	15	101	22	3	25
West Delta	12	14	26	7	5	12
Middle Egypt	23.5	0	23.5	9.5	0	9.5
Upper Egypt, New	206.5	336	542.5	0	73	73
Sinai, Suez East	250	6	256	40	2	42
Southwest Coast,	25	128	153	1	15	16
Total	603	499	1,102	79.5	98	177.5

Table 1-1-2.2 Increased production area and increased production of main farm products

(Area: $\times 10^3$ feddan; Production: $\times 10^3$ tons)

Farm Product	Five-Year Plan		Initial Year	
	New Cultivated Area	Increased Production	New Cultivated Area	Increased Production
Domestically consumed farm products				
Wheat	520	1819	210	551
Maize	416	2281	201	704
Sugar maize	66	260	40	86
Sesame	72	41	62	23
Fava bean	34	119	7	6
Exported farm products				
Cotton	90	181	90	118
Peanut	48	80	9	13
Vegetables	562	6810	111	1114
Fruits/Palm	140	1041	20	322
Medicinal plants	46	-	-	-
Labor-intensive farm products				
Onion	15	467	-	-
Sugar beet	15	559	9	375
High water consumption farm products				
Rice	▲410	▲1,414	▲340	▲1,317
Sugar cane	▲10	5	▲10	▲285

Table 1-1-2.3 Forecast production volume in Five-Year Plan for stock-raising industry and marine product industry ($\times 10^3$ tons)

	Forecast	Target		Increase (to 2001/02)	
	2001/02	2002/03	2006/07	2002/03	2006/07
Milk	3,560	3,650	4,200	90	640
Beef	700	716	812	16	112
Chicken	541	550	600	9	59
Eggs	223	230	300	7	77
Wool	20	21	25	1	5
Honey	14.5	15	18	0.5	3.5
Fish	750	775	925	25	175

Table 1-1-2.4 Agricultural production by production field in Five-Year Plan

(Unit: 1 billion LE)

Field	Agricultural Production Output			Net Change	
	2001/02	2002/03	2006/07	2002/03	2006/07
	Forecast	Target	Target	Target	Target
Farm products	53.9	55.8	64.2	1.9	10.3
Stock raising	20.2	20.7	23.5	0.5	3.3
Marine products	6.4	6.6	7.9	0.2	1.5
Total	80.5	83.1	95.6	2.6	15.1
Gross agricultural production	61	63.1	73.1	2.1	12.2

1-1-3 Socio-economic Conditions

The economy of Egypt was declining due to a reduced tourist revenue caused by terrorism on 9.11, 2001, but a favorable economic growth rate of 6.8% could be achieved in 2006. As for the reasons for this growth, it can be stated that in July 2004 with the inauguration of the Nazif Cabinet, the custom duties and personal income tax were decreased through the economic reform, stimulating the domestic consumption and the export of natural gases was launched on a full scale in 2005, contributing largely to a positive international trade balance. The IMF has the view that this favorable growth will continue at 6% or more in 2007 and 2008. The economy of Egypt shows a structure in which the huge deficit in the current balance of the international trade is covered by the four large revenues in foreign currencies, namely oil export, tourist revenue, remittances from laborers working abroad, and revenue from the Suez Canal. Since those revenues may be affected by external factors such as the situations of surrounding regions, the Government of Egypt is proceeding with the invitation of foreign money and entering into the FTA in order to foster the industry with international competitive power and to promote the export aiming at strengthening the economic base.

Table 1-1-3.1 Economic standard index

	2001/02	2002/03	2003/04	2004/05	2005/06
GDP (100 million dollars)	97,632	87,851	82,924	78,845	89,369
GDP Growth Rate (%)	3.52	3.19	3.11	4.18	4.94
National Income (dollars)	1,460	1,400	1,310	1,250	1,260
Population ($\times 10^3$)	68,585	69,913	71,267	72,642	74,033

Source: World Development Indicators , World Bank Database

The most important issues for the Egyptian Cabinet are the improvement of the high unemployment rate of more than 10%, the expanding gap between urban and rural areas, the gaps among regions, and the gap between the poor and the rich. There are also many middle-/long-term issues such as slow privatization, low agricultural productivity and little growth of export industry. According to the "World Fact Book (2007)", the GDP in 2005 was 89.34 million dollars and the GDP per head was 1,207 dollars. Under these circumstances, the structural ratio by GDP sector has changed as shown in Table 5 below.

Table 1-1-3.2 Structural ratio by GDP sector (%)

Sector	01/02	02/03	03/04	04/05	05/06
1) Agriculture	16.56	16.46	16.68	15.18	14.92
2) Manufacturing	33.33	33.20	34.54	36.87	36.07
3) Service Industry	50.11	50.34	48.78	47.95	49.1

Source: World Development Indicators , World Bank Database

1-2 Background of the Project

1-2-1 Background and Outline of Request

The agricultural sector which has had a share of about 16% of the GDP for the recent five years in Egypt is ranked at the third place among the main industries following the service and industrial production sectors. On the other hand, the self-sufficiency rate of wheat as the main food in Egypt remains at about 50%. Many food items depend upon imports and the amount of farm products imported accounts for 27% (in 2003) of the total import amount. Against this background, the arable land is only 4% of the broad national land (1,001,000 km^2), and the population increase is not checked and it is forecast that the population of 72.6 million in 2004 will increase to 86 million in 2022. Thus, the horizontal expansion policy (agricultural land expansion) and the vertical expansion policy (increse of production volume and productivity) that are promoted by the Egyptian Government are very important, and it is an urgent necessity to realize a higher food self-sufficiency rate and an increase of food production to cover the increased population.

The Egyptian Ministry of Water Resources and Irrigation is carrying forward the project of renewal of the old main water utilization facilities which are installed in the River Nile and its branch streams as well as in the irrigation canals, aiming at solving the problems of increasing food production and shortage of water resources that are pressing with growing urgency. For realization of higher food self-sufficiency rate as one of the national policies of Egypt, it is essential to build a rational water resource management system. As a concrete measure for achieving this, the construction and rehabilitation of modern types of regulators and intake facilities are making progress under the recognition that these measures will be the key to the basic solution of the problems as mentioned above.

The Bahr Yusef Canal which is supporting agriculture in the Middle Egypt Region is supplied with precious water resources of 5 billion m^3/year, 9% of the total water volume of 55.5 billion m^3/year as limited under the Nile Treaty, so that agricultural land of approximately 883,000 feddan (approx. 371,000 ha) is irrigated by that Irrigation Canal. There are 4 sites of intake regulators installed along the Irrigation Canal, which have the function of stably supplying irrigation water to the beneficiary areas covered by the regulators. However, each of the regulators has been in service for about 100 years after their construction and is very outdated to be able to provide the required functions. Therefore, the Lahoun Regulator (1971), the Mazoura Regulator (2002) and the Sakoula Regulator (2006) were rehabilitated in grant aid programs by Japan. The Dahab Regulator located at the most upstream location of the Bahr Yusef Canal has the important role of irrigating beneficiary agricultural land of 88,490 feddan (about 37,170 ha) and stably discharging the required volume of irrigation water to 3 downstream Regulators which have been rehabilitated, but which depend upon the Dahab Regulator as a lifeline. The rational and accurate water resource management at the Dahab Regulator allows the entire irrigation system of the Bahr Yusef Canal to function normally.

The existing Dahab Regulator built in 1900 that is very outdated after 100 years of service after construction is in the unfavorable condition that its safety is a concern. In addition, 20 gates installed at the Regulator are also in the adverse condition in which not only heavy water leaks from the gates are caused, but also no efficient gate operation is performed due to the manual opening/closing operation requiring many hours. As a result, the water level of the Bahr Yusef Canal in the upstream of the Dahab Regulator is not stabilized, ensuring no stable intake can be carried out at secondary canals. Therefore, a stable supply of irrigation water to the upstream beneficiary areas cannot be realized and water shortages in the beneficiary areas remain commonplace at present. At the same time, the required water volume cannot be discharged efficiently and stably from the Dahab Regulator to the three downstream Regulators.

To solve these current problems, the Egyptian Government has made the request for this grant aid program in which the existing Dahab Regulator will be rehabilitated by renewing the main body of the Dahab Regulator and by introducing overflow-type gates capable of easy and accurate control of water levels and flows, in order to allow the appropriate water management to be exercised to realize the stable supply of irrigation water to the beneficiary areas and the steady discharge of the required volume of water to the downstream canals. The components of the request will be described below.

1-2-2 Components of Request

- Renewal of the main body of the existing Dahab Regulator
- Conversion of the main gate into an electromotive overflow gate type
- Construction of an attached bridge
- Construction of a control house

Since the Bahr Yusef Canal is a main canal system to support agriculture in the Middle Egypt Region, this grant aid program planned to recover the stable intake and discharge functions of the Dahab Regulator located at the most upstream location of the Canal is deemed to be an essential project required to realize the stable operation of the irrigation system by the rational use of water resources, so that, as a result, improved agricultural productivity and increased food production can be expected in this Region.

1-3 Trend of Japan's Assistance

The Government of Japan has attached the importance to agriculture in the assistance projects to Egypt. The assistance projects that have been implemented for the agricultural sector in recent years will be described below.

(1) Grant Aid Programs

Table 1-3-1 Records on Japan's grant aid programs in the agricultural sector

Name of Project	Years	Description
1) The Project for Rehabilitation of Floating Pump Stations in Upper Egypt (Phase 1)	1991 ~ 93	Rehabilitation of floating pumps at 10 stations in the Upper Egypt Region
2) Project for Wheat Production Increase through Mechanization in Nile Valley	1993	Installation of laser equipment for agricultural land leveling
3) Project for the Improvement Increase of Rice Storage Centers (Phase III)	1993	Installation of Rice Storage Silos
4) The Project for Rehabilitation of Floating Pump Stations in Upper Egypt (Phase 2)	1995 ~ 98	Rehabilitation of floating pumps at 11 stations in the Upper Egypt Region
5) The Project for Rehabilitation and Improvement of Mazoura Regulator on Bahr Yusef Canal	1995 ~ 97	Rehabilitation of Lahoun Regulator
6) The Project for Rehabilitation and Improvement of Bahr Yusef Canal	2000 ~ 02	Rehabilitation of Mazoura Regulator
7) The Project for Rehabilitation of Floating Pump Stations in Upper Egypt (Phase 3)	2003 ~ 04	Rehabilitation of floating pumps at 5 stations in the Upper Egypt Region
8) The Project for Rehabilitation and Improvement of Sakoula Regulator on Bahr Yusef Canal	2004 ~ 06	Rehabilittion of Sakoula Regulator
9) Increased of Food Production	1984 ~ 2004	Grant of agricultural equipment and materials

(2) Technical Assistance

① Technical assistance project

1) The Rice Mechanization Pilot Project (Agriculture Engineering Research Institute): 1981 ~ 92

Phase I	Verification test on applied machines at verification testing fields in Kafr El-Sheikh and Karine District
Phase II	Establishment of the rice farming mechanization system for low-cost cultivation in satellite fields in Central Delta
Follow-up	Measures for higher germination rate and against weeds, measure for soil structure maintenance, training for maintenance and inspection of agricultural machines

2) The Water Management Improvement Project in the Nile Delta: 2000 ~ 2005

The demand for water has rapidly increased in recent years, but various problems, including an excessive irrigation by the spread of irrigation pumps, the ineffective water discharge and shortage of water in the end waterways managed by farmers, occurred due to the decline of water distribution efficiency. To solve these problems, the Government of Japan is promoting the technical assistance to the city of Tanta and peripheral areas aiming at modernization of the end facilities and efficient water utilization in taking into account the cost sharing by farmers.

② Dispatch of experts (since 1996)

1) Irrigation and Drainage Project	June 1996 ~ June 1999
2) Irrigation Technology	June 1996 ~ June 1999
3) Training, research and development, and operation of facilities for rice treatment and processing	February ~ May 1999
4) Third country training (Rice farming technology)	July ~ August 1999
5) Irrigation and Drainage Project	October 1996 ~ October 2001
6) Third country training (Rice cleaning technology)	November 9 ~ November 20, 1999
7) Third country training (Stock-raising technology)	March 3 ~ March 18, 2000
8) Rice blight	July ~ August 2000
9) Stock-breeding technology (breeding)	October 13 ~ October 23, 2000
10) Rice cleaning technology	October ~ November 2000
11) Agricultural water resources advisor	July ~ December2003
12) Gate operation technology	August ~ December 2003

③ Reception of trainees (since 2004)

1) Action year: 1999～2003
2) Courses: Type of participatory water operation (Specially established trainees)
3) Number of trainees: 5/year

④ Third country training program

1) Meat processing technology (October ~ November 1999) People's Republic of China
2) Meat processing technology (October ~ November 2000) People's Republic of China
3) Rice Cultivation Techniques (2002 ~ 2006) Arab Republic of Egypt
4) On-farm Water Management (Irrigation and drainage) (2004 ~ 2006) Arab Republic of Egypt

⑤ Development study

1) Bahr Yusef Irrigation Rehabilitation Project (1990 ~ 92: F/S)
2) Study on Farmland Environmental Improvement Project in the Omoum Area. (1990 ~ 92): F/S)
3) The Study for the Improvement of Irrigation Water Management and Environmental Conservation in the North-east Region of the Central Nile Delta
(1998 ~ 99: M/P and F/S)
4) North Sinai Integrated Rural Development Project (Phase 3) (Detailed Design Study)in the Arab Republic of Egypt (1999 ~ 2000: D/D)

1-4 Trend of Assistance by Other Donors

1-4-1 Large-scale Regulator Rehabilitation Projects

Some European countries are involved in the rehabilitation of large-scale regulators in the River Nile which are similar to the Dahab Regulator, but different in scale. France implemented a feasibility study of the Esna Regulator (170km downstream off Lake Nasser) in 1986 which is the first regulator in the lower stream of the Aswan High Dam and completed its construction at the total project cost of about 19.4 billion yen in 1994. The large-scale work with a total width of 820m including a power generation plant and locks was completed under a loan and grant aid by Italy and under loans by Romania and Australia as well as under the funds of the Egyptian Government.

For the "Nag-Hammadi Regulator" located at about 350km in the lower stream of Lake Nasser, Italy made a study in 1985 and Canada made a preliminary feasibility study, and Germany made a feasibility study from 1996. At present, the work is underway under the finance of KfW (Kreditanstalt für Wiederaufbau) and will be completed in 2008.

All the rehabilitation projects for the 4 Regulators in the Bahr Yusef Canal in which the Dahab Regulator is located are projects under grant aid assistance by Japan including the works for 3 Regulators that have been completed and the Dahab Regulator under this study, but no other assistance organizations are engaged in those projects.

1-4-2 Irrigation Improvement Project (IIP)

The Irrigation Improvement Project (IIP) is implemented under finance from the World Bank and its objectives include the realization of efficient water management at field level in preparation for the future shortage of agricultural water, fair water distribution by improvement of the irrigation system, improvement of project operation and management ability of concerned officials, and support to organize hydrological unions. Since 1988, feasibility studies have been made for 17 areas comprising a total area of approximately 400,000 feddan (170,000 ha) until the improvement pilot project for meskas including the trunk canal system to cover 10 Districts in the Upper Egypt and the Delta Area has been implemented. The meska improvement project is developed in Minia for the beneficiary areas of the Ibrahimia Canal, but the project does not include this Bahr Yusef Canal at present.

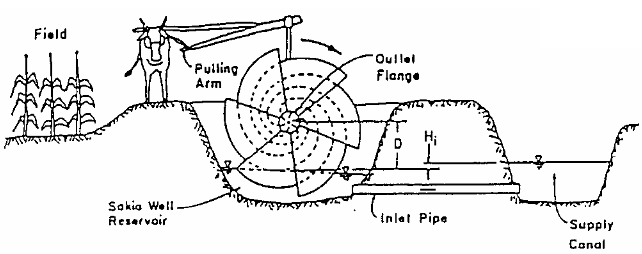
1-4-3 USAID Project

The Ministry of Water Resources and Irrigation introduced a Telemetering system under assistance by USAID in 1995. This system has the function of supervising the discharge rates at about 800 points in the branch canals of the entire Nile irrigation water system including 5 Regulators in the Bahr Yusef Canal and instructing the gate operations by telephone. Water level measurements are made at 4 Regulators, the Lahoun, Mazoura, Sakoula and Dahab Regulators to make the water distribution at the Asyut Irrigation Directorate controlling the Assuit Intake Regulator that is the intake source for the Bahr Yusef Canal and transfer the water-level records successively to the Remote Supervising System Department in Cairo Headquarters. The future introduction of a Telecontrol System is also under examination and the remote control operation is also made experimentally at the Salhia diversion canal from the Ibrahimia Canal.

1-4-4 Meska Improvement Project

Farmers have pumped up water from canals by the traditional pumping facilities called "sakia" using cattle power (as shown in the diagram below) and conveyed the pumped water from a meska to a marwa (end field waterway). This operation is possible because the water level in the meska is kept lower than that in the field.

Image of Sakia



This sakia is usually operated by a group of several farmhouses called "sakia ring" (a water utilization organization). However, the sakia has the disadvantages that its pumping power is too low to make appropriate irrigation in the right season and that it is unmovable if the water level is low. Thus, electric pumps have recently spread among farmhouses that are anxious about drought disasters.

The electric pumps have high pumping power, but are apt to perform excessive intake and upstream intake preference, resulting in unfair water distribution. Egypt, for which the effective use of water is a pressing problem, needs to use improved meskas to cope with the limitation of rice farming needing a high volume of water and the improvement and renewal of regulator and intake facilities in trunk canals as well as the efficient use of water at field level.

Under these circumstances, the meska improvement project has been started under the assistance by USAID. The meska improvement project by USAID employs the water distribution method to distribute water to fields through low-pressure pipelines using electric pumps, or the water distribution method called J-section method using U-shaped open channels. The pipeline-based improved meska consists of a simple roof to protect the electric pump owned by farmers, a low distribution tower (of about 2m high) and a pipeline made of vinyl chloride pipes. The water distribution to fields is performed by opening and closing ALFALFA valves. The J-section type improved meska forms an open channel in which secondary concrete products with a J-section are connected with mortar at their bottom center. The water distribution to fields is performed by using concrete turnouts. The improved meska methods are selectable depending upon the planned installation point of an electric pump and the types of field owned by the farmers. The required cost for these meska improvements is appropriated from soft loans by the Egyptian Government which is to be reimbursed over 15 years on the basis of an unredeemed term of 5 years.

The meska improvement projects implemented in the Salhia canal under the finance by USAID and thereafter under the funding of the Egyptian Government have had the following effects:

① Higher efficiency of irrigation in fields (reduction of conveyance loss in waterways in fields)

② Reduction of pump operation time

③ Correction of upstream intake preference (decrease of water troubles between upstream and downstream farmers)

Chapter 2　Contents of the Project

Chapter 2　Contents of the Project

2-1　Basic Concept of the Project

2-1-1　Project Purpose

2-1-1-1　Necessity of the Project and its Positioning

The purpose of this project is to resolve the unstable water level problem in the upper part of the Bahr Yusef Canal resulting from the existing aging Dahab Regulator, by ensuring a stable and continuous water intake to the secondary canals through the rehabilitation and improvement of the Dahab Regulator, which is one of the four regulators built on the Bahr Yusef Canal and is located at the uppermost part of the canal. Another purpose of the project is to simultaneously ensure an accurate and stable supply from the Dahab Regulator to the lower part of the Bahr Yusef Canal of the necessary irrigation water.

The Dahab, Sakoula, Mazoura and Lahoun Regulators are located from the upper to the lower parts of the Bahr Yusef Canal which serves as the main irrigation water resource for the Middle Egypt region. As all of these regulators were built around 100 years ago, it has become difficult to maintain the water level within the canal system, which is a basic function any regulator should have. Three of the regulators have been completely rehabilitated and improved as grant aid programs of Japan, starting with the Lahoun Regulator in 1997 to the Mazoura Regulator in 2002 and the Sakoula Regulator in 2006.

As with the three regulators rehabilitated in the past, the purpose of this project is to enable the Dahab Regulator to fulfill its expected role fully by upgrading both the regulator itself and its gate which are unable under present conditions to fulfill their expected functions smoothly, so that the following two original functions of the regulator can be restored.

1. The state of the existing facilities of the Dahab Regulator has caused water shortages in the agricultural fields because the required water level above the regulator cannot be ensured due to the age of the regulator and its gate, and the inefficiency of manual operation. Resolving this unstable water management situation and bringing about a reasonable water management system necessitates the recovery of the original functions of the Dahab Regulator.

2. Effective use of Nile-dependent water resources can be brought about by ensuring the discharge of an appropriate water volume from the Dahab Regulator located at the uppermost part of the Bahr Yusef Canal. In particular, if water management at the uppermost Dahab Regulator is not accurate, the water resources available at the three regulators lower down will become unstable. Since the three regulators located below the Dahab Regulator account for 88% of the Bahr Yusef Canal in terms of beneficiary area, the accuracy of the Bahr Yusef Canal water supply system depends on the accuracy of the water management system at the Dahab Regulator. The function of the Dahab Regulator to discharge an appropriate amount of water in a highly accurate manner must be recovered in order to provide the amount of irrigation water required at the three lower regulators.

2-1-1-2 Overall Goal and Project Purpose

The Terms of Reference of this project state that the overall goal of this project is to improve agricultural productivity in the subject area (approx. 32,000ha).

The overall goal is the development effect expected from the achievement of the purpose of this project. An unstable irrigation water supply in the beneficiary area has been caused by the difficulty of "ensuring a stable water level," which is a key function of a regulator, due to the aging of the Dahab Regulator. If the problem of this unstable irrigation water supply is resolved, it will lead to the increase and stabilization of crop yields in the subject area (beneficiary area) and thus to an increase in agricultural production. Therefore, the overall goal of this project is defined as follows:

Overall Goal: Improvement of agricultural productivity in the subject area

The Terms of Reference propose as the project purpose the improvement of irrigation efficiency in the area covered by the Dahab Regulator irrigation system.

Taking the rehabilitation and improvement of the Dahab Regulator as a foundation, the improvement of irrigation efficiency is an effect which can be produced only through the improvement of the secondary canals and pump stations and the improvement and expansion of the infrastructure of the improved "meska" (farm ditchs), as well as through the spread of water-saving irrigation farming techniques, with rotation irrigation replacing conventional irrigation techniques.

It is understood from the above that the primary effect of the improvement of irrigation efficiency in the area in question through the rehabilitation and improvement of the Dahab Regulator will be the stabilization of the supply of irrigation water to the area covered by the Dahab Regulator irrigation system.

The Project Purpose of this project is defined as follows:

Project Purpose: Improvement of irrigation efficiency in the area covered by the Dahab Regulator

2-1-2 Basic Concept of the Project

2-1-2-1 Activity Plan of the Project

The Activity Plans to achieve the project purpose described above are as follows:

(1) Japan's Activity Plan

The Activity Plan to achieve the project purpose is as follows:

- Construction of the Dahab Regulator
- Replacement of the gate

- Construction of the maintenance bridge attached to the regulator
- Construction of the foundation work of the control house and supply of equipments for gate control system in the control house.

(2) Egypt’s Activity Plan

- Rehabilitation and improvement of the secondary canals and pump stations (as necessary)
- Construction of the control house

A summary of the above is shown in the PDM below:

Summary of Project	Objectively Verifiable Indicators	Means of Obtaining Objectively Verifiable Indicators	Important Assumptions
1. Overall Goal Improvement of agricultural productivity in the subject area	・Crop yields ・Farm incomes	・Statistical data by Agricultural Bureau ・Baseline survey	・Continuation of the rehabilitation and improvement of the Bahr Yusef Canal ・No change in the Egyptian government’s policy for water management
2. Project Purpose Improvement of Irrigation efficiency in the area covered by the Dahab Regulator irrigation system	・Volume of irrigation water intake	・Water level records of the channel above the Dahab Regulator	
3. Outputs ・Increase in the volume of irrigation water ・Increase in crop yields ・Increase in agricultural production ・Reduction in operating time and cost of the pump stations ・Improvement of local transportation conditions	・Volume of irrigation water intake ・Crop yields ・Farm incomes generated from agriculture ・Operating time and cost of the pumps ・Traffic volume of the attached maintenance bridge	・Baseline survey ・Statistical data by Agricultural Bureau ・Irrigation facility survey ・Management and maintenance records of the Dahab Regulator ・Traffic volume survey	・Assignment of experienced engineers with good knowledge of water management ・Continued implementation of Egypt’s Activity Plan

Summary of Project	Objectively Verifiable Indicators	Means of Obtaining Objectively Verifiable Indicators	Important Assumptions
4.Activities	Input plan		Pre-conditions
・Construction of the weir body ・Renewal of the gates ・Construction of the regulator bridge ・Construction of the foundation work of the control house and installation of remote control equipments in the control house	<Japanese side> ・Detailed design / supervision of construction ・Rehabilitation of the Dahab Regulator. Design discharge volume: 210.15 m^3/s ・Installation of overflow gate 8m x 4gates ・Construction of the regulator bridge width 10m ・Construction of the foundation work of control house and Remote control panel of the gates and generator.	<Egyptian side> ・Rehabilitation of the secondary canals. ・Preparation of temporary yard. ・Supply of water and electricity to the sight. ・Preparation of required budget and staff ・Coordination between related ministries and agencies. ・Construction of the control house	・Construction works born by the Egyptian side is implemented as planned ・Required procedures for security and exemption form taxation are carried out by related ministries and agencies by the executive agency

2-1-2-2 Outline of the Project

(1) Replacement of Body of Existing Dahab Regulator and Gates

For the purpose of stopping leakage from the Dahab Regulator through the body and gates, the Regulator shall be reconstructed with electric powered driven overflow-type gates. This type makes delicate-regulation of water level at upstream possible and flow-rate control at the Regulator smooth and easy by available correspondence between small and large discharges better than underflow-type in order to stable the water level at upstream of the Regulator.

Japan's Grant Aid Scheme, therefore, offers funds for supplying irrigation water to the beneficial area stably by replacing over-aged existing Dahab Regulator to modern regulator with electric powered driven overflow-type gates.

(2) Construction of the Regulator Bridge

The maintenance bridge of Dahab Regulator lies in the center of the flow of local people and agricultural products, and it plays an important role in the daily local traffic. Based on the investigation of traffic at the Basic Design Study, the wheel traffic, which is related with the distribution including the crops, such as trucks, small trucks, tractors and carriages are about 2,500 cars/day, the bicycles and coachs are about 1,400 car/day. Moreover, the comings and goings including people are about 600 people/day. Thus, regulator bridge plays an important role for not only the distribution and comings and goings but the daily transportation.

However, the width of existing regulator bridge is only 4 m and vehicles have to follow one way traffic only, and it is crowded with both vehicles and passersby. The type of the bridge is a brick arch structure, surface brick is broken off and large vehicles are prohibited to pass according to load limit. Therefore, this maintenance bridge is planned to be improved to suit present condition of traffic and transportation of agricultural products and to contribute to improvement of the circumstances of flow to the market in the beneficial area of the Project.

(3) Control House

To regulate water level and flow-rate accurately by the mentioned overflow-type gates, maintenance equipment and facilities such as gate control panel, electric facilities and emergency generator are necessary. Also, storage facility to protect these from bad weather like sand storms shall be provided. To maintenance the regulator body, gate and the above equipments, an operation and maintenance office that can correct operation data shall be installed. Furthermore, a water management office that plays a sub-system of flow-rate control management and unitary water management system in the whole Bahr Yusef Irrigation Canal in future and the place for training of technology transfer is required. By the above reason, a control house shall be constructed.

(4) Outline of the Project Facilities

Outline of the Project facilities are shown in following table;

Table 2-1-2.1 Outline of Replacement of Dahab Regulator

1. Design water flow/ design water level	･ Maximum water flow: 210.15m^3/sec ･ Minimum water flow: 38.42m^3/sec ･ Maximum controlled upstream water level: 40.40m ･ Minimum controlled downstream water level: 36.23m
2. Regulator body	･ Reinforced concrete structure
3. Gate drive system	･ Electric motor-driven wire rope winch ･ Upper door: 1.5kW ･ Lower door: 5.5kW
4. Gate span	･ 8.0mW x 5.9mH x 4 spans ･ Gate height: 34.6m
5. Gate type	･ Overflow type gate ･ Forward three-way rubber watertight ･ Opening/closing speed: 0.3m/min or more ･ Sliding two-stage roller gate ･ Upper door height: 2.8m; Lower door height: 3.1m
6. Apron	･ Upstream apron length: 6.0m ･ Middle/downstream apron length: 41.5m ･ Upstream apron foundation height: 34.10m ･ Downstream apron foundation height: 34.05m
7. Bed protection work	･ Concrete block work ･ Downstream length: 52m Width: 38m
8. Cofferdam	･ Steel sheet pile IIIw and IVw type L=12.0 ~ 14.0m ･ Stone dyke slope protection work Total length L=135m
9. Revetment work	･ Steel sheet pile IIIw and IVw type L=13.0 ~ 14.5m ･ Stone dyke slope protection work Total length L=213m
10. Regulator bridge	･ Reinforced concrete T-girder ･ Bridge length: 40.8m ･ One-way lane width: 10.0m
11. Control House	･ Work by Japanese side: Control house foundation, and equipment and materials ･ Work by Egyptian side: Control house works upper than foundation
12. Operation panel/ (remote operation) / (local operation)	･ Upper/lower gate operation button ･ Buzzer stop button ･ Lamp test button ･ Upper/lower gate opening angle gauge ･ Up-/downstream water level gauge ･ Gate discharge integration meter ･ Water-level, gate opening angle and discharge quantity self-recording gauge ･ Emergency stop button ･ Telephone sets, etc.
13. Standby generator	･ 65kVA, 380V 1 unit
14. Spare gate	･ The spare gate for the Lahoun Regulator provided under the grant aid will be diverted.

2-1-3 Environmental and Social Considerations

According to the JICA Guidelines for Environmental and Social Considerations, "environmental and social considerations" involves "giving consideration to the impact on air, water and soil, the impact on nature including ecosystems and biodiversity, population migration and involuntary resettlement, respect for the human rights of the indigenous population, and other impacts on the society".

Since the aim of this program is to rehabilitate and improve the existing Dahab Regulator and its associated facilities, i.e. not to build new irrigation facilities on a natural river where no facility currently exists, it is judged that this project will put no burden on the current environment or the local community.

More specifically, this project consists of these facility programs: 1) rehabilitation and improvement of the existing Dahab Regulator, 2) upgrading of the existing gate, 3) rehabilitation and improvement of the attached maintenance bridge, and 4) improvement/construction of the control house. Since these facility programs consist of the rehabilitation and/or construction of the facilities on the Bahr Yusef Canal where the current Dahab Regulator exists and at its neighboring site, they will neither bring about new environmental changes nor have any negative impact on the society; while they will make a big contribution to the livelihood of the residents and farmers living in the vicinity and to their agricultural activities.

This project was judged as Category "B" in screening by the Egyptian government. While the assessment is being decided on the basis of the field survey through careful consideration by the Egyptian Environment Affairs Agency (EEAA) submitted a official letter to the Ministry of Water Resources and Irrigation to approve this Project based on the national law on July, 2007. Basically, EEAA approve construction works in this Project, however especially EEAA proposed that we must attention the Egyptian Law No.4/1994 as follows.

①To prevent floating materials and oil and reduce percentage of turbidity in the canal water during works of sheet pile construction.
②To attention air pollution of exhaust gas during construction works.
③To attention noise during construction works.
④To attention healthiness of environment and security for labor in construction works.
⑤To use electric pump to prevent leaking of oil and fuel.
⑥To remove weeds in swamps near the temporary bridge and temporary coffer dam.
⑦To dispose of solid wastes and concrete wastes to the proper place.
⑧To execute the self-monitoring plan to watch the labor environment.
⑨To execute construction follow the construction plan.

About above mentioned, we will plan as follows and to reduce the load for environment, we use our experience of participation in planning the rehabilitation and improvement projects for the other three regulators in the past.

①Contractor should establish oil fence during works of sheet pile construction to prevent floating materials and oil and reduce percentage of turbidity in the canal water.

②Contractor should use backhoe and bulldozer with low exhaust gas.

③Contractor should use low noise generator for supplementary power.

④Contractor should establish security fence around temporary yard and construct the rest room and a toilet.

⑤Contractor should use electric pump to discharge water from temporary coffer dam.

⑥Basically, Contractor should remove weeds in swamps near the temporary bridge and temporary coffer dam for once awake, however ,we will execute removal plan properly for situation.

⑦Contractor should dispose of good solid wastes and concrete wastes to the navigation lock near the site, and sediment from excavation to the disposal area from the site at 25km.

⑧Contractor should execute the self-monitoring plan to watch atmospheric temperature.

⑨Contractor should execute construction according to plan with observing above mentioned.

Especially, although Egyptian government approved above mentioned ⑦, Egyptian government should confirm this issue to related organization.

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Overall Policy

(1) Preconditions for the Basic Design

The basic design for the following four facilities will be implemented in this grant aid program.

1) Dahab Regulator
2) Gates
3) Maintenance bridge attached to the regulator
4) Foundation work of the control house

The purpose of this project is to stabilize the water level above the Dahab Regulator by restoring the water control function, which is the primary function of the regulator, and to provide a stable supply of irrigation water to the beneficiary area irrigated by the regulator through rehabilitation of the regulator and ancillary facilities, which have seriously deteriorated due to age as more than 100 years have passed since their construction in 1901.

The Bahr Yusef Canal, on which the Dahab Regulator is located, is not a natural river on which a river regulator would normally be constructed, but a canal created artificially for the purpose of discharging irrigation water drawn from the River Nile. In the history of the River Nile, the Bahr Yusef Canal has been developed by converting one of the rivulets formed in the flood plain into an irrigation canal with a base width of approximately 70m through widening and improvement works, for the purpose of supplying irrigation water to the Fayum Basin. Later, with the construction and commissioning of the Aswan High Dam in the upper reaches of the River Nile in 1976, flood control of the River Nile has been carried out at the dam. As a consequence, all the hydraulic structures downstream of the dam have been freed from the threat of flood and the need to install a floodgate function as part of the development of the facility has been eliminated.

According to the records of the water level at the Dahab Regulator for the past 15 years (from 1992 to 2006) obtained during the field survey of this project, the highest water level was 40.85m, while the basic design puts the design afflux water level of the Dahab Regulator at 40.40m. From the fact that the difference between the highest past water level and the design water level is 0.45m and the fact that the ground elevation of the hinterland of the canal is 41.00 – 42.00m, it has been confirmed that there is no risk that flooding of the River Nile will cause the water level in the Bahr Yusef Canal to rise. Although the three regulators for which the grant aid program of Japan has been implemented in the past have gate facilities for water discharge, none of them has a floodgate function.

Also in this basic design for the Dahab Regulator, we have shown that there are no grounds for considering the flood gate function as part of the design because of the characteristics of the Bahr Yusef Canal, it not being a natural river, as described above; and it has been confirmed that there is no need to include the floodgate function as a design precondition.

To achieve the aim of the Project for Rehabilitation of the Dahab Regulator, namely to restore the basic functions of the regulator, the following basic policies have been drawn up for the overall rehabilitation of the above-mentioned four facilities.

1) **Basic policy – 1:** The design will comprise facilities which comply with the water resources policy of Egypt.

Almost all water resources available in Egypt are derived from the River Nile. "Integrated Water Resources Management," established by the Ministry of Water Resources and Irrigation in the "National Water Resources Plan 2017" as the basic concept for the national water resources plan, will be used as the foundation for the design of the basic policies in this project.

Because of the unstable water control function of the Dahab Regulator, the water level above the regulator is maintained at a higher level than what is needed for water intake, which may cause excessive water intake through the secondary canal. Such excessive water intake causes critical water shortages at the three regulators located on the Bahr Yusef Canal below the Dahab Regulator as the amount of water available in the canal is limited. From the viewpoint of the effective use of water resources, which are limited to 55.5 billion m^3 per year under the Nile Treaty, we recognize that this rehabilitation project is needed to provide the Dahab Regulator, which is located uppermost of the four regulators on the Bahr Yusef Canal, with a more accurate water control function than that of the other three regulators, which have already been rehabilitated.

2) **Basic policy– 2:** The Rehabilitation Project will aim at stabilizing the water level above the Dahab Regulator.

From the viewpoint of water management at the Dahab Regulator, the unstable water level control implemented by the existing regulator has often made it impossible to supply the required amount of irrigation water to the beneficiary area via the secondary canal. The suggested cause of this repeated inability is the difficulty of constantly maintaining the water control function in a stable condition through 20 3m-wide, 2.85m-high, two-stage manual roller underflow gates. In the present design, the policy of establishing an accurate water management method with flow rate control at the Dahab Regulator will be adopted to replace the existing unstable water management method whereby the water level is controlled below the regulator.

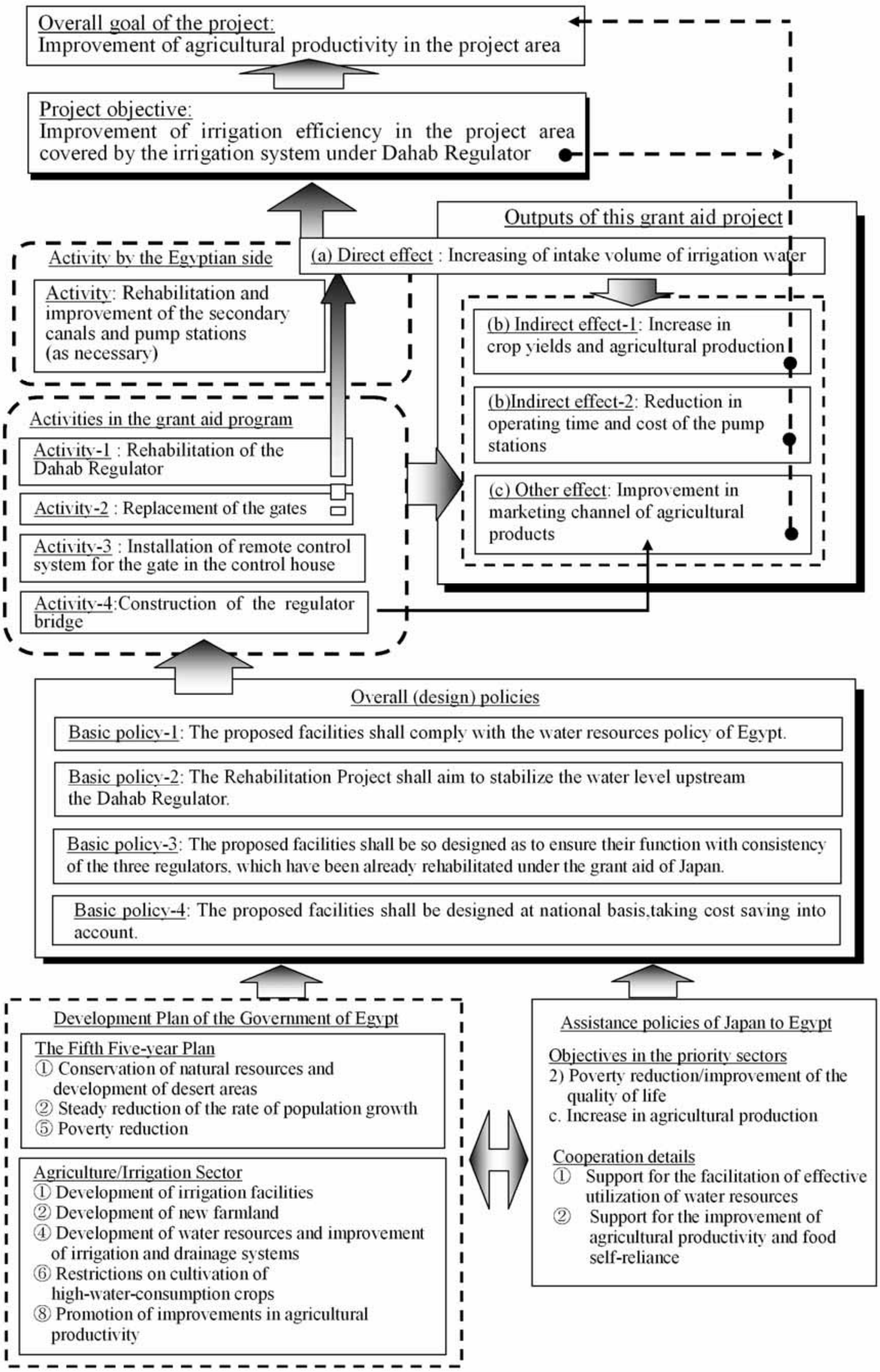
3) **Basic policy – 3:** The design will ensure the performance of facility functions consistent with those of the three regulators that have already been rehabilitated under past grant aid programs.

The Bahr Yusef Canal System has a total beneficiary area of approximately 750,000 feddan (or 315,000 ha). As mentioned above, as a major irrigation canal in Central Egypt the canal plays an important role in supplying approximately 5 billion m^3 per year of irrigation water. As it uses 9% of the total water resources available in Egypt and supplies water to 11% of the total arable land in Egypt, it is a significant piece of infrastructure in terms of both water resources and the irrigation and agricultural policies of Egypt. The performance of water resources management at the Dahab Regulator located in the uppermost part of the Bahr Yusef Canal has a great effect on the three regulators located lower down the canal and their beneficiary areas. The limited amount of water resources means that there exists a large number of problems, such as the growing population, the growing demand for industrial water and urban and domestic water, pressure for improved food production from the perspective of food security and the growing popularity of high-water-consumption crops (rice and sugar cane), which demand the implementation of efficient water resource utilization policies. Therefore, the facility design policy for the rehabilitation of the Dahab Regulator is to make the scale and functions of the facilities consistent with those of the existing three regulators located lower down, in order to achieve the high-precision water resource utilization and water management needed to prevent the adverse effects on these three regulators of the ineffective or excessive discharge of valuable water resources.

4) Basic policy – 4: The design will be a rational one aiming for cost reduction.

Just like public works implemented in Japan, grant aid programs are implemented using funds derived from the taxes paid by ordinary taxpayers. With this fact in mind, in the actual design of each component the project will adopt the policy of planning and designing a cooperative project of 'minimum necessary' scale, rather than catering to 'desirability', giving overall consideration to the validity of the contents of the request, the functions required and the capacity of the counterpart organization for implementation and maintenance/management, which items have been revealed by the field survey.

Figure 2-2-1.1 Relationship between the Project Purpose and Overall Basic Policies



The circled numbers are those used in the respective reference materials.

2-2-1-2 Policies relating to Natural Conditions

(1) Consideration of High Temperatures

(a) Mixing, Casting and Curing of Concrete

In the hot months of summer (from May to September) and particularly in July, the high temperature is around 36.9℃ on average and can occasionally reach over 45℃. Therefore, the mixing and curing temperature will be controlled carefully during the apron and dam pillar works, in which the casting of a large amount of concrete is expected.

1) The concrete mixing temperature will be lowered.
2) Casting will be done when the temperature is relatively low.

(b) Provision of Heat Insulation

As a control panel including computers is to be installed in the Control house, the building will be provided with sufficient heat insulation and ventilation.

(2) Measures against Strong Winds and Wind-blown Sand

From April to July and in September, strong winds with a velocity of 3.6～8.2m/sec are experienced every other day on average. In addition, wind-blown sand is a problem from April to July. Therefore, dust proofing will be incorporated in the design of the Control house.

(3) Consideration of the Topography

There is a 60m-wide, 250-long sandbank on the left-bank side of the Dahab Regulator. There is a 30m-wide, 70m-long vacant lot on the right bank, below the regulator. These pieces of land can be used as equipment/material depots during the work.

(4) Consideration of the Water Level

The upper highest high water level (U.H.H.W.L.) was calculated by adding wave height to the 100 years-probability water level estimated from the results of the analysis of the water level above the regulator (for reference see "Design Standards – The Channel Works" of the Ministry of Agriculture, Forestry and Fisheries of Japan). As it is assumed that the water level falls by approximately 0.1m when water passes the regulator, the downstream highest high water level (D.H.H.W.L.) was calculated as shown below.

1) The upper highest high water level: WL.40.80m + 0.20m = U.H.H.W.L. 41.00m
2) The downstream highest high water level: U.H.H.W.L.41.00m- 0.10m =D.H.H.W.L. 40.90m

2-2-1-3 Policies relating to Geology and Soil Conditions

(1) Geology and Soil Composition and Structure

The geological survey conducted at and around the Dahab Regulator revealed the following geology: There is a stratum of backfill soil from ground level to an elevation of approximately 41m created during the excavation works conducted for the construction of the existing regulator and lock. A clay stratum of Nile Sedimentary Strata is observed at an elevation of around 36m and above. Below the clay stratum are sand strata of Nile Sedimentary Strata. The following soil conditions relating to the foundation of weir and depth of sheet pile were derived.

Table 2-2-1.1 Geology and Soil Composition around the Dahab Regulator

Soil stratum classification		Soil classification	Base elevation (EL. m)	Base depth (m)	N-value	Uniaxial compressive strength (kgf/cm²、(N/mm²)	Coefficient of permeability (cm/sec)
Backfill soil		Clay mixed with sand	40.6～41.2	1.0～2.5	10～27		
Nile Sedimentary stratum (clay)		Clay	35.1～41.2	2.0～7.0	8～19	1.02～2.74 (0.10～0.27)	
Nile Sedimentary strata (sand)	Upper part	Fine sand mixed with silt	31.1～35.2	8.0～12.0	7～35	0.84～0.93 (0.08～0.09)	2.41×10^{-2}～ 7.45×10^{-3}
	Middle part	Fine to medium sand mixed with silt	26.3～29.7	13.0～16.0	> 50		1.29×10^{-2}～ 3.38×10^{-3}
	Lower part	Fine to medium sand mixed with silt	26.3～29.7 or below	13.0～16.0 or below	> 50		4.34×10^{-2}

(2) Soil Conditions

The following soil conditions (of the Nile Sedimentary Stratum – clay: EL. 35.1 – EL. 41.2m) relating to the design of the Dahab Regulator were derived from the results of the geological survey.

(a) Unit Weight of the Soil

As the unit weight of a clay stratum under natural conditions is 1.78 – 1.81 t/m^3, the following unit weights of soil will be adopted.

- Dry soil: 1.6 t/m^3
- Wet soil: 1.8 t/m^3
- Underwater soil: 2.0 t/m^3

(b) Internal Friction Angle of the Soil

As the N value for the layers of clay and fine sand mixed with silt is 7 – 25, the following figure for the internal friction angle of the soil was obtained using the equation, $\phi = \sqrt{15xN} + 15$.

- Average N value: N = 16
- Internal friction angle: $\phi = \sqrt{15x16} + 15 = 30°$

(c) Soil Cohesion

As the uniaxial compressive strength of the strata of clay and fine sand mixed with silt (q) is 0.82～2.74 kgf/cm^2, the soil cohesion is minute, at C = 1/2・q = 0.41～1.37 kgf/cm^2. Therefore, soil cohesion will be ignored in the design.

- Soil Cohesion: C = 0 kgf/cm^2

2-2-1-4 Policies relating to Socio-Economic Conditions

(1) Consideration of Security

The El Minya District, in which the project site is located, is in the middle reaches of the River Nile. There are bases of so-called Muslim fundamentalists in the middle to upper reaches of the River Nile. Therefore, the movement of foreigners is restricted for reasons of security. It should be noted that not only are there police checkpoints at key points on the highways, but also that movement and activities in the area require mandatory notification to the police or a police escort.

(2) Consideration of Religions

While the majority of Egyptians are Muslim, a significant number of Coptic Christians (believers in an ancient form of Christianity) live in their own villages around the town of Asyut. There are also some villages of Coptic Christians in the El Minya District. Therefore, when preparing the work progress schedule or planning the employment of workers at the construction site, these religions and religious activities and holidays will be taken into consideration.

(3) Maintenance of the Functions of the Existing Dahab Regulator

As the Bahr Yusef Canal is the only source of irrigation water in the beneficiary area covered by this grant aid program, appropriate measures will be taken during the temporary and construction works so that restrictions on water intake caused by the works will not affect farming activities during the work period.

(4) Construction of a Temporary Bridge

The 4m-wide bridge attached to the existing Dahab Regulator is used heavily by horses and vehicles, in addition to its function as a pedestrian bridge. The existing bridge is an important structure connecting the villages on either side of the Bahr Yusef Canal. Discontinuation of use of the bridge will not only impose an excessive load upon the Saft Bridge located approximately 7km below the Dahab Regulator, but will also cause considerable adverse effects on the traffic system in neighboring areas. Therefore, a temporary bridge will be constructed to replace the existing bridge during the period of rehabilitation work on the regulator.

(5) Other Issues

The Bahr Yusef Canal provides valuable waterfront space to the local residents. Its right bank is used in daily life as a place to wash clothes and tableware, as a watering spot for domestic animals and as a place to bathe.

Therefore, appropriate measures will be taken to avoid causing any inconvenience to the daily activities of the residents during the work period.

2-2-1-5 Policies relating to Farming and Irrigation Conditions

In the beneficiary area of the Dahab Regulator the method of irrigation on the old farmlands is gravity irrigation. In this system, the water intake gates and the secondary canal comprise the major irrigation facilities. The field survey confirmed that the secondary canal and terminal irrigation canals have been maintained in a relatively good condition. Because of the unstable water level at the Dahab Regulator, there is a shortage of water intake into the secondary canal. If the water level required for the water intake is maintained stably and the flow rate is controlled properly after the rehabilitation of the Dahab Regulator, it will become possible to ensure a sufficient water intake.

However, the new farmlands developed under the 'Horizontal Extension Policy" rely on pumped irrigation. The water is being pumped up from the Bahr Yusef Canal and its secondary canal, the Manshaat el Dahab Canal, by water-intake pumps and used for irrigation via branch canals and relay pumps. As is the case in the gravity irrigation zones, the rehabilitation of the Dahab Regulator will stabilize the suction water levels of the water-intake pumps and ensure a stable supply of pumping discharge. (The flow capacity of the secondary canal is being investigated in detail.)

Therefore, the use of traditional farming methods including crop rotation, systematic planting and rotational irrigation, that have been handed down over the generations and continuously improved, will continue after the completion of the project. Meanwhile, the rehabilitation of the Dahab Regulator is expected to improve irrigation conditions in the beneficiary area greatly through the stable maintenance of the required water level. In this project, a rehabilitation plan for facilities other than the regulator will be proposed such as the Rahil canal which is located about 300m upstream from the Dahab regulator to be undertaken at the responsibility of the counterpart, at those locations where water intake into the secondary canal is considered likely to be obstructed despite the maintenance of the required water level in the Bahr Yusef Canal.

2-2-1-6 Policy relating to the Bahr Yusef Canal

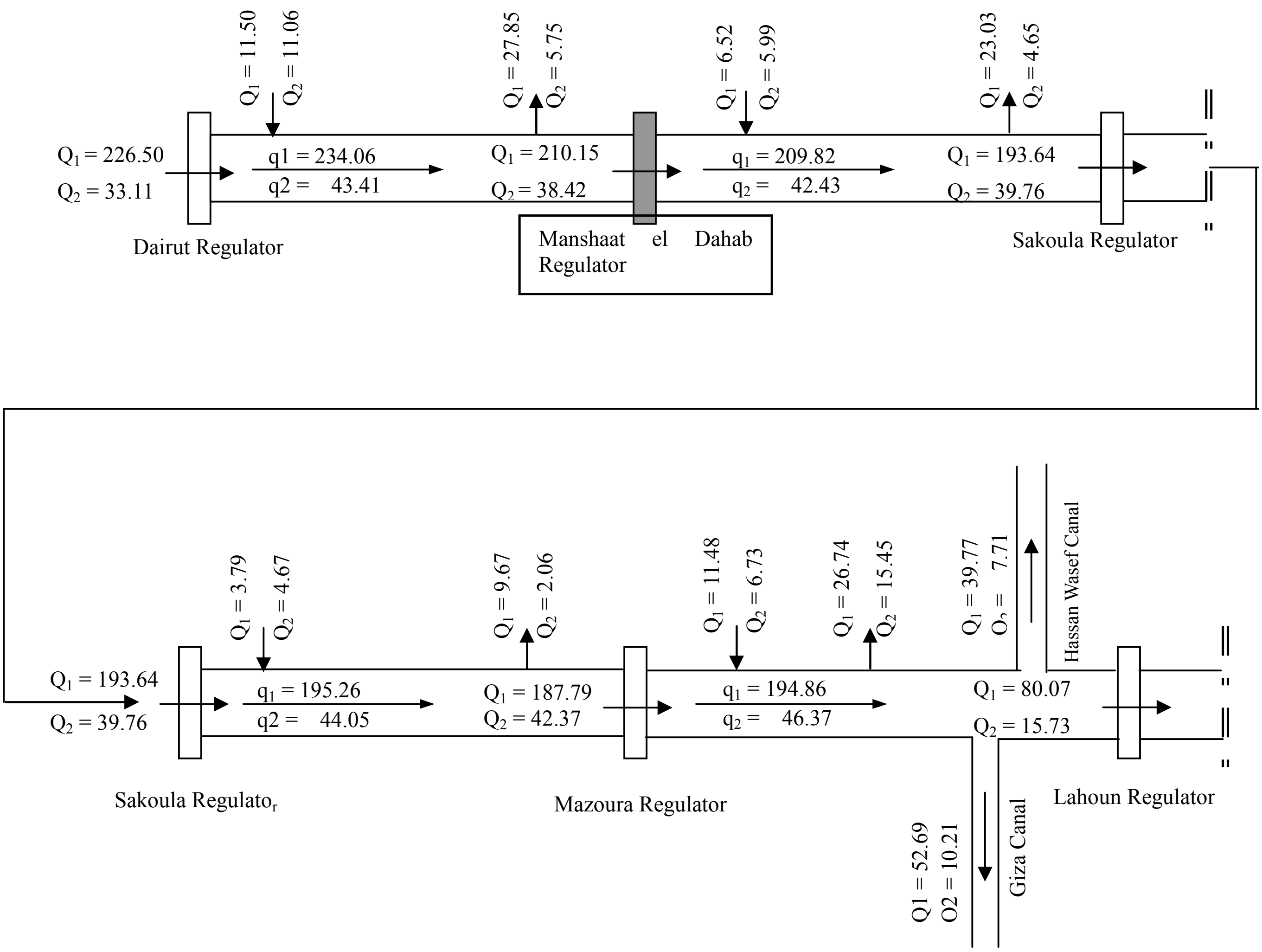
The Bahr Yusef Canal, on which the Dahab Regulator is located, is a large-scale irrigation canal with a total length of 313km. In order for the water control function of the Dahab Regulator to be utilized fully after rehabilitation in the same way as the three previously rehabilitated regulators are functioning on the sections of the canal on which they are located, it must be ensured that the cross-section of the canal both above and below the Dahab Regulator meets the requirements and is capable of discharging water at the maximum design flow rate without problem.

(1) Design Discharges

The design discharge for the Bahr Yusef Canal at the Dahab Regulator are shown in the figure below, "Design discharge for the Bahr Yusef Canal," prepared at the time of the development study (see Fig. 2-2-1.2).

- Maximum Design Discharge (in July): $Q_{max} = 210.15m^3/sec$
- Minimum Design Discharge (in October): $Q_{min} = 38.42m^3/sec$

Figure 2-2-1.2 Design Discharge for the Bahr Yusef Canal



Discharge from regulator, influx and efflux in section

$Q1 = Qmax$ (July) (m^3/s)

$Q2 = Qmin$ (Oct.) (m^3/s)

Maximum flow rate in section

$q1 = qmax$ (July) (m^3/s)

$q2 = qmin$ (Oct.) (m^3/s)

(2) Design Water Levels

Figures 2-2-1.3 and 4, prepared at the time of the development study, show the standard cross-section and design longitudinal section, respectively, of the Bahr Yusef Canal. The design water levels shown below were derived from these figures.

- Upstream highest high water level (U.H.H.W.L.) : 41.00m
- Upstream high water level (U.H.W.L.) : 40.80m
- Maximum upstream controlled water level (Max. U.W.L.) : 40.40m
- Downstream highest high water level (D.H.H.W.L.) : 40.90m
- Maximum downstream controlled water level (Max. D.W.L.) : 39.59m
- Minimum downstream controlled water level (Min. D.W.L.) : 36.23m

1) The maximum upstream controlled water level of 40.40m is the water level at the maximum design flow rate in the canal ($Q_{max} = 210.15m^3/sec$). The afflux water level at minimum design flow rate ($Q_{min} = 38.42m^3/sec$) will be set at the same level. This setting will enable water intake from the secondary canal at the minimum flow rate.

2) The maximum downstream controlled water level of 39.59m is the water level at the maximum design flow rate in the canal ($Q_{max} = 210.15m^3/sec$). The minimum downstream controlled water level of 36.23m is the water level at the minimum design flow rate in the canal（$Q_{min} = 38.42m^3/sec$）.

3) The upstream highest high water level of 41.00m is derived by adding a wave height of 0.20m to the maximum 100-year probability upstream afflux high water level of the Dahab Regulator, which is 40.80m.

4) As the water level falls by approximately 0.1m when water passes the regulator at the maximum design flow rate, the downstream highest high water level is set at 40.90m.

(3) Criteria for Hydraulic Calculation

The average flow velocity used in the calculation of the flow rate at the canal cross-section will be calculated using Manning's formula.

$Q = A \cdot V$

where Q : Discharge (m^3/sec)

A : Flow Area (m^2)

V : Average flow velocity (m/sec); Manning's formula：$V = 1/n \cdot R^{2/3} \cdot I^{1/2}$

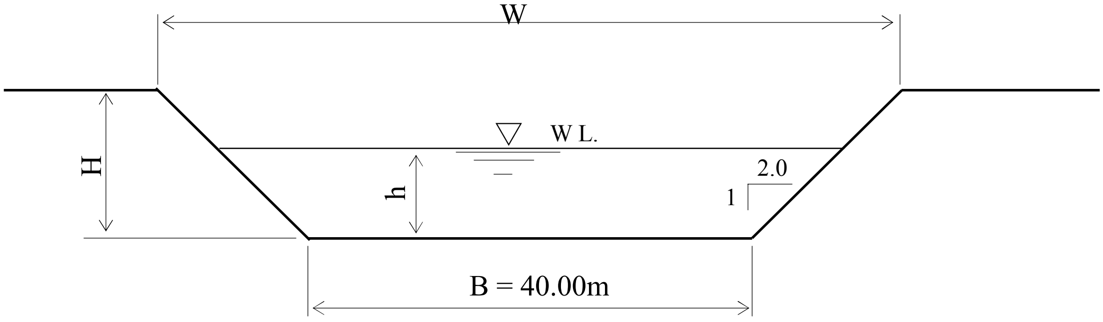
n : Roughness coefficient, for concrete lining canals：n = 0.015

and for other canals：n = 0.030

R : Hydraulic radius (m)

I : Hydraulic gradient

Figure 2-2-1.3 Typical Cross-section of the Bahr Yusef Canal (at the Dahab Regulator)



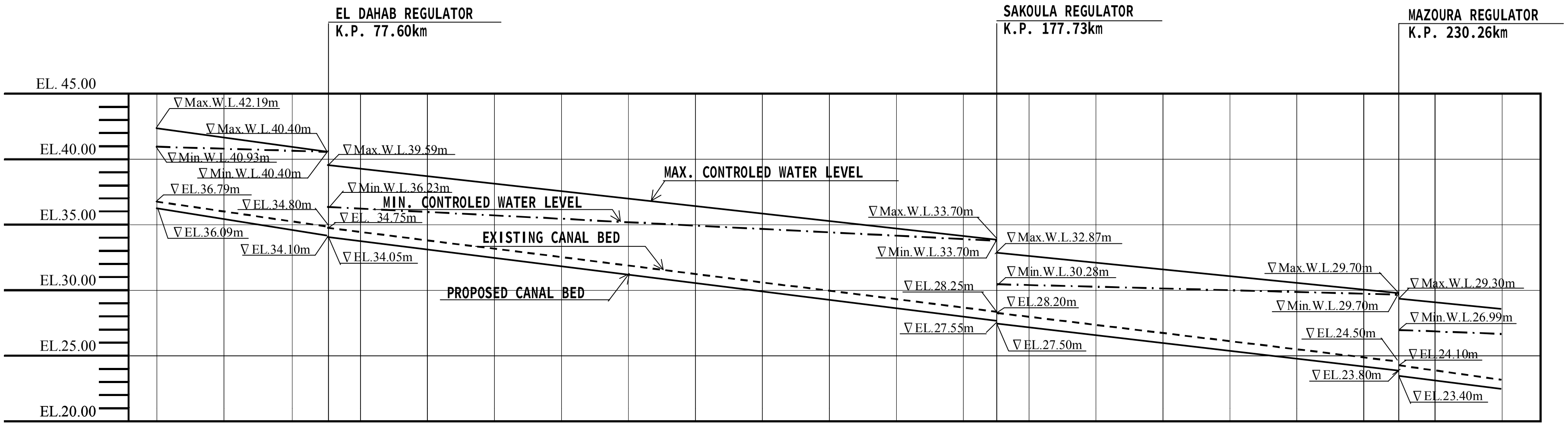
Item	Symbol	Unit	Upstream cross-section		Downstream cross-section	
			At maximum discharge	At minimum discharge	At maximum discharge	At minimum discharge
Design discharge	Q_d	m^3/s	210.15	38.42	210.15	38.42
Design water level	WL	m	40.40	40.40	39.59	36.23
Design bottom elevation	EL	m	34.10	34.10	34.05	34.05
Bottom width of canal	B	m	40.00	40.00	40.00	40.00
Top width of canal	W	m	70.00	70.00	70.00	70.00
Height of side wall	H	m	7.50	7.50	7.50	7.50
Slope of side wall	N	—	1 : 2.0	1 : 2.0	1 : 2.0	1 : 2.0
Longitudinal gradient	I	—	1/22,700	1/681,000	1/14,400	17,000
			0.00004400	0.00000147	0.00006950	0.00005856
Roughness coefficient	n	—	0.030	0.030	0.030	0.030
Water depth	h	m	6.30	6.30	5.54	2.18
Flow area	A	m^2	331.38	331.38	282.98	96.70
Hydraulic radius	R	m	4.861	4.861	4.369	1.944
Flow velocity	V	m/s	0.63	0.12	0.74	0.40
Calculated discharge	Q	m^3/s	210.25	38.42	210.15	38.42

Manning's formula: $Q = A \times 1/n \times R^{2/3} \times I^{1/2}$

At present, the Bahr Yusef Canal near the Dahab Regulator has a large flow cross-section with a base width of approximately 70m. However, as a flow cross-section with a base width of 40m is sufficient for the design flow rate as shown above, a plan for the rehabilitation of the Dahab Regulator will be prepared that is consistent with the above design specifications of the Bahr Yusef Canal.

This is expected to bring about a reduction in the costs of the rehabilitation of the Dahab Regulator.

Figure 2-2-1.4 Proposed Longitudinal Profile of Bahr Yusef Canal



STATION	50.0	60.0	70.0	77.8	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0	160.0	170.0	177.73	180.0	190.0	200.0	210.0	220.0	230.0	230.26	240.0	250.0
ACCUM. DISTANCE (m)	50,000	60,000	70,000	77,800	80,000	90,000	100,000	110,000	120,000	130,000	140,000	150,000	160,000	170,000	177,730	180,000	190,000	200,000	210,000	220,000	230,000	230,260	240,000	250,000
PROPOSED MAX. CONTROLED WATER LEVEL	42.19	42.19	42.19	40.40 39.59	39.45	38.86	38.27	37.68	37.10	36.51	35.92	35.33	34.74	34.16	33.70 32.87	32.73	32.13	31.53	30.92	30.32	29.72	29.70 29.30	28.85	28.39
ABOVE GRADIENT	Ib = 6.44cm/km (1/15,500)				Ib = 5.88cm/km (1/17,000)											Ib = 6.02cm/km (1/16,600)							Ib = 4.62cm/km (1/21,600)	
PROPOSED MIN. CONTROLED WATER LEVEL	40.93	40.59	40.78	40.40 36.23	36.17	35.67	35.67	35.42	35.16	34.91	34.66	34.41	34.15	33.90	33.70 30.28	30.26	30.14	30.03	29.92	29.81	29.70	29.70 26.99	26.93	26.86
ABOVE GRADIENT	Ib = 1.89cm/km (1/52,800)				Ib = 2.53cm/km (1/39,600)											Ib = 1.10cm/km (1/90,800)							Ib = 0.67cm/km (1/149,000)	
EXISTING CANAL BOTTOM ELEVATION	36.09	35.37	35.37	34.10 34.05	33.91	33.26	32.61	31.96	31.31	30.66	30.01	29.36	28.71	28.06	27.55 27.50	27.34	26.64	25.93	25.23	24.52	23.82	23.80 23.40	22.91	22.41
ABOVE GRADIENT	Ib = 7.15cm/km (1/14,000)				Ib = 6.5cm/km (1/15,400)											Ib = 7.0cm/km (1/14,300)							Ib = 5.0cm/km (1/20,000)	
PRESENT CANAL BOTTOM ELEVATION	36.79	36.07	35.36	34.80 34.75	34.61	33.96	33.31	32.66	32.01	31.36	30.71	30.06	29.41	28.76	28.25 28.20	28.04	27.34	26.63	25.93	25.22	24.52	24.50 24.10	23.61	23.11
ABOVE GRADIENT	Io = 7.15cm/km (1/14,000)				Io = 6.5cm/km (1/15,400)											Io = 7.0cm/km (1/14,300)							Io = 5.0cm/km (1/20,000)	

2-2-1-7 Policy relating to the Rehabilitation of the Dahab Regulator

(1) The Need for Overall Rehabilitation of the Dahab Regulator

The Dahab Regulator was constructed in 1901. The weir is made of bricks and is approximately 100 years old. To measure the strength of the existing dam, core samples were withdrawn from the piers of the dam and subjected to a uniaxial compressive strength test. The test results revealed that the strength of the brick piers was below the generally accepted design concrete strength of 210kgf/cm^2 by a large margin, as they had a strength of 14.81～21.31kgf/cm^2, which is equivalent to 7 – 10 % of the generally accepted design strength. The weir suffers from deterioration due to age, and some bricks are missing from its surface. If bricks continue to be lost from the surface, the weir may collapse. Meanwhile, those interviewed as part of the study reported progressive scouring at the apron on the downstream side. A gate operator testified that it had not been possible to open Gate No. 5 for more than 10 years. Such a dangerous situation requires urgent measures. Analyzing the situation comprehensively from the viewpoint of civil engineering, we have concluded that it would be difficult to carry out a partial rehabilitation plan comprising reinforcement works on the existing regulator.

Therefore, complete rehabilitation of the weir and gates will be planned in order to improve the functions of the regulator.

(2) Location of the Rehabilitated Dahab Regulator

The following three alternative proposals are under consideration as sites for the rehabilitated Dahab Regulator.

Alternative Proposal A-1: The proposal adopted by the feasibility study (F/S) conducted in 1992 (Replacement on the left bank)

Alternative Proposal A-5: Proposed at the time of the preliminary study conducted in 2006 (Replacement on the sandbank)

Alternative Proposal A-6: Proposed at the time of the preliminary study conducted in 2006 (Replacement on the site of the existing regulator. This is also the proposal put forward in the request by the counterpart government.)

The Development Study, "Rehabilitation and Improvement of Water Delivery System on Bahr Yusef Canal," (F/S in 1992) compared four proposals and selected Alternative Proposal A-1. The selection was based on the advantages of this proposal, namely non-interference with the function of the lock and cost reduction in the temporary works, as the dam construction could be carried out as an above-ground construction (see Fig. 2-2-1.5). However, as the proposed construction site is located on private farmland, it is expected that it would take considerable time and effort to acquire the land.

Alternative Proposal A-5 proposed by the preliminary study was chosen because of the advantages it offers in that the use of the sandbank between the existing regulator and lock eliminates the need to acquire private farmland and that the rehabilitation work on the regulator can be carried out as a semi-above-ground construction.

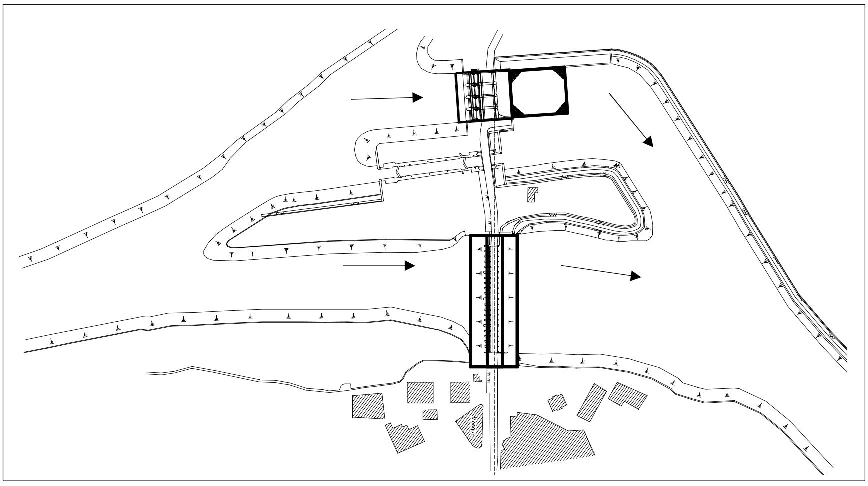
Alternative Proposal A-6, also proposed by the preliminary study, is to remove the left-bank-side half of the existing regulator and reconstruct a new regulator on the vacated site, taking into consideration the flow in the canal and maintenance and management of the regulator (see Fig. 2-2-1.5). The counterpart implementing agency intends to replace the existing Dahab Regulator with a new regulator on the current site because of the problems of land acquisition and road access.

Ease of work execution is one of the factors to be considered when selecting the site of the regulator. However, as the works carried out at the Mazoura and Sakoula Regulators have confirmed that it is possible to implement work in the canal (the canal bypass works, cofferdam and drainage of construction wastewater) at the Dahab Regulator, above-ground construction is no longer an essential condition.

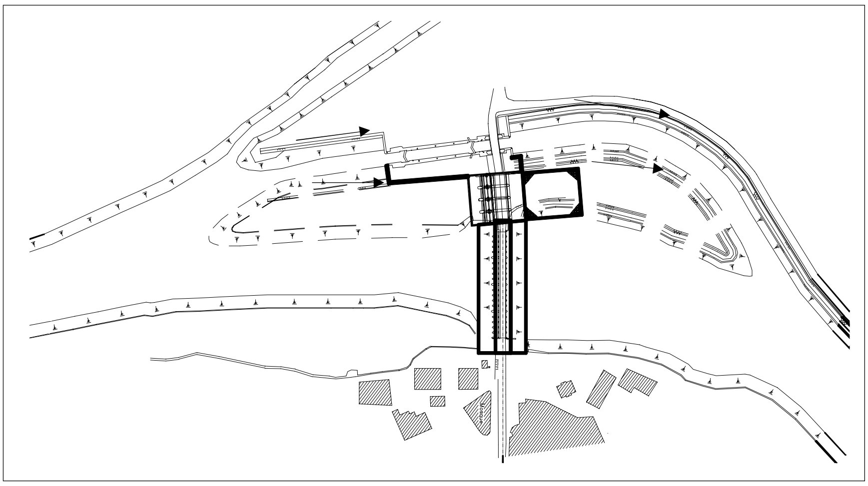
The policy adopted in the basic design was to carry out a comparative study of Alternative Proposals A-1 (adopted by the F/S: above-ground construction on farmland), A-5 (proposed by the preliminary study: semi-above-ground construction on the sandbank) and A-6 (proposed by the preliminary study: construction in the canal on the site of the existing regulator) taking into account the alignment of the canal, land acquisition, ease of work execution (canal bypass works, cofferdam and drainage of construction wastewater), alignment of the existing roads and economy.

All things having been considered in the comparative study as shown in Table 2-2-1.6 Alternative Proposal A-6 is considered the best proposal. According to adopt this proposal we will be able to construct regulator with good alignment canal and road, with the least influence on around land, with the lowest cost. Then we will plan properly to establish oil fence against turbidity in the water during construction works.

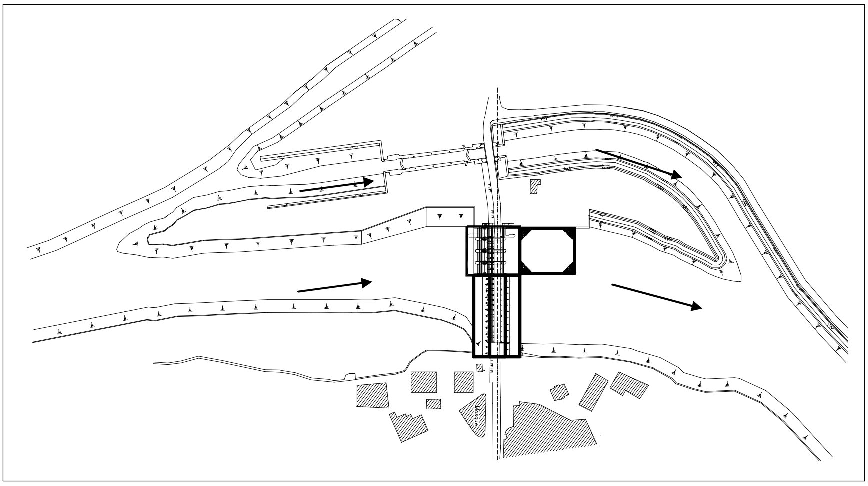
Figure 2-2-1.5 Comparison of the Alternative Sites for the Dahab Regulator



Alternative Proposal A-1: Proposal to Replace on the Left Bank
(Proposal of the development study, on land construction)



Alternative Proposal A-5: Proposal to Replace on the Sandbank
(Proposal of the preliminary study, semi-on land construction)



Alternative Proposal A-6: Proposal to Replace on the Site of the Existing Regulator
(Proposal of the preliminary study and the request document, underwater construction)

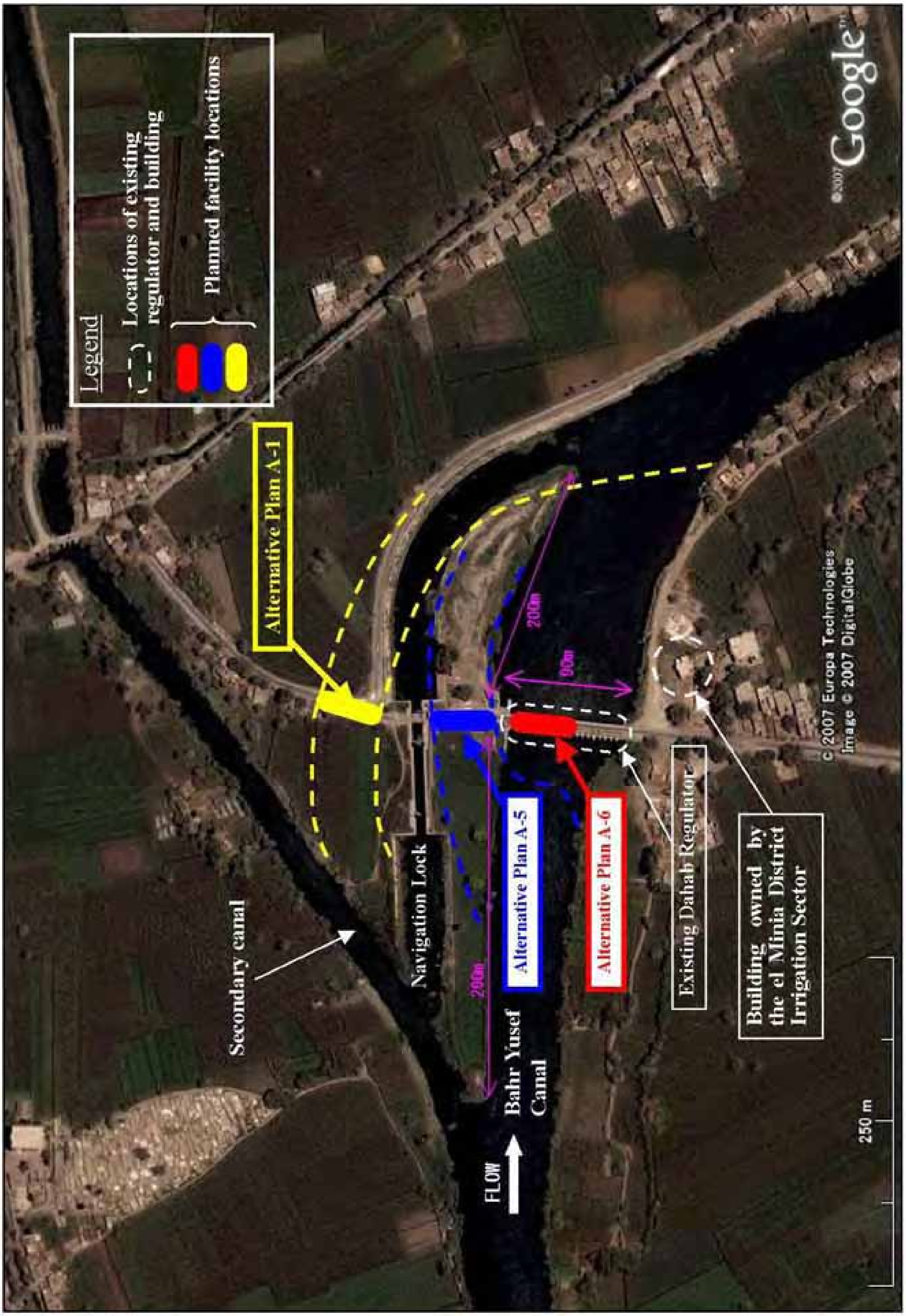

Legend
Locations of existing regulator and building
Planned facility locations
Alternative Plan A-1
Alternative Plan A-5
Alternative Plan A-6
Secondary canal
Navigation Lock
Existing Dahab Regulator
Building owned by the el Minia District Irrigation Sector
Bahr Yusef Canal
FLOW
200m
200m
90m
250 m
© 2007 Europa Technologies
Image © 2007 DigitalGlobe
©2007 Google™

Table 2-2-1.6 Comparative Study of Proposed Locations for the Dahab Regulator Rehabilitation

Items covered by comparative study		A-1: adopted by F/S (Replacement on the left bank, on land construction)		A-5: Proposal of the preliminary study (Replacement on the sandbank, semi-on land construction)		A-6: Proposal of the preliminary study (Replacement on the site of the existing regulator, underwater construction)	
Location		Farmland on the upstream and left-bank side of the existing regulator		Public land on the sandbank		Left-bank side of the existing regulator, in the canal	
Cofferdam method		Tie-rod steel sheet pile earth retaining		Tie-rod steel sheet pile earth retaining and tie-rod double steel sheet pile cofferdam		Tie-rod double steel sheet pile cofferdam	
Regulator bridge		Width: 10.0m, Length: 40.0m		Width: 10.0m, Length: 40.0m		Width: 10.0m, Length: 40.0m	
Land Acquisition		13,000m^2		0m^2		0m^2	
Civil works Direct construction costs (Million Yen)	1. Approach to canal earth works	Length: 520m	104	Length: 450m	90	Length: 90m	5
	2. Temporary works		81		99		166
	Construction road	Length: 550m	(3.0)	Length: 500m	(3.3)	Length: 490m	(3.5)
	Temporary bridge	Length of bridge: 0m	(0.0)	Length of bridge: 0m	(0.0)	Length of bridge: 100m	(23.1)
	Steel sheet pile earth retaining and cofferdam	Steel sheet pile earth retaining: 320m Cofferdam: 0m	(59.2) (0.0)	Steel sheet pile earth retaining: 40m Cofferdam: 165m	(7.4) (54.8)	Steel sheet pile earth retaining: 0m Cofferdam: 230m	(0.0) (76.4)
	Drainage works	Well points: 6	(14.0)	Well points: 12	(28.1)	Well points: 20	(46.8)
	Work Yard	On the sandbank: 6,700m^2	(3.0)	On farmland: 8,500m^2	(3.0)	On the sandbank: 6,700m^2	(3.0)
	Concrete plant	1 set	(2.2)	1 set	(2.2)	1 set	(2.2)
	Pollution prevention works	Not necessary	(0.0)	At the lock: 30m	(0.3)	In the canal: 240m	(2.3)
	Cut-off works on the existing dam	Deep mixing method: 0	(0.0)	Deep mixing method: 0	(0.0)	Deep mixing method: 35	(9.2)
	3. Demolition of existing structures		10		16		26
	Demolition of upper part	Demolition of upper part: 20 gates	(10.2)	Demolition of upper part: 16 gates	(8.1)	Demolition of upper part: 10 gates	(5.1)
	Demolition of the entire structure	Demolition of the entire structure: 0 gate	(0.0)	Demolition of the entire structure: 4 gates	(8.3)	Demolition of the entire structure: 10 gates	(21.2)
	4. Dam work	Dam length: 38m	141	Dam length : 38m	141	Dam length : 38m	141
	5. Bed protection works	Bed protection works: 2,000m^2	26	Bed protection works: 2,000m^2	26	Bed protection works: 2,000m^2	26
	6. Sheet pile revetment works	Length of revetment: 190m	73	Length of revetment: 190m	73	Length of revetment: 220m	81
	7. Stone pitching revetment works	Stone pitching: 7,000m^2	37	Stone pitching: 7,000m^2	37	Stone pitching: 4,100m^2	22
	8. Construction works	Control house: 80m^2	18	Control house: 80m^2	18	Control house: 80m^2	18
	9. Accessory hardware works	Guard rails on the regulator bridge etc.	13	Guard rails on the regulator bridge etc.	13	Guard rails on the regulator bridge etc.	13
	10. Ancillary works	Access road: 310m	29	Access road: 190m	18	Access road: 150m	16
	Subtotal		**532**		**531**		**514**
Land acquisition (million Yen)	Land for the regulator rehabilitation		6		0		0
	Subtotal		**6**		**0**		**0**
Items covered by comparative study		A-1: adopted by F/S (Replacement on the left bank, on land construction)		A-5: Proposal of the preliminary study (Replacement on the sandbank, semi-on land construction)		A-6: Proposal of the preliminary study (Replacement on the site of the existing regulator, underwater construction)	
Project cost	Total(Million Yen)	**538(1.05)**	Δ	**531(1.03)**	Δ	**514(1.00)**	○
Work period (Months)	Temporary work		5		5		5
	Main construction work		12		12		12
	Removal/ cofferdam		8		8		5
	Total	**25**	Δ	**25**	Δ	**22**	○

Alignment of the channel	・Alignment of the channel will be poor.	Δ	・Alignment of the channel will be relatively poor.	Δ	・Alignment of the channel will be good.	○
Alignment of road	・Horizontal alignment of the road will be straight.	○	・Horizontal alignment of the road will be straight.	○	・Horizontal alignment of the road will be straight.	○
Land acquisition and compensation for crops	・There will be need for land acquisition and compensation for crops.	Δ	・There will be need for compensation for crops.	Δ	・There will be no need for land acquisition or compensation for crops.	○
Effect of the work on the existing regulator	・There will be no effect on the existing regulator.	○	・There will be no effect on the existing regulator.	○	・Vibration caused by the work will affect the existing regulator.	Δ
Attached/temporary bridge during the work	・The existing bridge attached to the regulator can be used.	○	・The existing bridge attached to the regulator can be used.	○	・A temporary bridge will be required.	Δ
Bypass canal during the work	・There will be no need for a bypass canal.	○	・There will be no need for a bypass canal.	○	・Part of the existing regulator can be used as a bypass canal.	Δ
Cofferdam/water inflow during the work	・No cofferdam will be needed. Water inflow will be minor.	○	・No cofferdam will be needed. Water inflow will be minor.	○	・Cofferdam will be needed. Water inflow will be significant.	Δ
Turbidity in the water during work.	・A little turbidity for mainly working in land	○	・A little turbidity for mainly working in land	○	・Need to take some measure against turbidity in the water	Δ
Influence on around land	・Greatly influence for changing alignment of the channel		・Greatly influence for changing alignment of the channel		・No influence for not change alignment of the channel	
Economics and work period	・The construction costs will be high. The work period will be long.	Δ	・The construction costs will be relatively high. The work period will be relatively long.	Δ	・The construction costs will be low. The work period will be short.	○
Overall evaluation	△		△		○ (adoption)	

(3) Width of the Dahab Regulator

The existing Dahab Regulator has a width of 88m. The width was determined to give it a cross-section large enough for the safe discharge of flood water, employing a design theory similar to that used for natural rivers, some 60 years before the construction of the Aswan High Dam. The construction of the Aswan High Dam changed significantly the flow regime in the Bahr Yusef Canal. The flood control function of the regulator has fallen out of use. Therefore, the rehabilitated Dahab Regulator will have a flow cross-section that meets the requirements for the design maximum flow rate (210.15 m^3/sec).

It is economically advantageous to minimize the flow cross-section of a regulator, as long as the cross-section is large enough to guarantee discharge at the design maximum flow rate. Meanwhile, as the Bahr Yusef Canal is an earthen canal, a high flow velocity would create the risk of scouring. As the walls and base of the canal are of sand mixed with silt and clay, the maximum allowable flow velocity is 1.00～1.20m/sec. The regulator will be designed with a width that will allow the flow velocity to be maintained at less than the maximum allowable flow velocity of the canal while establishing a smooth flow regime with a current flow velocity of 0.6～0.7m/sec in the canal above and below the regulator.

In addition, in order to avoid sedimentation on the bed of the gates, the design flow velocity near the gates will be set at 1.5 to 2.0 times the flow velocity in the canal above and below the regulator (see "The Channel Works," Land Improvement Design Standards). Therefore, the design flow velocity will be set at

0.6～0.7m/sec in the canal above and below the regulator and approximately 1.2m/sec near the gates. Using these figures, the total width of the regulator is calculated as follows:

$B = Q / V / H$

where B : Total width of the regulator (m)

Q : Design flow rate, $Q = 210.15\ m^3/sec$

V : Flow velocity near the gates, V = 1.15m/sec

H : Water depth near the gates, H = Max. U.W.L. 40.40m － EL. 34.60m = 5.80m

$B = 210.15m^3/sec / 1.15m/sec / 5.80m = 31.5m \quad 32.0m$

Thus, the total width required for the regulator will be 32.0m, which is 3m smaller than the design width of 35m from the F/S, which is based on a design with five 7.0m-wide gates. This reduction will result in a cost reduction of approximately 9% (3m/35m = 0.086). On the request letter, total width of the weir was mentioned to be 46.6m including piers.

(4) Sedimentation near the Regulator and Retention of Suspended Debris at the Gates

In general, sedimentation in a natural canal occurs when sediment that has become suspended in the water as a result of a disturbance of the flow or an increase in the flow velocity caused by an increased flow at time of flood is deposited in areas of low flow velocity as the flood water recedes. However, since the construction of the Aswan High Dam there is no longer any threat of flood in the Bahr Yusef Canal, on which this regulator is situated; and so there is no marked suspension of sediment to create sediment. Moreover, as the design flow velocity of the water discharge from the Dahab Regulator downstream of the afflux will be set at approximately 1.2m/sec, a flow velocity will be maintained that is approximately 1.8 times larger than the average flow velocity of 0.6m/sec～0.7m/sec in the Bahr Yusef Canal. Therefore, it is considered that there will be no fear of sedimentation downstream of the afflux.

The existing Dahab Regulator is equipped with 20sets x 3.0m-wide x 2.80m-high, two-leaves gates. A large amount of suspended debris including grass and trees drifts from the upper part of the Bahr Yusef Canal to the Dahab Regulator. As each gate has a watercourse width of 3.0m and is of the underflow-type gate operation, the debris remains permanently immediately above the gate and obstructs the smooth and normal discharge function of the Dahab Regulator. However, as each gate on the Dahab Regulator after the rehabilitation will have a span length of 8.0m and will be of the overflow-type gate operation, the debris will not remain immediately above the gates.

In fact, no obstruction caused by the retention of suspended matter has been observed at the existing three regulators that have already been rehabilitated.

(5) Design standards

The design standards (relating to load, reinforced concrete, regulators and canals) of Egypt which were verified during the field survey will be adopted. However, the rehabilitation design will also comply with the design standards of the Ministry of Agriculture, Forestry and Fisheries of Japan (design standards relating to channel works, head works, pumps and fill dams), with the Specifications for Highway Bridges and with the Technical Standards for Gates and Penstocks. Where there is discrepancy between the standards of Egypt and Japan, the Egyptian standards will be adhered to.

(6) Basic conditions for the structural design of the dam

(a) Seismic force in Egypt

The ‘head work’ design standards of Japan were adopted as the design standards of the dams for the rehabilitation of the three regulators carried out in the past. In many cases, a horizontal seismic coefficient (K_H) of 0.2 is adopted as the seismic force. The technical construction standards in Egypt adopt a design seismic force of 0.06, approximately one third (= 0.06/0.20) of the corresponding value in Japan, as Egypt experiences fewer earthquakes than Japan, as shown below.

”The design of reinforced concrete COLUMNS” according to the new Egyptian code concept 1990 established by the structural design engineer Khalil Ibrahim Waked gives the following seismic force.

$K_h = Z \cdot I \cdot K \cdot C \cdot S$

where K_h: Design horizontal seismic coefficient

Z: Seismic zone factor Z = 0.30

I: Importance factor (for dams) I = 1.25

K: Structure factor (for structural wall, beams and pillars) K = 1.333

C: Standard design horizontal seismic coefficient

$$C = \frac{1}{15x\sqrt{T}} = \frac{1}{15x\sqrt{0.395}} = 0.106$$

T: Proper period (sec)

$$T = \frac{0.09xH}{\sqrt{b}} = \frac{0.09x17.0}{\sqrt{15.0}} = 0.395 \text{ sec}$$

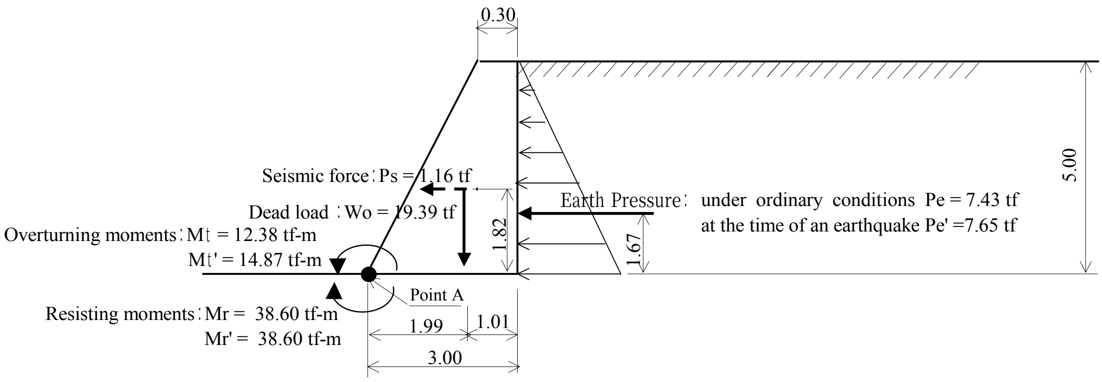
S: Ground condition factor (for ground with medium compaction), S = 1.15

K_h = 0.30 x 1.25 x 0.106 x 1.15 = 0.06

(b) Basis for Designing Structures Based on Stability under Ordinary Conditions.

The following is an example of a study on a ‘gravity retaining wall’ in Egypt when a small seismic force acts on the wall.

1) Diagram of the study subject



a) Overturning moment under ordinary conditions: Mt (moment caused by earth pressure)

Mt = 7.43tf x 1.67m = 12.38tf-m

b) Overturning moment at the time of an earthquake: Mt’ (Moment caused by seismic force and earth pressure at the time of the earthquake)

Mt’ = 1.16tf x 1.82m + 7.65tf x 1.67m = 2.11 + 12.76 = 14.87tf-m

c) Resisting moments under ordinary conditions and at the time of an earthquake: Mr & Mr’ (moment caused by the dead load)

Mr = Mr’ = 19.39tf x 1.99m = 38.60tf-m

2) Results of the study

The following are the results of the study on the stability (against overturning, sliding and reaction force of foundation soil) of the gravity retaining wall

Results of the Study on the Stability

(against overturning, sliding and reaction force of foundation soil)

Study item		Symbol	Unit	Under normal circumstances	At time of earthquake	Ratio
Dead and live loads	Dead load	Wo	tf	19.39	19.39	1.00
	Seismic force	Ps	tf	0.00	1.16	8
	Earth pressure	Pe	tf	7.43	7.65	1.03
Overturning	**Overturning moment**	**Mt**	**tf-m**	**12.38**	**14.87**	**1.20**
	Resisting moment	Mr	tf-m	38.60	38.60	1.00
	Eccentric distance	**e**	**m**	**0.15**	**0.28**	**1.87**
	Allowable eccentric distance	e_a	m	0.50	1.00	2.00
	Eccentric distance/allowable eccentric distance ratio	e/e_a	-	0.29	0.28	0.94
Sliding	**Resultant force of horizontal load**	**ΣP**	**tf**	**7.43**	**8.81**	**1.19**
	Resultant force of resistance	ΣPr	tf	11.24	11.24	1.00
	Safety ratio	**Fs**	**-**	**1.51**	**1.28**	**0.84**
	Required safety ratio	Fsa	-	1.50	1.20	0.80
	Safety ratio/required safety ratio	Fs/Fsa	-	1.01	1.06	1.05
Load bearing capacity of the ground	Load bearing capacity of the ground	q	tf/m^2	8.37	10.03	1.20
	Allowable load bearing capacity	q_a	tf/m^2	10.00	20.00	2.00
	Load bearing capacity/Allowable load bearing capacity ratio	q/q_a	-	0.84	0.50	0.60

As is seen in the study results, because of the horizontal seismic force of 1.16tf and increase of 0.22tf in the active earth pressure at time of earthquake, the resultant force of the horizontal load at time of earthquake (8.81tf = 7.65tf + 1.16tf) is 1.19 times the resultant force of the horizontal load under ordinary conditions (7.43tf). The increase ratio of 1.19 is within the range of the allowable increase ratio of 1.50 for stress.

The overturning moments at time of earthquake and under ordinary conditions are 14.87tf-m and 12.38tf-m, respectively. The increase ratio of 1.20 （=14.87/12.38）is below the allowable increase ratio of 1.50 for the moment. The eccentric distances at time of earthquake and under ordinary conditions are 0.28m and 0.15m, respectively. The increase ratio of 1.87 (= 0.28/0.15) is below the allowable increase ratio of 2.00 for the eccentric distance.

The safety ratio for sliding under ordinary conditions is 1.51, which is larger than the required safety ratio of 1.50, while the safety ratio for sliding at time of earthquake is 1.28, which is larger than the required safety ratio of 1.20. Thus, the safety ratio at time of earthquake is 0.84 times the safety ratio under ordinary conditions. As the required safety ratio of 1.20 at time of earthquake is 0.80 times the required safety ratio of 1.50 under ordinary conditions, the drop in the safety ratio is within the allowable range.

The load bearing capacities of the ground at time of earthquake and under ordinary conditions are 10.03tf/m^2 and 8.38tf/m^2, respectively. The increase ratio of 1.20 (= 10.03/8.38) is below the allowable increase ratio of 2.00.

In a country such as Egypt where seismic forces are small, in order to ensure safety, structures must be designed in line with “design conditions for normal case”.

(7) Handling of the Existing Navigation Lock

The navigation lock attached to the existing Dahab Regulator is managed by the Irrigation Office and owned by the governor of El Minya District. Although it is not functioning as a lock, the study team was informed that in its written response to the Irrigation Improvement Sector (IIS) at the time of the explanation of the inception report the Navigation Authority had requested that the lock be maintained in its current condition after the rehabilitation of the Dahab Regulator.

When the study team met the Deputy Minister later, the Deputy explained to the team the contents of the agreement whereby the lock could be dealt with in the same way as in the previous rehabilitation projects for the other three regulators. In fact, an official letter sent to the Ministry of Water Resources and Irrigation by the River Transport Sector of the Ministry of Transport in 1998 clearly stated that the sector has no future plans to restore and utilize the navigation locks on the Bahr Yusef Canal because alternative means of distribution, such as road and rail transport, had already been established and there was no economic advantage in water transport using the Bahr Yusef Canal.

Furthermore, in its letter sent to JICA Egypt Office in April 2007, IIS stated specifically that there was no need to construct new navigational facilities or a viaduct crossing them in the rehabilitation of the Dahab Regulator for future use, as IIS considers the Bahr Yusef Canal unsuited for waterway transport.

Based on the above-mentioned facts, the design will adopt the policy of maintaining the current condition of the lock attached to the Dahab Regulator in the same way as in the past projects for the three other regulators; and the soil excavated during the work will be put to effective use as backfill banking where necessary, to reduce the project costs for the long-distance transport of waste.

2-2-1-8 Policy relating to Selection of Gate Type

(1) Basic Conditions for Selection of Gate Type for the Dahab Regulator

As described in ‘Basic Policy -1’ at the beginning of ‘2-2-1 Design Policy,’ the design will adopt a gate type that is suitable for a facility in compliance with the water resources policy of Egypt and suitable for stabilizing the water level above Dahab Regulator.

As mentioned earlier, the Bahr Yusef Canal on which the Dahab Regulator is located is not a natural river. Therefore, there is no need to consider abnormal flow caused by the discharge of floodwater from the drainage area. This fact is a precondition worth special mention in the selection of the gate type. In other words, in the design of the Dahab Regulator there is no need to consider the possibility of a man-made accident, in which a delay in gate operation at a river dam at the time of flood causes afflux backwater to overflow a dyke or cause dyke breakage. Therefore, the policy of selecting the gate type most appropriate for the performance of the water control function will be adopted. The following are the basic conditions for selection.

① A gate type that will enable control of the flow rate through high-precision gate operation for appropriate water management, as excessive water intake above the Dahab Regulator, which is located uppermost on the Bahr Yusef Canal, may cause critical water shortage at the three regulators located below it.

② A gate type that will be able to discharge water stably with a wide range of flow rate, from a maximum of 210.15m^3/sec to a minimum of 38.42m^3/sec.

③ A gate type that will ensure dependable implementation of the ‘flow rate control method’ adopted as the water management method on the Bahr Yusef Canal by the Ministry of Water Resources and Irrigation.

④ A gate type that will be compatible with the three regulators that have already been rehabilitated, so that a rational water management system with integrated management of the four regulators can be established under the Integrated Water Resources Management, which is the basic concept of the Ministry of Water Resources and Irrigation. Further, three number of rehabilitated regulators were installed by over flow type gate.

(2) Gate Types to be Considered for Selection

The following two types of gates in terms of discharge method will be considered as gate types capable of performing the water control function required for the Dahab Regulator.

① Underflow gate (One-leaf gate)

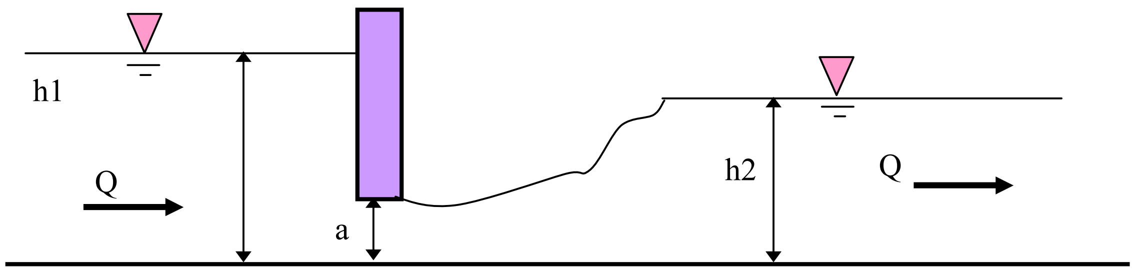
② Overflow gate (Two-leaves gate)

① As shown in the figure on the following page, an underflow gate discharges water through the space between the bottom of the winched-up one-leaf gate and the gate sill. While this type is suitable for discharging water at a large discharge as described below, in hydraulically views, it is an orifice-type gate which discharges water through an opening in the side of a reservoir, so that a slight opening/closing operation of this type of gate results in a large variation in water discharge flow rate. To prevent mechanical failure caused by vibration and overheating of the winch motors, the minimum opening is set at approximately 0.10m. When an underflow gate is operated with the minimum opening of 0.10m, the minimum discharge per operation it can handle is 5m^3/sec/gate, resulting in ineffective discharge.

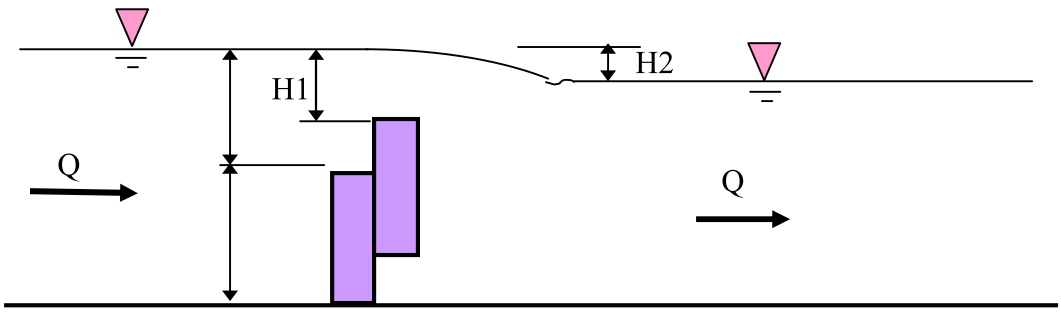
② An overflow gate discharge water by letting water flow over the top of the gate when the upper gate leaf is lowered into the water. As water is allowed to flow over the top of the gate via the so-called free-flow surface, a large overflow depth is required for water discharge at a large flow rate. High-precision discharge control can be achieved by minute adjustment of the overflow depth. Underflow discharge can also be achieved by winching up the lower gate.

(3) Accuracy of Discharge Control

The discharge from the Dahab Regulator to the lower canal changes seasonally, from 38.42m^3/sec in October to 210.15m^3/sec in July. A high-precision discharge control function is required to control the discharge flow rate which changes significantly from a small rate to a large rate, using the four gates (a gate width of 8m, see the following section, 'Span Division'). Prior to the engineering study on gates, the hydraulic difference in performance of the two types of gates will be clarified under identical gate-opening conditions.



Flow regime of underflow gate



Flow regime of overflow gate

The flow rates for the cases shown in the above figures were compared, the underflow gate having a minimum opening (a) of 0.10m and the overflow gate having an overflow depth (H) of 0.10m.

1) The discharge flow rate from the underflow gate (with a minimum opening; a = 0.10m)

$$Q = C_c \cdot B \cdot a \cdot \sqrt{2g(h_1 - Cc \cdot a)}$$
$$= 0.61 \times 8.00 \times 0.10 \times \sqrt{2 \times 9.8(5.80 - 0.61 \times 0.10)}$$
$$= 5.18 m^3/sec$$

(equivalent to 13.5% of the minimum flow rate of 38.42 m^3/sec and 2.5% of the maximum flow rate of 210.15m^3/sec, approximately 8% on average)

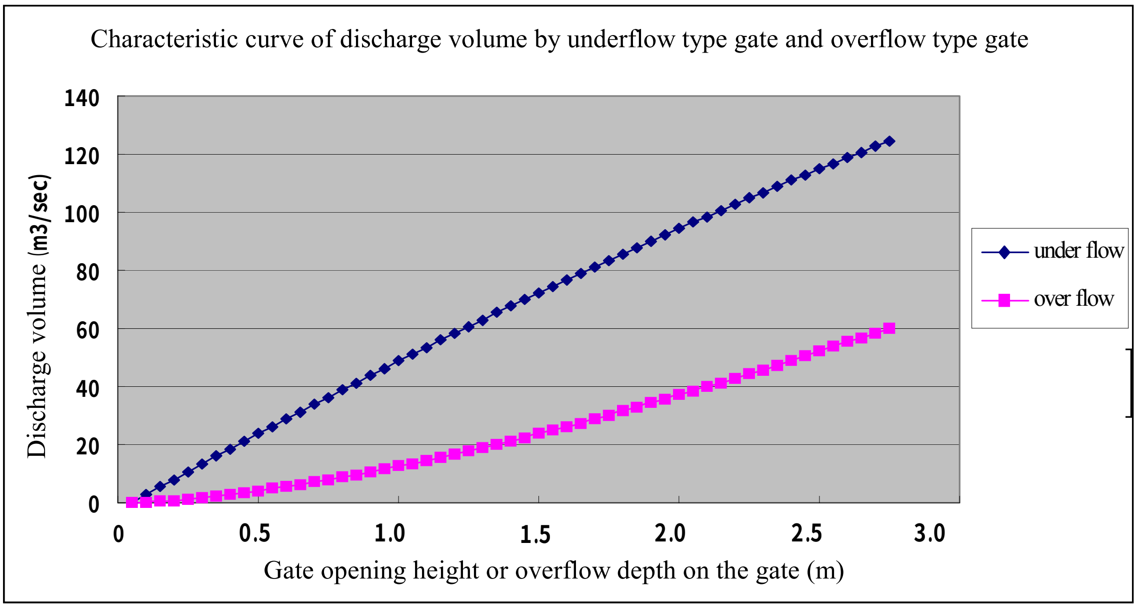
2) The discharge flow rate from the overflow gate (with a minimum overflow depth; H_1 = 0.10m)

$$Q = C_r \cdot B \cdot H^{3/2}$$
$$= 1.94 \times 7.00 \times 0.10^{3/2}$$
$$= 0.43 m^3/sec$$

(equivalent to 1.1% of the minimum flow rate of 38.42 m^3/sec and 0.2% of the maximum flow rate of 210.15m^3/sec, approximately

0.7% on average)

The above results show that an overflow gate can achieve flow rate control with approximately 10 times greater accuracy than an underflow gate under identical conditions of a 0.10m gate opening.



(4) Study of Gate Types from Perspective of Effects Anticipated after Rehabilitation of the Dahab Regulator (Study of investment effect of the introduction of overflow gates)

In general, an overflow gate (with two leaves gate) is more expensive than an underflow gate (with one leaf gate) because the former requires twice as gate leaf, gate guide frame and hoisting devices. The construction costs of the two types of gate for this project were roughly estimated using the data from the completed rehabilitation project for the Sakoula Regulator. While the cost of an overflow gate is estimated at approximately 800 million Yen, for an underflow gate the cost was estimated at approximately 640 million Yen. Thus, the difference was estimated at 160 million Yen (a cost ratio of approximately 1:1.25).

However, with regard to the characteristics of the flow rate control function and precision, more meticulous flow rate control can be achieved with overflow gates than with underflow gates.

In the following, the investment effect of the introduction of overflow gates will be explained by considering the effects on agricultural production of the difference in the volume of water lost (the amount of water discharged below the Dahab Regulator that is not taken or used as irrigation water in the beneficiary area irrigated by the regulator) at the time of gate operation, derived from the difference in hydraulic characteristics between underflow and overflow gates.

(a) Study Method

- Monthly water requirements for crops in the gravity irrigation area of the beneficiary area of the Dahab Regulator were used to establish the design water requirements, and the current water shortfall was obtained using the design water requirements and the data relating to actual water intake (in

2005).

- Then, agricultural yields in the beneficiary area irrigated by the Dahab Regulator when the design water requirements are met were estimated using the ratio of yield increase expressed as the ratio of the yield with irrigation to yield without irrigation, and the anticipated agricultural output was estimated using these yields and the unit prices (as of 2005) of crops.
- The agricultural output per unit of water delivered (1MCM) was estimated using the estimated design water requirements and the anticipated agricultural output.
- Using the various factors in the beneficiary area irrigated by the Dahab Regulator obtained above, water loss from the targeted design water requirements created by the given accuracies of overflow and underflow gates was estimated and converted into economic loss.
- The difference in the economic losses estimated for the respective gates shows the economic advantage of one over the other within the beneficiary area. The extent of this advantage (difference) is the investment effect derived from the initial investment to the gates.

(b) Study Results

The study of the monthly water requirements for crops and the actual water intake (in 2005) in the gravity irrigation area of the beneficiary area of the Dahab Regulator reveals that, while the actual annual volume of water delivered is 437.4MCM, the design water requirement obtained from the water requirements of the beneficiary area is 489.6 MCM/year. Therefore, at present, there is a water shortfall of 52.2MCM/year in the beneficiary area irrigated by the Dahab Regulator.

This shortfall is converted to a loss of 89,000t of agricultural yield, which can be converted to approximately 1,243 million Yen at market prices. In other words, by delivering an additional amount of water corresponding to the water shortfall of 52.2MCM/year and achieving the design water requirement of 489.6 MCM/year, an economic effect of approximately 1,243 million Yen (increase) can be realized. This figure can be converted to 23.8 million Yen/year/1MCM of water

Using the above results as the conditions for the calculation of investment effect, the economics of overflow and underflow gates were studied as described below.

The degree of sufficiency against the design water requirement of 489.6 MCM/year is estimated below, using the accuracy of flow rate control for each type of gate as calculated above. Please note that the accuracies in flow rate control of the respective gates used to estimate sufficiency include both over- and under-discharge conditions.

- Degree of sufficiency against the design water intake of the overflow gates: 99%˜100%－0.7% (control accuracy – for both over- and under-discharge)
- Degree of sufficiency against the design water intake of the underflow gates: 92%＝100%－8.0% (control accuracy – for both over- and under-discharge)

The aim of this study being to estimate the economic effects, only over-discharge from the gates should be studied, because it is considered that over-discharge at the regulator will result in water shortages in the beneficiary area and loss of expected agricultural production, while under conditions of under-discharge a sufficient amount of water will be provided to the beneficiary area so that agricultural production is unlikely to be affected.

It is considered that the validity of the economic effect can be evaluated by taking the average effect as the expected economic effect, instead of the maximum effect. (A diagram illustrating the investment effect is shown in the following section.)

Therefore, the average accuracy of flow rate control for each type of gate at time of over-discharge was estimated.

● The average accuracy against the design water intake for the overflow gate at the time of over-discharge	: 0.18%	Corresponding to the average from 0.35%, which is half of the flow rate control accuracy of 0.7%.
● The average accuracy against the design water intake for the underflow gate at the time of over-discharge	: 2.00%	Corresponding to the average from 4.0%, which is half of the flow rate control accuracy of 8.0%.

Using the average accuracies for over-discharge from the overflow and underflow gates shown above, the economic losses against the targeted design water requirement (489.6 MCM/year) were estimated. The agricultural output per 1MCM was calculated to be 23.8 million Yen/MCM/year.

- Loss caused by underflow gates: 233 million Yen
  (489.6 MCM/year x 23.8 million Yen/MCM/ year x 2.00%)
- Loss caused by overflow gates: 21 million Yen

—) (489.6 MCM/ year x 23.8 million Yen/MCM/ year x 0.18%)

Difference 212 million Yen/year

In other words, the overflow gates will bring to the beneficiary area an economic advantage of 212 million Yen/year more than the economic advantage of underflow gates. This amount is greater than the difference of 160 million Yen in the initial investment between the underflow and overflow gates. The difference of 160 million Yen can be offset with approximately one year of operation.

The above study has confirmed that overflow gates have a greater investment effect than the underflow gates, and a greater economic effect can be anticipated.

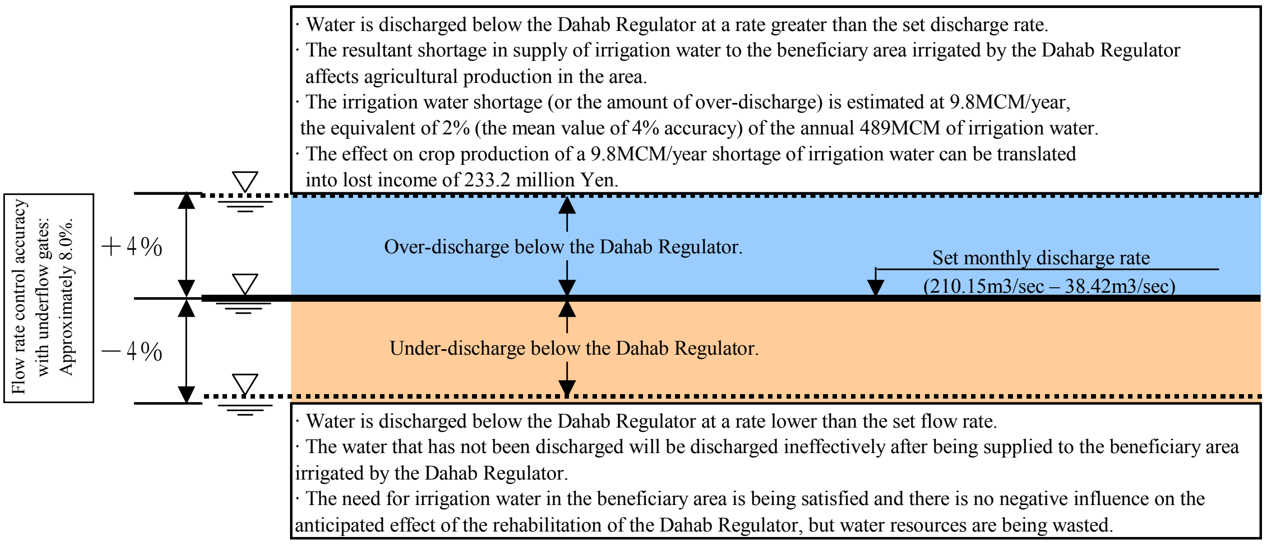
In addition, the economic effect of the overflow gates will be observed continuously over a long period of time, over the next 10 to 20 years, as there is expected to be little difference in operation and maintenance/management costs between the two types of gate.

However, strictly speaking, overflow gates are superior to underflow gates in terms of gate operation costs. As the overflow gates are comprised of two leaves gate, the weight of the leaf gate to be operated is less for an overflow gate than for an underflow gate. Thus, an overflow gate requires less expenditure for electricity than an underflow gate.

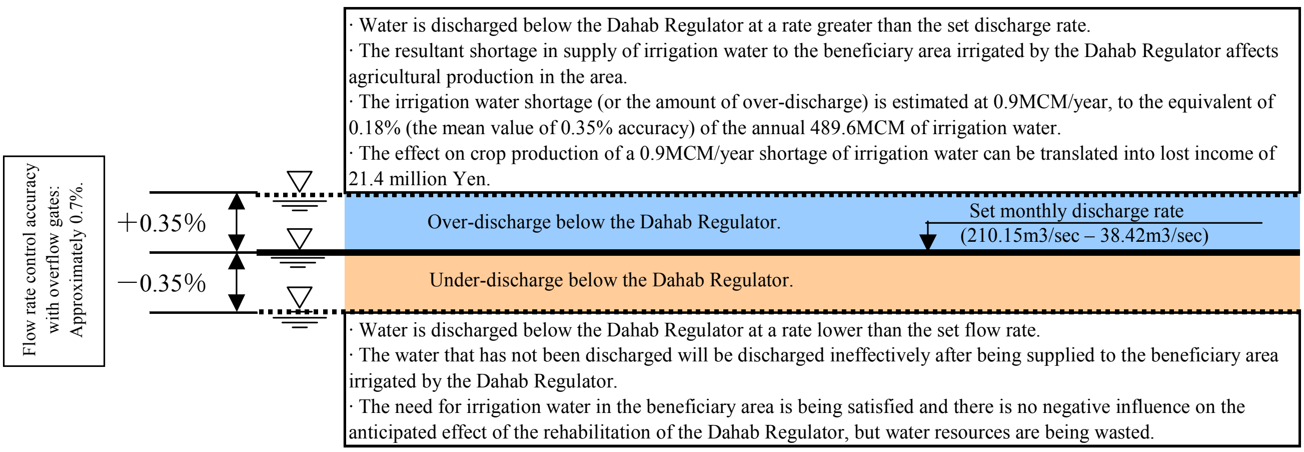
The difference in maintenance/management costs between the two types of gates lies in differences in driving force (either electric or hydraulic drive) and size. As both types of gate under the study were of equivalent gate leaf size and used the same hoisting force (electricity), there was little difference in maintenance/management activities (regular maintenance/management works, including adjustment of equipment and repainting of gates, and their costs) associated with the gate leaf and the hoisting force. In addition, as the civil engineering facilities in which the gates are to be installed are of similar scale regardless of the type of gate, there will be little difference in maintenance/management costs.

Diagram Illustrating of Investment Effect of Introducing Overflow Gates

【 Downstream Discharge from Underflow Gates】



【Downstream Discharge from Overflow Gates】



(5) Other Effects of Introduction of Overflow Gates

(a) Effect on Improvement and Conservation of Water Environment

The overflow gates are also expected to have a major effect on the water environment. As mentioned above, there is a great difference in the discharge mode of overflow and underflow gates. This difference in discharge mode has a significant effect on the accumulation of trashes above the gates. Most of the trashes move downstream suspended near the water surface. An underflow gate with a discharge point near the bottom obstructs the downstream movement of trashes, and the trashes remain near the gate. A real-life example of this phenomenon is observed at the Dahab Regulator itself. Removal (manual removal by the gate operators) of a large amount of trashes retained at the top side (upstream) of the gates costs money and labor. In addition, the trashes have a negative effect on water quality by causing the water to stagnate.

An overflow gate on the other hand has its discharge point near the surface of the water, letting the trashes flow down along with the flow of water and does not obstruct the movement of the trashes; thus it is expected that the deterioration of water quality resulting from the retention of trashes will be alleviated. In addition to this anticipated effect of the improvement and conservation of water quality and the social environment of the surrounding area, the introduction of overflow gates is also expected to have the effect of reducing maintenance and management costs as the manual removal of the debris will no longer be required.

(b) Effect of Reduced Influence on Concrete Structures

Because of the difference in discharge mode the two types of gates have different effects on concrete structures including abrasion of the concrete base downstream from the gates. An underflow gate discharges water downstream through the opening at the bottom and over the concrete base with a high flow velocity. Continuous exposure to high velocity flow causes abrasion of the concrete surface. As the abrasion progresses it results in the exposure and, eventually, corrosion of the reinforcing bars, which leads to deterioration of the concrete structure. An overflow gate on the other hand discharges water at the surface downstream from the gates, so that the water acts like a cushion and there is no direct contact between the discharge and the concrete surface. Therefore, overflow gates are considered less likely to cause abrasion of the concrete base compared with underflow gates, and it is considered that it will be possible for the overflow gate facilities to remain in operation for a longer period of time.

(6) Selection of gate type

<u>The basic design adopts overflow two-stage gates as the water control gates for the Dahab Regulator</u> because the study on the investment effect of overflow gates conducted in (4) above and the overall evaluation shown in the following comparative analysis have confirmed the superiority of the overflow two-stage gates.

Table 2-2-1-8.1 Comparative analysis of gate types.

Gate type	Point	Underflow gate		Overflow gate	
Gate structure	—	・This type of gate has been in manufacture for a long time. • The panel structures are relatively simple (one panel)		・This type of gate has been manufactured since the 70's ・The two-stage gates require a relatively complicated panel structure (two panels).	
Panel height	—	Crown elevation：EL. 40.50m Base elevation：EL. 34.60m Panel height： 5.90m		Crown elevation： 40.50m Base elevation： 34.60m Panel Height: 5.90m	
Maximum possible discharge	—	・$456.64m^3/s > 210.15m^3/s$	Evaluation	・$210.93m^3/s > 210.15m^3/s$	Evaluation
Water level control function	20	・Because of the possibility of vibration of the panel when there is a small opening, the water level cannot be controlled when water is being discharged at a low flow rate. ・As discharge at the unit opening is large, the water level cannot be fine-tuned. ・Maintenance of the water level above the regulator is difficult.	10	・As there is no risk of vibration on the panel when there is a small opening, it is possible to adjust the water level when water is being discharged at a low flow rate. ・As discharge at the unit opening is small, the water level can be fine-tuned. ・Maintenance of the water level above the regulator is easy.	20
Flow rate control function	20	・The flow rate control accuracy is 13.9% and 2.5% of the minimum and maximum flow rates, respectively. ・The flow rate cannot be controlled within 5% of the operational loss for the irrigation scheme ・As the discharge at the unit opening is large, the flow rate cannot be fine-tuned.	10	・The flow rate control accuracy is 1.1% and 0.2% of the minimum and maximum flow rates, respectively. ・The flow rate can be controlled within 5% of the operational loss for the irrigation scheme. ・Because of the small discharge rate at the unit opening, the flow rate can be fine-tuned.	20
Gate operability gate	20	・Overflow can be allowed with gauge monitoring. ・As neither the water level nor the flow rate can be fine-tuned, operating frequency will be high. ・Gate operation is easy since underflow is the only method of discharge	16	・Overflow can be allowed with gauge monitoring. ・As the water level and the flow rate can be fine-tuned, operating frequency will be reduced. ・As both overflow and underflow discharge can be used, gate operation will be slightly complicated. ・Operation of the lower panel will be done by direct operation only. ・Remote operation will be possible only when the lower panel is completely shut.	10
Maintenance/management of gates and regulator	20	・Because of the simple one-panel gate structure, few gate problems or operational problems are expected.	10	・Because of the complicated structure of the two-panel gates, there is danger of gate and operational problems occurring.	16

		・ Because of the large operational load, maintenance/management costs will be high. ・Suspended debris is likely to be retained. ・There is a risk of scouring in the canal below the regulator.		・Because of the small operational load, maintenance and management costs will be low. ・Suspended debris will not be retained. ・There is little risk of scouring in the canal below the regulator.	
Economy (taking the cost of underflow gates as 1.00)	20	・, The total panel weight of a one-panel gate is less than that of a two-panel gate and the cost of the gate is accordingly lower. (1.00)	20	・The total weight and cost of a two-stage (two-panel) gate will be heavier and higher than for a one-panel gate (1.25).	16
Overall evaluation (points)	100		66	○ (adoption)	82

Note） 1) A crown elevation of the gate of 40.50m was obtained by adding the freeboard (0.10m) to the maximum upstream controlled water level (40.40m)

2) In accordance with ‘the Head Works, Design Standard of the Ministry of Agriculture, Forestry and Fishery, the freeboard was set at 0.10m as mentioned above.

(7) Decision to adopt the design with four overflow gates.

The design incorporating two overflow and two underflow gates was considered incompatible with actual operation from the economic viewpoint and the reasons given below. The policy will be for <u>the overflow type to be adopted for all four gates</u>.

① To achieve a high-precision flow rate control function, the discharge has to be overflow only, through the operation of overflow gates. As the water level difference below the Dahab Regulator at the maximum flow rate of 210.15m^3/sec, H_2, is 0.81 m (= Max. U.W.L. 40.40m – Max. D.W.L 39.59m), the overflow depth of the exclusive overflow (H_1) has to be 2.42m or less (< 3 x 0.81m).

② The ordinary rule for the daily gate operation is for a certain number of gates to be opened to an identical degree. The simultaneous operation of overflow and underflow gates may lead to man-made operational errors.

③ The simultaneous use of overflow and underflow gates causes a hydraulic drawdown at the underflow gates: when water is drawn by the underflow, the approach flow velocity at the underflow gates becomes greater than that of the surface overflow near the dam pier. As a result, it would be difficult to keep the upstream water level stable, which is one of the main functions of the Dahab Regulator.

④ As can be clearly seen from the scouring of the canal bed to a depth of 5m immediate below the existing Dahab Regulator, the impact on the apron below the regulator and scouring caused by high velocity flow is concerned, despite the advantage the underflow gate offers of enabling discharge at a greater flow rate.

⑤ All the gates are required to have identical function in order to maintain the function of the regulator, even when a gate is under repaired, with the remaining gates.

(8) Gate span division

The gate span will be divided between multiple gates to spread risk. An economic comparison of the costs of the civil engineering works (for the gate piers only) and gate facilities was conducted, comparing two proposals: 1) the proposal for five 7.0m-span gates recommended by the development study and the request document, and 2) the proposal for four 8.0m-span gates enabling the sharing of guard gates with another regulator.

2-2-1-9 Policy relating to the Control House

(1) Confirmation of Current Condition of the Existing Building and Diagnosis of its Functions by Local Experts

The preliminary study suggested the possibility of converting the existing building into the control house of the Dahab Regulator after the rehabilitation. The study team conducted a visual inspection/survey of the existing building to confirm its current condition and to diagnose its functions. The team discovered a large number of cracks on the exterior and interior walls and recognized the need for a professional investigation of the structure, the strength of the floor slabs and the load-bearing capacity of the ground. Therefore, the team commissioned local experts to conduct a survey and diagnosis of the building to provide an objective evaluation of the possibility of it being used as the Control house of the Dahab Regulator in the future.

(a) Location, Appearance, Structure and Results of Schmidt Hammer Test

Location	・ The building concerned is in an ideal location for the Control house, approximately 20m below the right-bank edge of the Dahab Regulator.
Appearance	・ The building in question, which was built in 1964 (43 years ago) is made of bricks without concrete pillars and is owned by the Regional Irrigation Service. ・ At present, it is not being used or maintained/managed properly. ・ A large number of large and small cracks can be seen on the walls above the door and window openings of all the rooms on the ground floor. The wall on the western side of the room on the north-eastern side on the ground floor has a large vertical crack (approximately 2mm wide, stretching from the ceiling almost to the floor). However, none of these cracks penetrates the entire width of the wall.
Structure	・ The brick walls are erected directly on the foundation. ・ The thickness of the building floor is 10 cm. Reinforcing bars with a diameter of 8mm are arranged at intervals of 15cm. Concrete has peeled off from the floor and rust is visible on the reinforcing bars.
Schmidt Hammer test	・ The results of the Schmidt Hammer test show a degradation of the strength of the interior brick wall to 45～85 kgf/cm^2 (31 – 85% of the strength of a newly-constructed brick wall) and that of the upstairs floor to 100～160 kgf/cm^2 (48 – 76% of the strength of concrete)

(b) Study of the Structure

The following results were obtained from rough structural calculation of the existing building.

1) Bending moment of 0.50 t-m was detected on the floor slab (floor dimension: 5m x 5m, floor thickness: 10 cm, with 15cm-mesh bar arrangement) on the upstairs floor of the existing building.
2) The results of the structural analysis show a tensile stress of 2,340 kgf/cm^2 (167% of the allowable stress of 1,400 kgf/cm^2) on the reinforcing bars arranged in the floor slab, and compressive stress on the floor slab concrete is estimated at 70 kgf/cm^2 (175% of the allowable stress of 100/2.5 = 40 kgf/cm^2).
3) The stresses generated on the reinforcing bars and concrete are 1.67 and 1.75 times the allowable stresses, respectively. However, as these figures are below the yield point stresses (2.5 to 3.0 times the allowable stresses), there is no immediate risk of the collapse of the floor slab. Nonetheless, the building is in a very dangerous condition.
4) The existing 10cm-thick floor is not thick enough to support the 515kg/m^2 load of the gate operating system (actual figure taken from the project at the Sakoula Regulator) as a thickness of at least 11cm is required for a floor with characteristics identical to the existing floor to support this load. (Composition of the 515kg-load: Dead load of the floor: 250kg/m^2 + the load of the gate operating system: 200kg/m^2 + the load of floor finish: 65kg/m^2.)
5) Moreover, the current bar arrangement (described in (1)) is not capable of supporting the design load under the conditions mentioned above. (Bars need to be arranged at intervals of less than 63mm.)

(c) Recommendations of Local Experts

The study by the local experts has revealed that 1) the existing building was originally constructed as a lodging facility for the staff of the Irrigation Service and thus does not have the structure to accommodate heavy items such as a gate operation console and a generator; 2) cracks are observed on almost all the walls, as 43 years have passed since its construction; and 3) the strength of many of the reinforcing bars has been compromised because the rust gathered on them has caused the loss of the required cross-section. This being the case, the local experts reported that the use of the building concerned as the Building of the Dahab Regulator is problematic on the grounds of structural safety, and that a considerable degree of rehabilitation work will be required on the building if it is to be used.

(2) Policy regarding construction of the Control House

The control house will be constructed under responsibility of Egyptian side based on the self-help efforts which meet the policy on the grant aid project by Japanese Government.

(3) Effective use of existing building

One of the basic design policies of this basic design study is ‘a rational design aiming at cost reduction.’ Although it is not possible to use the existing building as the control house, from the viewpoint of reducing the project costs through effective use of available facilities, it will be used as the site offices of the contractor and consultant during the work in order to reduce the budget for the temporary works.

For reference, the following works and budget are considered necessary for the conversion of the existing building into site offices.

1)	Plumbing repair work	520,000 Yen
2)	Repair of cracks	1,280,000 Yen
3)	Repair of electrical facilities	480,000 Yen
4)	Other construction works	380,000 Yen
	Total	2,660,000 Yen

Meanwhile, the estimate for the project gives the following as the budget for the site offices calculated as temporary building costs

1)	Site office of the contractor	103,000LE (2,160,000 Yen)
2)	Office of the consultant	103,000LE (2,160,000 Yen)
	Total	206,000LE（4,320,000 Yen）

Therefore, a cost reduction of 1,720,000 Yen (= 4,320,000 – 2,660,000 Yen) is anticipated through the use of the existing building as site offices.

2-2-1-10 Policy relating to the Regulator Bridge

(1) Current Traffic Volume

A traffic volume survey on the Dahab Regulator was conducted in order to understand the current traffic situation. The study results revealed that the 24-hour traffic volume on a weekday was 2,500 passenger-vehicle-equivalent automobiles, 1,400 bicycles and horse carriages and 600 pedestrians. In spite of this traffic volume, the width of the bridge attached to the Dahab Regulator is only 4m. Thus, the passage of vehicles, horse carriages and pedestrians causes confusion on the bridge. (See Appendixes 6-2).

Results of Traffic Volume Survey

24 hours on a Weekday / Type of Traffic	Dahab Regulator (number of vehicles or pedestrians)	Lower bridge (for comparison) (number of vehicles or pedestrians)
Car	2,500	4,700
Bicycles and horse carriages	1,400	1,600
Passenger	600	800

(2) Width of the Regulator Bridge

(a) Policy relating to Width of the Regulator Bridge

It is evident from the current traffic volume at the site that the volume of vehicle traffic will remain the same in the future. Therefore, under the prevailing road width conditions in Egypt, the minimum width required both to ensure the safe passage of pedestrians and horse carriages and to enable the smooth flow of general traffic will be determined taking into account traffic volume, means of traffic, public interest, costs, ease of execution and environmental and social considerations, with the aim of ensuring the safe and smooth flow of vehicles and pedestrians on the Dahab Regulator and with a policy of providing separate traffic lanes for general automobiles and bicycles/horse carriages which travel at significantly different speeds (Road Structure Ordinance, the Ministry of Land, Infrastructure and Transport of Japan).

(b) Width of the regulator bridge

In accordance with the above-mentioned policy, the design width of the regulator bridge has been decided, making reference to the current situation regarding road width in Egypt as described below, and Japanese standards.

【Effective width of the regulator bridge: 10.0m】 = ［Width of lanes for automobiles, bicycles and horse carriages: 4.0m x 2］ + ［Width of the sidewalks: 1.0m x 2］

Details of the basis on which the decision was made are shown below:

【**Road Standards in Egypt** (Current situation with regard to road width)】

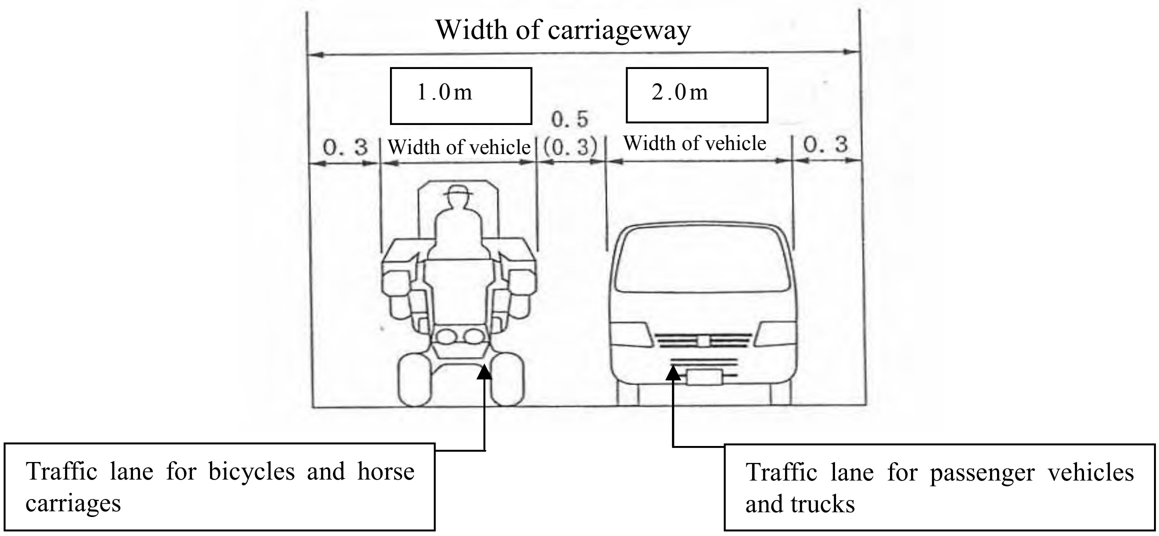
・The road standards of Egypt do not include standards relating to the width of road bridges. The width of the bridge attached to the Minya Regulator across the Ibrahimia Canal constructed in 1992 is 12m. However, the width of the relatively new road bridges crossing the Bahr Yusef, Ibrahimia and Seri Canals is 10m. Meanwhile, the total width of the Saft Bridge (completed in 1993), on which the traffic volume survey was conducted, is 10m (8m and 2m for vehicle and pedestrian traffic, respectively).

【**Japanese Road Standards; General Traffic**】

［The width of lanes for automobiles, bicycles and horse carriages: 4.0m x 2］

4.0m

The case of 2 lanes



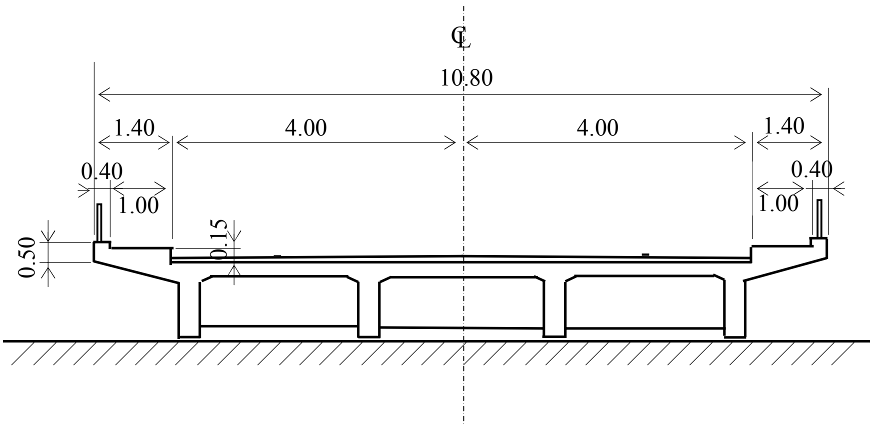
［Width of sidewalks: 1.0m x 2］

Location	Standards etc. on which based	Standards for Road Width	Adopted Width
Width of sidewalk	Road Structure Ordinance, the Ministry of Land, Infrastructure and Transport of Japan	・3.5m or more and 2.0m or more for roads with heavy pedestrian traffic and other roads, respectively. ・Exception: Width can be "decided taking into consideration the conditions of pedestrian traffic on the road in question."	・To be set at 1.0m, applying the exception standard described in the column on the left, as the daily traffic volume is 600 pedestrians.

［Maintenance/Management of the Gates during the Construction Work］

1) A width of approximately 6m is required to enable a 25t-class truck crane to work on the regulator bridge (with the outrigger extended and parked sideways on the bridge) for the maintenance and management of the gates (lifting of the gate hoists and gate panels).

Figure 2-2-1.6 Typical Cross-section of Regulator Bridge



2-2-1-11 Policy relating to the condition of the construction industry and procurement

There are many construction companies, from large-scale companies with experience in the execution of large-scale projects and of a relatively high technological standard, to small local construction companies. Although these companies do have the capacity to execute general civil engineering and construction works, this project must be completed within the short period of approximately two years; therefore the execution capacities of these companies will be evaluated and construction and procurement methods that will enable completion of the project within the planned period using their capacities will be looked into.

Some Egyptian contractors have proven cofferdam experience, gained during dam construction as members of joint ventures with foreign companies. There are few contractors who can execute the work alone. Therefore, Egyptian contractors are not considered to have sufficient management capability in a wide range of fields, from integrated management in the construction period, quality and safety to site management, and are considered to be in need of guidance from foreign construction companies.

2-2-1-12 Policy relating to procurement procedures for the gate facilities

To realize one of the important basic policies of this project, "stability of the water level above the Dahab Regulator," the design has adopted two-stage-panel gates. One of the preconditions for the realization of this policy is that the function of these gates be fully utilized. Therefore, the source of procurement of the gates will not be selected only from consideration of the cost. To prevent malfunction in the gate operation and reduced operation rate affecting the effectiveness of this project, a source will be selected that offers positive guarantees of quality, functionality and punctual delivery in accordance with the project schedule. With the following four points recognised as the major evaluation criteria, procedures for procurement in Egypt, from a third country and from Japan will be evaluated.

1) Evaluation of record and quality of design and technology in manufacture of two-stage-panel gates, and dispatch of skilled laborers.
2) Evaluation of manufacturing and installation coordination capacity when the two-stage-panel gates, gate hoists and electrical facilities are considered as a unit.
3) Evaluation of the capacity to manufacture and install equipment in strict adherence to the work schedule.
4) Evaluation of overall costs.

Comprehensive evaluation of the discussion of the above-mentioned four criteria shown below and the attached comparison table has led to the adoption of **the policy of procurement of the gate facilities from Japan.**

(1) Evaluation of record and quality of design and technology in manufacture of two-stage-panel gates, and dispatch of skilled laborers

a) Evaluation of record and quality of design and technology in manufacture of two-stage-panel gates

The two-stage-panel gates have been adopted as the gates for head works in many projects in Japan. A significant amount of experience has been accumulated and a high level of technology has been established in the manufacture and installation of this type of gate. At present, they are manufactured as being the gates with the best flow rate control performance. In recent years, gates for dams have been designed and manufactured in Egypt. However, the gates designed and manufactured in Egypt are relatively simple structures, such as one-panel gates. There is no record in Egypt of the manufacture of the two-stage-panel gates required for this project. Similarly, no third country, including any of the other industrialized countries, has experience in manufacturing two-stage-panel gates.

In other words, only Japan has experience in this type of gate. The quality of the gates manufactured in Japan has been confirmed by the fact that the gates provided for the three regulators (Lahoun, Mazoura and Sakoula Regulators) in the previous projects have been operating without problem.

b) On the possibility of the dispatch of skilled laborers

In recent years, there have been cases in which gates have been manufactured in a counterpart country or third country with the dispatch of skilled laborers under a grant aid program of Japan in another country. Although none of these projects involved the two-stage-panel gates, there is a need in this project to investigate the possibility of procurement in the beneficiary country or from a third country with the dispatch of skilled laborers. The following two conditions justifying the dispatch of skilled laborers, arising from the experience of projects implemented in the past, are used to evaluate this possibility.

[The manufacturer accepting skilled laborers is an overseas factory subsidiary to or affiliated with a Japanese company]

One of the conditions for the dispatch of skilled laborers is the readiness of the recipients to accept Japanese technology and provide unconditional cooperation, as the dispatched laborers have to work abroad. This condition also includes the assurance of punctual execution of this project. It is considered that foreign manufacturers subsidiary to or affiliated with Japanese companies are able to complete the work by the delivery date.

However, in this regard, as there is in Egypt no manufacturer that is subsidiary to or affiliated with a Japanese manufacturer, the dispatch of skilled laborers to Egypt is considered unrealistic.

[Guaranteed mutual benefit to both the manufacturer dispatching the skilled laborers and the manufacturer accepting them.]

In general, the advantage of procurement from a third country is cost reduction in manufacturing and transport. The dispatch of skilled laborers is associated with disadvantages, such as a technology drain from the Japanese side and increased costs including those for the dispatch of skilled laborers and new capital investment in local factories. As technology transfer from the Japanese side through the dispatch of skilled laborers, in particular, is a critical matter and associated with great risk for the Japanese manufacturers, the dispatch of skilled laborers will not materialize unless there is a business relationship, such as affiliation or capital investment, between the foreign company and the Japanese manufacturers.

Even if there is a business relationship between the recipient and the Japanese manufacturers, the costs of the dispatch and capital investment have to be borne by the manufacturers on both sides. Therefore, there has to be guaranteed mutual benefit offsetting such costs. In general, in the case of mass production or a long-term order, a mutual investment effect is likely to be guaranteed. In a certain past project in which the dispatch of skilled laborers to manufacture the gates did come about, the number of manufactured gates was approximately 30 (or 2,000 tons). However, the number of gates required in this project is limited to four (or approximately 400 tons), approximately one fifth the scale of the project in which the dispatch was brought about.

In the example of the above-mentioned projects, the cost of the dispatch of skilled laborers to companies subsidiary to or affiliated with Japanese companies in Asia is evaluated at approximately 760 million Yen (see attached table of comparison). This amount is not that small compared with the corresponding figure for procurement from Japan of approximately 780 million Yen. Furthermore, if procurement from a third country with the dispatch of skilled laborers is selected, there is a risk of no bids being placed as manufacturers see the project as being too small for them to expect any profit.

Based on the above evaluation, in this project the dispatch of skilled laborers to Egypt or a third country is concluded unrealistic.

(2) Evaluation of manufacturing and installation coordination capacity when the two-stage-panel gates, gate hoists and electrical facilities are considered as a unit

The purpose of this regulator can be achieved when the function of the gates (establishing water tightness by damming the flow), the function of the gate hoists (consistent and accurate lifting/lowering of the gate panels) and the function of the electrical facilities (providing these facilities with integrated direction) are performed without problem or hindrance. In particular, as the gate facilities are large-scale electro-mechanical facilities it is concluded that the manufacturing and installation coordination of them will require guidance by a highly-reliable technician as the three facilities must be considered as a unit.

The on-site survey confirmed that in Egypt, as in other countries, the gates, gate hoists and electrical facilities are manufactured and installed at the site by their respective manufacturers. In other words, though the manufacturers installed their products quickly in accordance with the clear demarcation of their responsibilities, there is no overall coordination of the installation unless the scale of the project is large enough to guarantee significant profit for the manufacturers to do so (more than 5,000t/month, according to the manufacturer interviewed). As a consequence, malfunction of the facilities manufactured and installed by these foreign companies happens frequently once the facilities are put to use. The scale of this project (approximately 400 tons) is not considered large enough for coordination under the guidance of a highly reliable technician.

Meanwhile, it is a common practice in Japan for the installation of the three facilities to be coordinated under the guidance of a highly reliable technician in both domestic and overseas projects, which practice guarantees consistent operation.

(3) Evaluation of the capacity to manufacture and install facilities in strict adherence to the work schedule

As this project has a short project period of approximately two years, the manufacture and installation of the gates has to be done without delay. In the project at the Sakoula Regulator, which was on the same scale as this project, the gates were installed 13 months from the commencement of the work (including the period of preparatory works). However, according to the information obtained during the field survey, the period required for Egyptian manufacturers to deliver all the gates for this project is 22 months from the commencement of the contract. Taking into consideration also the recent difficulty in procuring steel materials, Egyptian manufacturers cannot be relied upon for the manufacture and installation of the facilities within the project period.

Although foreign manufacturers subsidiary to or affiliated with Japanese companies are more reliable, procurement from a third country is unrealistic in this project for the reasons given above. Meanwhile, as the success of the project at the Sakoula Regulator has proven, punctual manufacture and installation of the facilities can be achieved with procurement from Japan.

(4) Overall cost evaluation

In the following comparison table, the costs of different sources of procurement were compared. On the basis of the field survey evaluation of Egyptian manufacturers as not being suitable sources for procurement, procurement in Egypt is excluded from this cost evaluation. The cost of dispatch of skilled laborers to local manufacturers subsidiary to or affiliated with Japanese companies in Asia was evaluated taking as examples projects that had utilized the dispatch of skilled laborers.

As mentioned above, the cost of procurement from a third country (with the dispatch of skilled laborers) is estimated at approximately 760 million Yen (see attached comparison table). The cost of procurement from Japan is estimated at approximately 780 million Yen, which is slightly higher than that of procurement from a third country. However, because of the small scale of this project, the bidding process will be stalled as manufacturers can expect little benefit from the dispatch of skilled laborers to a third country.

Therefore, though it is slightly more costly, procurement from Japan is considered appropriate, taking into consideration the realities of this project.

Comparison for the selection of the source of procurement of the two-stage-panel gates

Item for comparison	Procurement source	Egypt		Third country in Asia		Japan	
●Evaluation of technology and experience in two-stage-panel gates	Experience in manufacturing and quality	No experience in manufacturing the type of gate in question No experience in guaranteeing quality of the type of gate in question	×	No experience in manufacturing the type of gate in question No experience in guaranteeing quality of the type of gate in question	×	Plenty of experience in manufacturing the gates concerned Plenty of experience in guaranteeing quality of the type of gate in question	○
	Design technology	No technology for designing the type of gate in question	×	No technology for designing the type of gate in question	×	Many design technologies for the type of gate in question	○
	Manufacturing technology	No technology for manufacturing the type of gate in question	×	No technology for manufacturing the type of gate in question	×	Many manufacturing technologies for the type of gate in question	○
●Evaluation of the possibility of dispatch of skilled laborers	Affiliation with Japanese capital	No manufacturer is subsidiary to a Japanese company	×	In Asia, there are companies subsidiary to or affiliated with Japanese manufacturers.	○	Not applicable	—
	Costs associated with the dispatch of skilled laborers and evaluation of the costs	Excluded from the evaluation as there is no manufacturer subsidiary to a Japanese company in which dispatched skilled laborers can work	—	The Japanese side has to bear the burden of dispatching skilled laborers. As the number of gates to be manufactured is small, there is no mutual benefit and the bidding process may not go forward.	Δ	Not applicable	—
● Manufacture and installation coordination capacity when the gates, gate hoists and electric facilities are considered as a unit		In general, overall coordination of the three facilities is not implemented. There are many cases of operational problems	Δ	The dispatch of skilled laborers will enable Japanese skilled laborers to handle the matter.	○	Japanese skilled laborers can handle the matter	○
● Capacity to manufacture and install the gates within the project period		There is uncertainty as to whether the gates can be manufactured and installed within the project period.	Δ	Reliable, as schedule management is carried out by Japanese skilled laborers.	○	Reliability has been proved in the success of the previous project at the Sakoula Regulator	○
●Cost evaluation	Gates	Excluded from the cost comparison because it is unsuitable as a procurement source in almost all the above evaluation items.		175 million Yen		269 million Yen	
	Gate hoists			382 million Yen		338 million Yen	
	Electrical facilities			67 million Yen		100 million Yen	
	Costs for the dispatch of skilled laborers, and miscellaneous cost			61 million Yen		0 Yen	
	Transport costs (marine and land)			*78 million Yen		71 million Yen	

	Total			763 million Yen (0.98)	○	778 million Yen (1.00)	△
●Overall evaluation		Egypt does not have experience in manufacturing the type of gate in question or the environment to accept dispatched skilled laborers. There is uncertainty with regard to ability to adhere to the work schedule.	×	The cost is not much different from procurement from Japan because of the cost of the dispatch of skilled laborers. There is the possibility of the bidding process being suspended because little mutual benefit is expected from the small number of gates to be manufactured.	△	Although the cost is slightly higher than procurement from a third country, this is the most reliable method in terms of past achievement, manufacturing technology and the project period. It gives no uncertainty as a procurement source. It is the most reliable source of procurement.	○

※The transport costs from a third country include various costs associated with the arrangement of a vessel, as there is no regular service from the country concerned to Egypt

2-2-1-13 Policy relating to procurement procedures for other materials and equipment

In addition to the gates, procurement of the following materials and equipment is expected. The most appropriate methods will be chosen from procurement either in Egypt, from a third country or from Japan, taking quality, delivery date and costs into consideration.

1) Steel sheet piles and large steel H-beams: to be used in the temporary and main construction works
2) General construction materials: Cement, reinforcing bars, timber, general construction materials, electric wire, plumbing materials etc.
3) Construction machinery: Backhoes, bulldozer, trucks, cranes etc.
4) Framework materials, scaffolding and support: to be used in concrete casting

2-2-1-14 Policy relating to work schedule and construction methods

(1) Basic policy relating to the work schedule

As this project is for the rehabilitation of a structure in the canal, work execution in the canal is considered essential. Works in a canal generally include an embankment and/or sheet-pile cofferdam. In general, an embankment cofferdam is used where the water depth is shallow (3m or less), while a sheet-pile cofferdam is used where the water depth is 3m or more.

As the field survey conducted on the Bahr Yusef Canal under this project recorded a water depth of more than 5m, a sheet-pile cofferdam will be used.

(2) Earth work

Materials obtained from the excavation at the site will be utilized as much as possible as the backfill materials required for the earth work. Backhoes will be used for earth excavation and backhoes and bulldozers will be used to load earth onto dump trucks. Excavated earth usable as backfilling material will be stocked at a temporary depot. Meanwhile, earth of poor quality that cannot be used for backfill or banking will be transported to and disposed of at the closest location designated for surplus soil disposal.

(3) Removal of the existing regulator structures

Demolition by rock breakers, which are widely used in Egypt for excavation of soft rock, will be considered. Measures against noise and vibration during the demolition will be investigated and preventive methods (use of vibration-free and noise-free construction machines) will be included in the design where necessary. The rubble produced by demolition will be disposed under the ground in approved locations (including embedding within the cofferdam) in order not to create an adverse effect on the environment.

The amount of rubble to be produced: 5,400 m^3, the amount of excavated earth: 25,000 m^3, for backfilling: 27,000 m^3 (derived from the actual data from Sakoula)

(4) Concrete work

The design concrete strengths and quantities of this project are as follows:

Concrete strengths and quantities (derived from the actual data from Sakoula)

Item	Design strength (N/mm^2) (kgf/cm^2)	Quantity (m^3)
Reinforced concrete	21.0 (210)	6,140m^3
Plain concrete	18.0 (180)	210m^3
Total		6,350m^3

(5) Concrete plant

A survey of concrete plants in the area around the project site revealed that there is no commercial concrete plant within a 100km-radius area of the project site. Therefore, it is considered appropriate to establish a concrete plant of appropriate specifications at the site and to transport the concrete in concrete mixer trucks. As wastewater from the plant cannot be disposed directly into the canal, the design will incorporate environmental measures such as the treatment of wastewater in an infiltration-type reservoir. The use of concrete pumping trucks and mobile/fixed cranes for concrete casting will be considered.

(6) Finish of structures

The wooden lath method of framework that is widely adopted in Egypt is considered unsuitable for the finish of exposed concrete in this project because of the poor quality of the finish on the surface of joints. The use of steel plates or plywood with a coated surface is considered appropriate. The quality of the surface finish of a concrete structure depends on the accuracy of the framework. It has been confirmed that the quality of the surface finish of structures in Egypt is significantly inferior to that of the Lahoun, Mazoura and Sakoula Regulators. This fact will be taken into consideration in the selection of a source of procurement.

(7) Concrete casting

Structural stress, joint treatment, water tightness and concrete manufacturing and casting capacity will be taken into consideration in the design of appropriate block division. As the temperature reaches as high as 45 degrees in the summer, the possibility of casting concrete during the night, when the temperature drops, will be considered for those parts that require a large quantity of concrete to be cast, such as the dam pillars and aprons.

(8) Pre-cast method

A comparative study will be carried out with the pre-cast and cast-in-place methods as the method of constructing the beams for the regulator bridge and for the top of the dam pillars.

2-2-1-15 Policy relating to the temporary work

(1) Temporary detour and bridge

The existing bridge attached to the regulator is an important service road in the daily lives of the local residents. As the cofferdam in the canal and demolition of the existing dam to be implemented during this project will make it impossible to use the existing bridge, a temporary bridge crossing the canal will be required to maintain the general traffic (of pedestrians, horses, vehicles, etc.) and ensure the transport of construction material, equipment and machinery from outside.

A comprehensive comparative study will be carried out on the functionality, safety, easiness of execution and costs of the three alternatives for the location of a temporary detour and bridge: 1) a temporary bridge on part of the cofferdam, 2) a temporary bridge on the canal above the cofferdam and 3) a temporary bridge on the canal below the cofferdam. At present, despite the large volume of traffic, as the existing regulator bridge is for one-way traffic, two-way traffic will not be adopted. However, as construction vehicles will pass the bridge during the construction, the design width will be set at 6m or more to allow the two-way traffic of vehicles required for safety assurance.

Taking the above-mentioned into consideration, the appropriate width and structure of the temporary bridge will be decided.

(2) Cofferdam

The design conditions for the cofferdam assuming the regulator is to be constructed at the current site are described below. The height of the cofferdam will be decided by adding a freeboard of 0.5m to the second highest water level recorded in the past ten years (see "The Head Works," the Design Standard, the Ministry of Agriculture, Forestry and Fisheries of Japan).

・Design conditions of the cofferdam

Cofferdam height on the upper side: EL 40.60m ＋ 0.50m = EL 41.10m

Cofferdam height on the lower side: EL 39.90m ＋ 0.50m = EL 40.40m

Design water level, upper side: EL 40.54m ~ EL 40.60m, lower side: EL 39.90m

2-2-1-16 Policy relating to use of local companies

(1) Technical standard of construction companies in Egypt

This project includes a large-scale cofferdam in the waterway, work in which few Egyptian construction companies have experience. Construction-related companies in Egypt will take part in the project as subcontractors and suppliers of labor, materials and construction machinery under the supervision of a Japanese construction company with experience and a good record in this type of work, and will contribute to the completion of work on time in accordance with the schedule.

(2) Availability of construction machinery in Egypt

General construction machines are commercially available in Egypt. However, because of the small demand, construction companies and leasing companies own a limited number of specialized construction machines such as vibrohammers for casting steel sheet piles. Thus, they cannot be relied on as sources of such machines.

In Egypt, construction companies lease out their own machines. Rental fees are not low. Some of the machines for lease such as pile drivers, generators and compressors, are in poor condition and badly maintained. The rental and use of such machines may have a negative effect on the quality and period of the work. Therefore, transport from Japan and procurement from a third country will be considered.

(3) Labor force in Egypt

The technical standard of Egyptian laborers and the quality of skilled laborers are relatively high. The employment of capable engineers and skilled laborers trained in construction works has become easy. A sufficient labor force for the project can be obtained in Minya City near the Dahab Regulator. However, the recruitment in Cairo for additional laborers will be required at the busiest times during the construction, and of skilled laborers such as carpenters, steel erectors and plasterers, will be also considered.

2-2-1-17 Policy relating to facility operation and maintenance/management

The following policies will be adopted for the operation and maintenance/management of the facilities.

1) The current operation and maintenance/management systems will be used for the operation and maintenance/management of the Dahab Regulator after its rehabilitation. It will be controlled by the West Bahr Yusef Supervisor’s Office under the West Minya Irrigation Directorate.

2) The maintenance/management plan after rehabilitation will be formulated in such a way that it can be implemented by the Egyptian Government. However, as the continuously growing water demand linked with the population growth is intensifying the need to conserve water resources, recommendations will be made to the Egyptian side regarding the formulation of an integrated water management system with the four regulators and a maintenance/management plan based on rational water resources management.

3) In order for the rehabilitation to resolve the problem of irrigation water shortages in the beneficiary area of the Dahab Regulator, the appropriate development and maintenance/management of the secondary canals and pumping stations is essential. Therefore, recommendations will be made to the Egyptian side regarding the allocation of a sufficient budget for human and financial resources in the operation and maintenance/management of the various facilities.

2-2-1-18 Policy relating to operation and maintenance/management capacity of the implementing agency.

(1) Operation and maintenance/management capacity of the implementing agency.

No problem has been observed in the operation and maintenance/management of the three regulators (Lahoun and Mazoura Regulator) including the Sakoula Regulator, the rehabilitation of which was completed under the grant aid program of Japan as recently as May 2006. What will be the most important once the old and dilapidated Dahab Regulator has been restored and its original water control function has been reinstituted will be 1) acquisition and implementation of the gate control technology by which the water discharge can be properly controlled at the required flow rate and 2) facility improvement and maintenance/management capacity to enable constant supply of the required amount of irrigation water to the terminal beneficiary areas such as the secondary canals and pumping stations. In this regard, it has already been confirmed that the highest-level implementing agency on the ground, the West Minya Irrigation Directorate, has planning capacity and sufficient human resources to implement the plans as described above. Therefore, after the conclusion of the grant aid program of Japan, the immediate realization of the project outcome can be expected.

(2) Training of overflow gate operators

In view of the current situation in which all the gates on the existing regulator are underflow gates and as many as 20 gates are being operated manually, it is essential to have capable gate operators if the water control function is to be fully utilized from the early stages.

Fortunately, the daily operation of the Dahab Regulator, as well as the Sakoula Regulator, is under the responsibility of the Manshaat el Dahab Irrigation Zone Office, which is part of the West Bahr Yusef Supervisor’s Office under the West Minya Irrigation Directorate. Therefore, we recommend that, before the completion of the rehabilitation of the Dahab Regulator, the training of future gate operators should be continuously implemented at the Sakoula Regulator Administration Office under the same jurisdiction, as comprehensive preparation for smooth gate operation after the completion of the rehabilitation work.

2-2-1-19 Policy relating to the construction period

As this grant aid program will be a project requiring a period of approximately three years including implementation design, implementation supervision and construction, the policy of the use of "A-type national bonds" in the fiscal system of Japanese government will be adopted. E/N required for the project implementation will be exchanged separately for the implementation design and work execution.

During the implementation design period prior to the work execution, there is need for the counterpart to implement and complete land-leveling work and electricity and power supply facility work without delay, as the works to be completed at its responsibility prior to the commencement of the rehabilitation work on the main body of the Dahab Regulator.

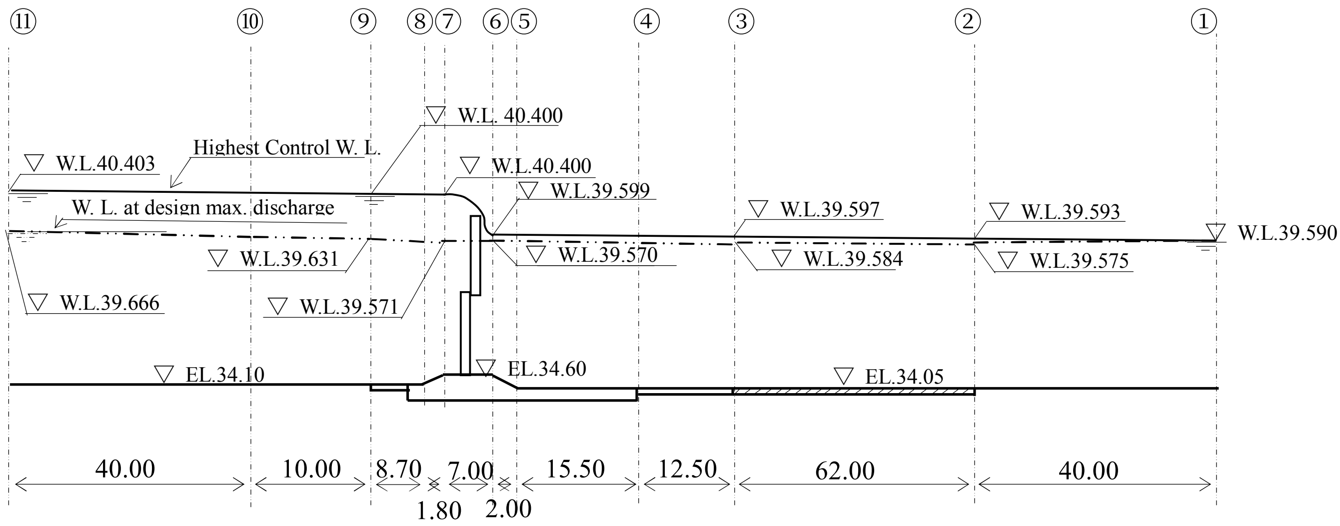
2-2-2 Basic Design

2-2-2-1 Dahab Regulator

(1) Cross Section of Flow Area

On the assumption that the total width of regulator is 32.0m and gates are full opened, the water level at upstream of regulator at releasing Design Maximum Discharge (Q = 210.15m^3/sec) is EL. 39.666m, does not exceed the Highest Control Water Level：Max. U. W. L. 40.40m (refer to Figure 2-2-2.1 and Table 2-2-2.1).

Figure 2-2-2.1 Hydraulic Profile at Design Maximum Discharge



(2) Elevations of Principal Part of Regulator

① Control Water Level

As a result of the field survey, the controlled water level of Dahab Regulator is designed as follow.

・ Extraordinary High Water Level (upstream)：	U.H.H.W.L. 41.00m
・ High Water Level (upstream)：	U.H.W.L. 40.80m
・ Highest Control Water Level (upstream)：	Max. U.W.L. 40.40m
・ Extraordinary High Water Level (downstream)：	D.H.H.W.L. 40.90m
・ High Water Level (Downstream)：	Max. D.W.L. 39.59m
・ Highest Control Water Level (downstream)：	Min. D.W.L. 36.23m

Table 2-2-2.1 Hydraulic Conditions at Design Maximum Discharge （Sill-up height: 0.50m）

Description	Symbol	Unit	Point ①	Point ②	Point ③	Point ④	Point ⑤	Point ⑥	Point ⑦	Point ⑧	Point ⑨	Point ⑩	Point ⑪
Design Max. Discharge	Q	m^3/sec	210.150	210.150	210.150	210.150	210.150	210.150	210.150	210.150	210.150	210.150	210.150
Design Highest Control W. L.	Max. W.L.	M	39.590	39.593	39.597	39.598	39.599	39.599	40.400	40.400	40.400	40.401	40.403
Elevation of canal	EL.	M	34.050	34.050	34.050	34.050	34.050	34.600	34.600	34.100	34.100	34.100	34.100
Width of canal	B	M	40.000	38.000	38.000	32.000	32.000	32.000	32.000	32.000	38.000	38.000	40.000
Distance	L	M	0.000	40.000	62.000	12.500	15.500	2.000	7.000	1.800	8.700	10.000	40.000
Water depth	D	M	5.540	5.525	5.534	5.531	5.533	4.970	4.971	5.491	5.531	5.533	5.566
Flow area of cross section	A	m^2	282.983	209.968	210.296	176.995	177.070	159.031	159.084	175.697	210.175	210.247	284.586
Wetted perimeter	P	M	64.776	49.051	49.068	76.249	76.267	71.758	71.771	75.924	62.735	62.744	64.891
Hydraulic radius	R	M	4.369	4.281	4.286	2.321	2.322	2.216	2.217	2.314	3.350	3.351	4.386
Velocity	V	m/sec	0.743	1.001	0.999	1.187	1.187	1.321	1.321	1.196	1.000	1.000	0.738
Velocity head	Hv	M	0.028	0.051	0.051	0.072	0.072	0.089	0.089	0.073	0.051	0.051	0.028
Coefficient of roughness	N	-	0.030	0.030	0.030	0.018	0.018	0.018	0.018	0.018	0.030	0.030	0.030
Hydraulic gradient	I	-	0.0000659	0.0001297	0.0001291	0.0001486	0.0001485	0.0001958	0.0001956	0.0001514	0.0001795	0.0001793	0.0000684
Max. W. L. after construction	W.L.	M	39.590	39.575	39.584	39.581	39.583	39.570	39.571	39.591	39.631	39.633	39.666
EL. of energy line	Eng	M	39.618	39.627	39.635	39.653	39.655	39.659	39.660	39.664	39.682	39.684	39.694
Friction head loss	Hf	M	0.000	0.004	0.008	0.002	0.002	0.000	0.001	0.000	0.001	0.002	0.005
Head loss by change of cross-section	He	M	0.000	0.005	0.000	0.004	0.000	0.003	0.000	0.003	0.004	0.000	0.005
Head loss by pier	Hp	M	0.000	0.000	0.000	0.012	0.000	0.000	0.000	0.000	0.012	0.000	0.000
Check of EL. of energy line	Eng. C	M	39.618	39.618	39.627	39.635	39.653	39.655	39.659	39.660	39.664	39.682	39.684

② Elevation of Apron

The elevation of canal at Dahab regulator (77.60 km from the starting point of Bahr Yusef Canal) is EL.34.10m at upstream of the regulator and EL.34.05m at the downstream, in the design profile of the Canal. Accordingly, elevations of apron at up/downstream are decided in conformity with the designed elevation.

- Elevation of Apron (upstream)： EL.34.10m
- Elevation of Apron (downstream)： EL. 34.05m

③ Sill Elevation of Gates

The designed elevation of canal at Dahab Regulator is EL. 34.10m at upstream of the regulator and EL. 34.05m at the downstream. Otherwise, the existing elevation of canal is about EL.34.80m.

The designed elevation of canal is 0.70m lower than the existing elevation, if gate sill levels are accorded with the designed elevation of canal, there would be a negative impact for complete and safe gate operation due to sedimentation under gates. Therefore, the gate sill elevation is designed 0.55m higher than the designed elevation of canal bottom.

- Sill elevation of gate： EL. 34.60m

④ Elevation of Gate Crest and Height of Gate

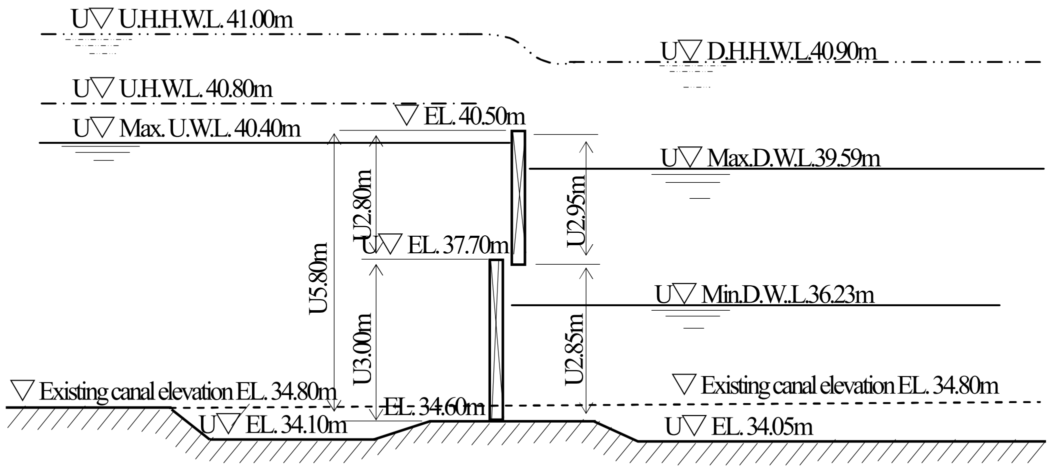
The elevation of gate crest is designed to meet the following two requirements.

1) The water level includes Freeboard：0.10m in Highest Control Water Level (upstream) ： Max. U.W.L. 40.40m .
2) Elevation of existing gate crest ：EL. 40.35m

- Elevation of gate crest： = （Highest Control Water Level at upstream）+（freeboard）
  = Max. U.W.L. 40.40m + 0.10m
  = EL. 40.50m

- Height of gate： = （elevation of gate crest）－（gate sill elevation）
  = EL. 40.50m － EL. 34.60m
  = 5.90m

Figure 2-2-2.2 Elevation of Gate Crest and Height of Gate



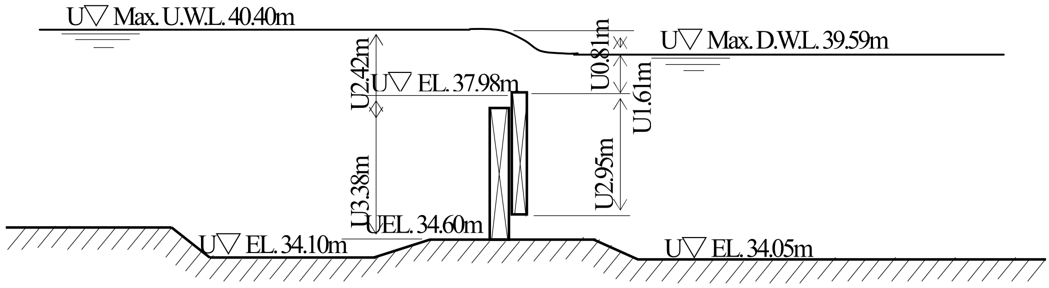
⑤ **Elevation of Lower Gate Crest**

Elevation of Lower Gate crest is designed to meet the following conditions.

1) Elevation that maximum discharge is able to release by overflow above upper gate

Elevation that maximum discharge is able to release by overflow above upper gate to release maximum discharge ($Q_{max.}$ = 210.15m^3/sec) by overflow above upper leaf, following overflow depth is required.

Figure 2-2-2.3 Release Situation by Overflow



h_2 = 1.610m < 2/3・h_1 = 2/3 x 2.42 = 1.613m (perfect overflow)

$$Q_{max.} = C_r \cdot B \cdot H^{3/2}$$

$$C_r = 1.706 \quad \frac{1+1.146\,(W/h_1)}{1+1.250\,(W/h_1)} \quad \cdots\cdots\cdots\cdot \quad ①$$

where, $2.5 < L/h_1 < 10$

$$C_r = 1.373 \quad \frac{0.984+(L/h_1)}{0.500+(L/h_1)} \quad \cdots\cdots\cdots\cdot \quad ②$$

where, $0.3 < L/h_1 < 2.5$

Q ； Discharge（m^3/s）

H ； Overflow depth with velocity head（m）,

$H = h_1 + h_v$（velocity head） = 2.42 + 0.00 = 2.42m

C_r ； Coefficient of discharge

B ； Width of regulator, B = (8.00 – 2 x 0.50) x 4 = 28.00m

L ； Length of regulator, L = 1.35m

W ； Height of regulator, W = 3.38m

h_1 ； Overflow depth, h_1 = WL.40.40 – EL.37.98 = 2.42m

* Velocity head (h_v) is not considerable.

$L/h_1 = 1.35/2.42 = 0.558$,

$C_r = 1.373 \times (0.984 + 1.35/2.42)/(0.500 + 1.35/2.42) = 2.001$

Q max. = $2.001 \times 28.00 \times 2.42^{3/2} = 210.93m^3/sec > 210.15m^3/sec$

Elevation that maximum discharge at downstream is able to release above upper leaf is ranged as below;

Elevation of lower gate crest ： EL.37.70m～EL.37.98m

2) Elevation for safety height of gate in structural

To meet the allowable deflection and allowable stress, the ratio of the gate height to clear gate span in case of roller gates must be within 1/10. Clear gate span of the regulator is 8.00m, a height is required over 0.80m, therefore, and the elevation of lower gate crest must be within following range.

・Elevation of lower gate crest：EL.37.70m～EL.39.70m

As a result of above examination, an elevation of lower gate crest is designed as follow, in order to release the maximum discharge by overflow release above the upper gate.

・Elevation of lower gate crest：EL.37.70m

⑥ Elevation of Gate Sill at Hoisting Gates and Elevation of Beam Bottom of the Regulator Bridge

The elevation of gate sill at hoisting gates and elevation of the beam bottom of the regulator bridge are designed as the total height of Extraordinary High Water Level at upstream and freeboard.

・ Extraordinary High Water Level (upstream)： U.H.H.W.L. 41.00m

・ Freeboard： $F_b = 0.05\,d + h_v + (0.20\sim0.30)$

$= 0.05 \times 6.90 + 0.63^2/(2 \times 9.8) + (0.20\sim0.30)$

$= 0.35 + 0.02 + (0.20\sim0.30)$

= 0.57m～0.67m

To stay on safe side, F_b is defined to 0.70m.

・ Elevation of gate sill at hoisting and elevation of beam bottom of the regulator bridge：

= U.H.H.W.L. 41.00 + 0.70m

= EL. 41.70m

⑦ Crest Elevation of Closure Dike and Steel Sheet Pile Retaining Wall at Up/downstream

1) Crest elevation of closure dike

To secure the height of shoe (0.05m), a height of beam（1.50m）and a height of the mound for pavement (0.15m) from elevation of beam bottom of maintenance bridge (EL. 41.70m), the crest elevation of closure dike is determined on EL. 43.40m.

2) The crest elevation of steel sheet piles retaining wall at up/downstream

a) The crest elevation of steel sheet piles retaining wall at up/downstream are derived from the addition of Ordinary Raising Water Level (High Water Level at upstream: U.H.W.L. 40.80m and Highest Control Water Level: Max. D.W.L. 39.59m) and freeboard of retaining wall (0.60m).

- Crest elevation of steel sheet piles retaining wall at upstream： 40.80 + 0.60 = EL. 41.40m
- Crest elevation of steel sheet piles retaining wall at downstream： 39.59 + 0.60 = EL. 40.19m

b) The crest elevation of steel sheet pile retaining wall at up/downstream are derived from Average Water Level at least 10 years (Average Water Level at upstream: U.A.W.L. 39.50m and Average Water Level at downstream: D.A.W.L. 38.90m) and a height of the top concrete (1.50m).

- Crest elevation of steel sheet pile retaining wall at upstream： 39.50 + 1.50 = EL. 41.00m
- Crest elevation of steel sheet pile retaining wall at downstream： 38.90 + 1.50 = EL. 40.40m

Therefore, the crest elevation of steel sheet piles retaining wall at up/downstream are designed as follows:

- Crest elevation of steel sheet pile retaining wall at upstream： EL. 41.40m
- Crest elevation of steel sheet pile retaining wall at downstream： EL. 40.40m

(3) Design of Regulator Body

① Regulator Body Type

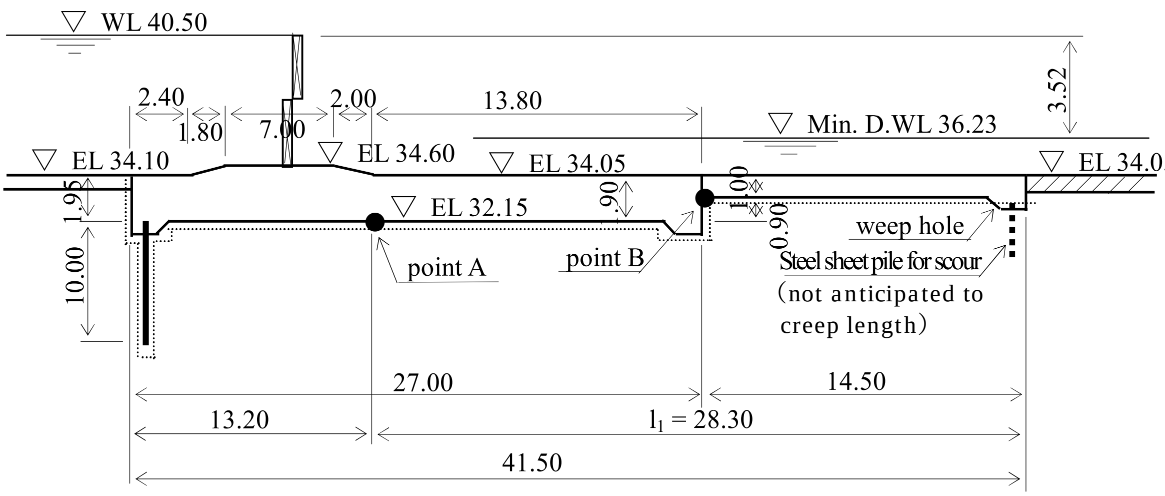
A regulator body of the type is divided into Fixed type (constructed on bedrock) and Floating type (constructed on sediment and gravels) depending on the permeability of the foundation. The type of Dahab Regulator is designed on Floating type for that geology at the regulator is sand with silt.

② Design of Middle and Downstream Apron

1) Profile for design

The design of middle and downstream aprons is designed, based on following profiles and criteria of Headwork for Land Improvement Project Standard of Japan.

Figure 2-2-2.4 Profile of Middle and Downstream Apron



2) Length of middle and downstream of apron

The length of middle and downstream apron is designed from Blugh's formula (refer to the criteria of Headwork for Land Improvement Project Standard of Japan).

$$l_1 = 0.9 \cdot C \sqrt{D_1} \quad = 0.9 \times 15 \times \sqrt{4.23} \quad = 27.77\text{m}$$

where, l_1 : Length of middle and downstream apron (m)

D_1 : Maximum head difference between up/downstream (m)

D_1 = EL 40.50m – Min. D.W.L. 36.23m = 4.27m

C : Coefficient of Blugh, (fine sand) C = 15

The length of middle and downstream apron is l_1 = 27.77m on calculation, l_1 = 28.30m is adopted as design length, in considering for the scale of the Regulator.

Table 2-2-2.2 Coefficient for Bligh's Method and Lane's Method

Foundation	Blugh's C	Lane's weighted creep ratio C'	Adoption
Very fine sand and clay	18	8.5	
Fine sand	15	7.0	○
Medium sand	—	6.0	
Coarse sand	12	5.0	
Gravel	—	4.0	
Coarse gravel	—	3.5	
Gravel with sand	9	—	
Gravel with cobble stone and gravel	—	3.0	
Rocks with cobble stone and gravel	—	2.5	
Rocks with gravel and sand	4～6	—	
Soft clay	—	3.0	
Medium Clay	—	2.0	
Heavy Clay	—	1.8	
Hard Clay	—	1.6	

3) Creep Length

a) Examination methods

To prevent piping, a safe creep length along the foundation of regulator and retaining wall must be ensured. The creep length must be designed from a larger value calculated by ① Bligh's method and ② Lane's one (refer to the criteria of Headwork for Land Improvement Project Standard of Japan).

The purpose of steel sheet piles at the end of the downstream apron is prevention for scour, and, but, or because weep holes must be provided in cutoff at the end of the downstream apron to reduce uplift pressure. Therefore, the steel sheet pile is not included in creep length.

b) Examination of creep length

i) Bligh's method

$S \geqq C \cdot \Delta H = 15 \times 4.27 = 64.05m \leqq 64.35m$

where, S ：Creep length measured along the foundation of regulator (m)

$S = 1.95 + 41.50 + 10.00 \times 2 + 0.90 = 64.35m$

C ：Coefficient of Bligh, (fine sand) C = 15

ΔH ：Maximum head difference at up/downstream, $\Delta H = 4.27m$

ii) Lane's method

$L \geqq C' \cdot \Delta H = 7.0 \times 4.27 = 29.89m \leqq 36.68m$

where, L ：Weighted creep length (m), $L = \Sigma\ l_v + 1/3 \cdot \Sigma\ l_h$

$L = (1.95 + 10.00 \times 2 + 0.90) + 1/3 \times 41.50 = 36.68m$

C' ： Lane's weighted creep coefficient, (fine sand) C' = 7.0

ΔH ： Maximum head difference at up/downstream, $\Delta H = 4.27m$

As above, preceding profiles are met with both formulas and keeps safety for piping.

4) Thickness of middle and downstream aprons

The thickness of middle and downstream apron is designed from a formula about the balance of uplift pressure (refer to the criteria of Headwork for Land Improvement Project Standard of Japan).

$t \geqq 4/3 \cdot (\Delta H - H_f) / (\gamma - 1)$

where, t ： Thickness of apron at certain point（m）

⊿H ： Maximum head difference at up/downstream, ⊿H = 4.27m

H_f ： Head loss of infiltrated flow at certain point （m）

γ ： Unit weight of reinforced concrete, γ = 2.35 t_f/m^3

4/3 ： Safety factor

a) Middle apron：examination at point A

- Total creep length：
  L = 1.95 + 41.50 +10.00 x 2 + 0.90 = 64.35m
- Creep length to point A：
  L_A = 1.95 + 13.20 + 10.00 x 2 = 35.15m
- Head loss of infiltrated flow to A point：
  $H_f = L_A/L \times \Delta H$ = 35.15/64.35 x 4.27 = 2.35m
- Thickness of middle apron：
  $t \geqq 4/3 \cdot (\Delta H - H_f) / (\gamma - 1)$
  = 4/3 x (4.27 – 2.35) / (2.35 – 1) = 1.90m

Consequently, the thickness of middle apron at point A shall be 1.90m.

b) Downstream apron：examination at point B

- Creep length to point B：
  L_B = 1.95 + 27.00 + 10.00 x 2 = 48.95m
- Head loss of infiltrated flow to point B：
  $H_f = L_A/L \times \Delta H$ = 48.95/64.35 x 4.27 = 3.25m
- Thickness of downstream apron：
  $t \geqq 4/3 \cdot (\Delta H - H_f) / (\gamma - 1)$
  = 4/3 x (4.27 – 3.25) / (2.35 – 1) = 1.00m

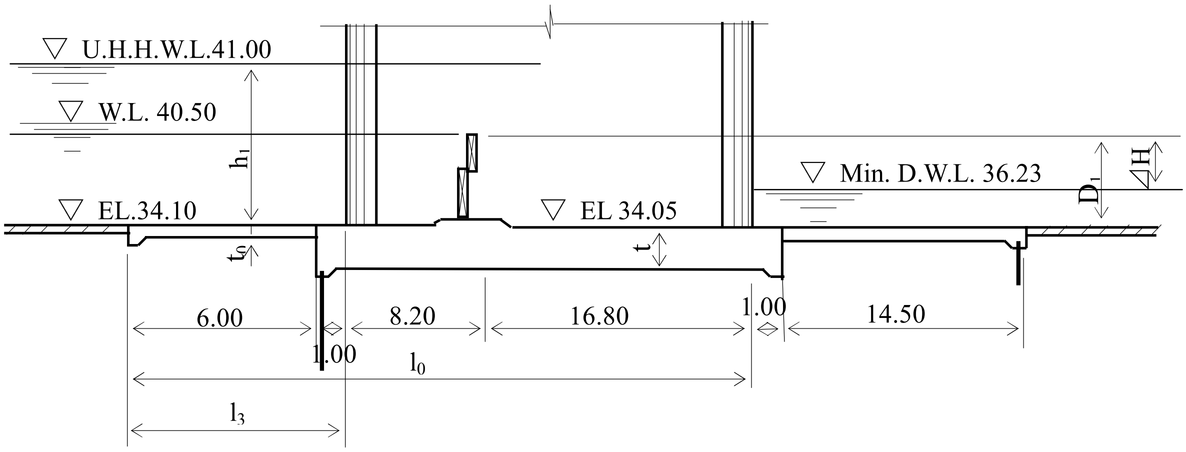
Thereafter, the thickness of downstream apron at point B shall be the minimum value, t = 1.00m.

③ Design of Upstream Apron

1) Length of upstream apron

The length of upstream apron shall be calculated by the description in the criteria of Headwork for Land Improvement Project Standard of Japan.

Figure 2-2-2.5 Profile of Upstream Apron



l_o in the above figure should be extended to over twice of the upstream water depth at designed high water level (h_1) and also l_3 should be over 3 times of the pier thickness, in order to operate as board crest weir and obtain the effect of roughness.

$l_o \geqq 2 \times h_1$ h_1 ; Design high water depth (= 6.90m)

$l_3 \geqq 3 \times B$ B ; Thickness of pier (= 2.00m)

Length of upstream apron assumed to be 6.00m.

$l_o = 6.00 + 1.00 + 8.20 = 15.20m \geqq 2 \times 6.90 = 13.80m$ OK

$l_3 = 6.00 + 1.00 = 7.00m \geqq 3 \times 2.00 = 6.00m$ OK

Thereby, Length of upstream apron is designed on 6.00m.

2) Thickness of upstream apron

The thickness of upstream apron is defined as 1/2 to 2/3 of the maximum thickness of downstream aprons according to the criteria of Headwork for Land Improvement Project Standard of Japan. The maximum thickness of downstream apron is 1.90m from said examination, the thickness of upstream should be ranged from 0.95 to 1.27m, therefore, it designed on 1.00m that is the minimum thickness.

(4) Gate Pier

The structure of gate piers shall be designed considering smooth water release, safety for loads and gate operation.

① Height and Thickness of Gate Pier

1) Height of gate pier

The height of gate piers is designed from the following formula in the criteria of Headwork for Land Improvement Project Standard of Japan.

Crest elevation of gate pier = Extraordinary high water level + Freeboard ① + Gate height + Freeboard ② + Top slab thickness

where, Extraordinary high water level；U.H.H.W.L. 41.00m

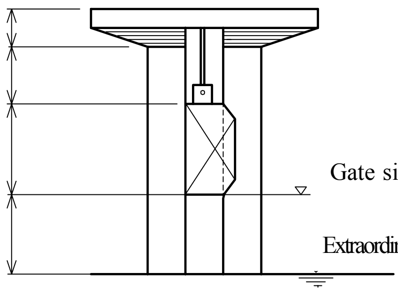
Freeboard ① ；Freeboard of Bahr Yusef Canal, 0.70m

Gate height ；Gate height of lower leaf, 3.10m

Freeboard ② ； Current gate height (generally, the height is assumed that overflow depth：2.80m + 0.30 m) + 1.20m, therefore, Freeboard ② is designed on 4.30m.

Top slab thickness；1.20m

Figure 2-2-2.6 Explanatory Profile for Crest Elevation of Pier



Crest elevation of gate piers is calculated as follow.

U.H.H.W.L. 41.00m + 0.70m + 3.10m + 4.30m + 1.20m = EL. 50.30m

And crest elevation of gate piers is designed EL. 50.30m.

2) Thickness of gate piers

The thickness of gate piers is designed from the following empirical equation in the criteria of Headwork for Land Improvement Project Standard of Japan.

$t_p = 0.12 (D_p + 0.2 \cdot B_t) \pm 0.25$

where, t_p ；Thickness of gate pier（m）

D_p ； Height of gate pier（m）

B_t ； Gate span（m）

D_p = EL. 50.30m – EL. 34.05m = 16.25m、B_t = 8.00m

$t_p = 0.12 (16.25 + 0.2 \times 8.00) \pm 0.25 = 1.89\text{m} \sim 2.39\text{m}$

As above, the thickness of gate piers is designed on 2.00m, and the pier thickness of both ends is designed on 1.40m subtracting the thickness of gate groove.

3) Length of gate pier

Considering the gate pier height, gate groove, disposition of hoisting device and the width of regulator bridge etc., the length of gate piers is designed 26.00m.

4) Space for hoisting device

To secure the space for installation of operating facilities and works for check and repair etc., the hoisting device space is determined 8.00m toward the canal direction, 40.8m toward the regulator axial direction.

② Examination of Upper Part Structure of Gate Pier

The upper part structure of gate piers shall be designed taking account not only stability for external forces but also working space for maintenance and check works.

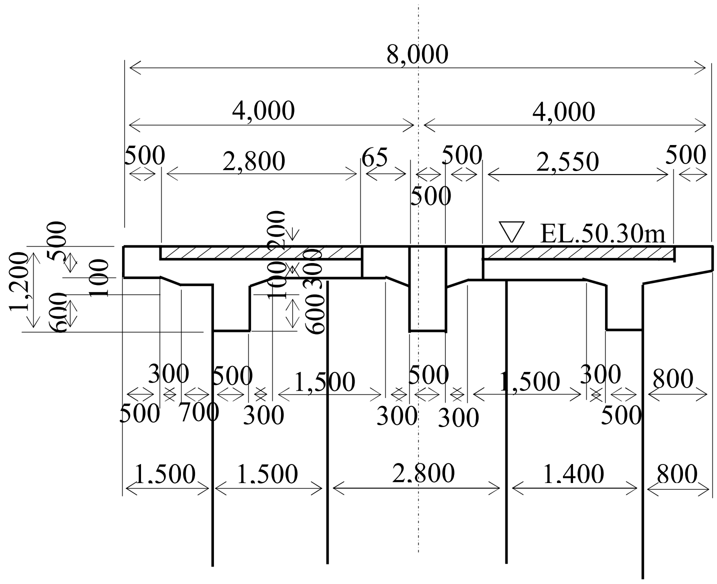
Items for maintenance and check at upper part of gate piers are tabulated below.

Table 2-2-2.3 Item for Maintenance and Check at Upper Part of Gate Pier

Item	Contents	Attention Point
Rubber	Check, repair and replacement	・Working space for adjustment, installation and remove of rubber is ensured.
Roller	Lubrication, check, repair, and replacement	・Easy to access to oil fill opening. ・Working space for check and remove of roller is ensured.
Operating facility	Lubrication, check and remove	・Easy to access to machinery room. ・Exit for equipment for check and repair is ensured and it is easy to carry out. ・Enough clearance around facility is ensured. （Minimum clearance for worker' passage is 0.6m from the wall）. ・Enough clearance between hoist facility and ceiling is ensured（Minimum clearance is 1.5m）.
Painting	Check	―

The workability of above maintenance works is depended on the structure of upper parts of gate piers. The thickness of gate piers is t_p = 2.00m, spaces for maintenance are endured sufficiently, therefore, a double pier structure is adopted.

Figure 2-2-2.7 Profile at Upper Part of Gate Pier of Dahab Regulator



(5) Design Criteria for Structural Analysis of Regulator Body

A structural analysis of the regulator body is designed from an allowable stress method. The design parameters for the calculation are shown in below.

① Allowable Stresses of Construction Material

The allowable stresses of construction materials, that are agreed upon IIS and the Basic Study Team and decided by them, are summarized as follows.

1) Allowable stress of reinforced concrete

Table 2-2-2.4 Allowable Stress of Reinforced Concrete

Allowable stress (kgf/cm^2)		28 days concrete strength (kgf/cm^2)	
		210	240
Bending compressive stress		80	90
Shear stress	Beams	6	6.5
	Slabs	8	8.5
Bond stress	Round bar	6	7
	Deformed bar	8	9
Bearing stress		55	60
Structures to be applied		Slabs, walls beams, columns and piers of main structures	Slabs of bridges

Note: The modular ratio (modulus of elasticity of steel/modulus of elasticity of concrete) of 10 will be used for the design of the project facilities.

Source: Reinforced concrete design handbook established 2002 by Dr. Shaker El Behairy.

2) Allowable stress of plain concrete

Table 2-2-2.5 Allowable Stress of Plain Concrete

Allowable stress (kgf/cm^2)	28 days Concrete Strength (kgf/cm^2)	
	120	180
Bending compressive stress	40	65
Bending tensile stress	-	-
Bearing stress	30	50
Structures to be applied	Lane concrete	Plain concrete

Source： Reinforced concrete design handbook established 2002 by Dr. Shaker El Behairy

3) Allowable tensile stress of steel

- Deformed bar (Steel 52) σ_{sa} = 1,800 kgf/cm^2
- Round bar (Steel 37) σ_{sa} = 1,400 kgf/cm^2
- Structural steel(SS400) σ_{sa} = 1,200 kgf/cm^2
- Steel sheet pile(SY295) σ_{sa} = 1,800 kgf/cm^2

② Loads

1) Dead Load

Unit weight of each material is as follows,

- Reinforced concrete γ_c = 2.50 tf/m^3
- Plain concrete γ_c = 2.35 tf/m^3
- Water γ_w = 1.0 tf/m^3
- Dry soil γ_e = 1.6 tf/m^3
- Wet soil γ_e = 1.8 tf/m^3
- Saturated soil γ_e = 2.0 tf/m^3
- Steel γ_s = 7.85 tf/m^3

Source: the criteria of Headwork for Land Improvement Project Standard of Japan

2) Live loads

Structures on which heavy wheels pass over the side of the structures should be designed for the wheel loads, and other structures should be considered a crowded load of 300 kg/m^2.

3) Seismic loads

According to the New Egyptian, seismic load in Egypt is smaller than that in Japan. The seismic horizontal acceleration in Egypt is approximately one third of that of Japan (= 0.06 / 0.20).

Therefore, the seismic loads are not considered for the design of the project facilities.

(6) Foundation of Regulator Structure

The elevation of existing apron sill is EL. 32.5m, and it is about 1m below from the top of Nile deposit (sand), the basis elevation of structures after the rehabilitation is assumed to be EL. 32.0m. The two boring holes, which are started from EL. 42.0m and EL. 43.2m, are drilled. Moreover, a standard penetration test was conducted in the holes. At boring hole No.1 on the right bank, N-value under EL. 32.0m is 27 and under 12.5m depth is over 50. N-value under EL. 32.0m at boring hole No.2 on the left bank is 35 and under 13.0m depth is over 50. Geology of both boring points is sand, which is not inter-bedded soft layers like clay, and it is suitable for the foundation of the structure. Therefore, a spread foundation is adopted in this rehabilitation.

Bearing capacity of the foundation, which N-value is27 and 35, in case of the spread foundation is shown in table 2-2-2.6. The required foundation reaction after the rehabilitation is about 20.3tf/m^2 (0.20N/mm^2), the foundation is evaluated that the foundation has sufficient bearing capacity.

Table 2-2-2.6 Calculation of Allowable Bearing Capacity of Regulator Foundation

Item	Foundation N-value is 27 (around BH-1)	Foundation N-value is 30 (around BH-2)	Remarks
Average N-value	27	35	$\phi = \sqrt{15N} + 15$ (the criteria of Headwork for Land Improvement Project Standard of Japan)
Internal friction ϕ	35	38	
Coefficient of Form α	1.3	1.3	
Cohesion C (tf/m^2)	0.0	0.0	
Coefficient of bearing capacity Nc	36.9	69.0	α ; square
Coefficient of Form β	0.4	0.4	β ; square
Unit weight of soil γ_1 (tf/m^3)	0.9	0.9	
Smallest width of foundation B(m)	7.4	7.4	
Coefficient of bearing capacity Nr	25.5	72.3	
Unit weight of soil γ_2 (tf/m^3)	0.8	0.8	Df ; Penetration depth is neglected in the calculation, on the safety side.
Penetration Depth Df (m)	0.0	0.0	
Coefficient of bearing capacity Nq	29.2	58.4	
Ultimate bearing capacity (tf/m^2)	67.9	192.6	
Allowable bearing capacity (tf/m^2)	22.6	64.2	

Note) Terzagi's Formula is applied for calculating the bearing capacity

$qa = 1/3 \times qu$

$qu = \alpha \cdot c \cdot Nc + \beta \cdot \gamma_1 \cdot B \cdot Nr + \gamma_2 \cdot Df \cdot Nq$

where,
- qa : Allowable bearing capacity (tf/m^2)
- qu ; Ultimate bearing capacity (tf/m^2)
- C ; Cohesion of foundation (tf/m^2)
- γ_1 ; Unit soil weight under foundation (tf/m^3) (Submerged unit weight is adopted for soils below water table)
- γ_2 ; Unit soil weight above foundation (tf/m^3) (Submerged unit weight is adopted for soils below water table)
- α, β ; Coefficient of form
- Nc,Nr,Nq ; Coefficient of bearing capacity (Function of internal friction ϕ)
- Df ; Depth of foundation from the lowest ground level near the foundation (m)
- B ; Smallest width of foundation(m)

(7) Stability of Gate Pier

① Design Conditions

1) Examination case on stability of pier

The following 6 cases will be examined on stability of pier.

Case ① ; Stability on flood time, gate-open and normal loads in flow direction.

Case ② ; Stability on low water, gate-closed, normal load, 0.30m-overflow above gates and 0.70m-sediment before gates in flow direction.

Case ③ ; Stability on no flow, gate-opened and normal load in flow direction.

Case ④ ; Stability on flood time, gate-opened and normal load in regulator axial direction.

Case ⑤ ; Stability on low water, gate-closed normal load, 0.30m-overflow above gates and 0.70m-sediment before gates in regulator axial direction.

Case ⑥ ; Stability on no flow, gate-opened and normal load in regulator axial direction.

2) Load conditions

The combination of loads in above cases is accordance with the load combination about the stability calculation for gate piers, which is shown in Table 2-2-2.7. Seismic load is not considered.

Table 2-2-2.7 Combination of Loads by Examination Case

Loads item \ Calculation case			Case ①	Case ②	Case ③	Case ④	Case ⑤	Case ⑥
Condition	Water level condition		Flood	Low water	No flow	Flood	Low water	No flow
	Gate condition		Open	Close	Open	Open	Close	Open
	Normal / quake		Normal	Normal	Normal	Normal	Normal	Normal
	Direction		Flow	Flow	Flow	Traverse	Traverse	Traverse
Vertical	W_p	Pier weight	○	○	○	○	○	○
	Wt	Platform weight	○	○	○	○	○	○
	Wg	Gate leaf weight	○	○	○	○	○	○
	Wm	Hoist weight	○	○	○	○	○	○
	Wb	Bridge weight	○	○	○	○	○	○
	Ww	Water weight	○	○		○	○	
	U	Uplift force	○	○		○	○	
	We	Earth weight				○	○	○
Horizontal load	P_{w1}	Wind load (at pier)	○	○	○	○	○	○
	P_{w2}	Wind load (at gate)	○		○			
	P_{w3}	Wind load (at bridge)		○				
	P_{w4}	Wind load (at platform)	○	○	○			
	P_g	Static hydraulic pressure (at gate)		○				
	P_p	Static hydraulic pressure (at pier)	○	○				
	P_{m1}	Dynamic hydraulic pressure (at gate)		○				
	P_{m2}	Dynamic hydraulic pressure (at pier)		○				
	P_{e1}	Sediment pressure		○				
	P_{e2}	Earth pressure (at side-wall)				○	○	○

3) Safety conditions

Safety conditions for the examination of overturn, sliding and base load of gate pier are tabulated below.

Examination	Allowable value on normal time
① Overturn	e ≦ B/6
② Sliding	Fs ≧ 1.5
③ Base Load	Q ≦ Qa (tf/m^2)

4) Results of the stability calculation

Results of the stability calculation for gate pier is shown in Table 2-2-2.8.

Table 2-2-2.8 Results of the Stability Calculation for Gate Pier

Item / Gate pier	Case	Normal/quake	Water level	Direction	Vertical force ΣV (tf)	Resistant moment ΣV・x (tf・m)	Horizontal force ΣH (tf)	turning moment ΣH・y (tf・m)	Sliding: Safety Factor Fs		Sliding: Required Fsa	Turning: Eccentric distance e (m)		Turning: B/6 (m)	Foundation capacity: Reaction ; Q_1 (tf/m^2)	Foundation capacity: Reaction ; Q_2 (tf/m^2)		Foundation capacity: Bearing capacity (tf/m^2)
Central pier	①	N	F	F	2,210.05	31,067.52	10.65	187.44	106.41	>	1.5	0.37	<	4.58	8.68	7.39	<	22.60
	②	N	L	F	2,067.81	27,960.82	211.29	1,354.92	4.98	>	1.5	0.18	<	4.58	7.82	7.22	<	22.60
	③	N	N	F	2,565.86	36,507.76	35.83	471.48	37.36	>	1.5	0.20	<	4.58	9.73	8.93	<	22.60
	④	N	F	A	2,210.05	11,050.25	24.28	358.93	46.67	>	1.5	0.18	<	1.67	8.92	7.16	<	22.60
	⑤	N	L	A	2,139.81	10,699.05	56.20	599.03	19.44	>	1.5	0.32	<	1.67	9.62	6.30	<	22.60
	⑥	N	N	A	2,565.86	12,829.30	83.54	750.97	16.02	>	1.5	0.32	<	1.67	11.14	7.52	<	22.60
Middle pier	①	N	F	F	2,227.05	31,407.52	30.53	433.95	38.50	>	1.5	0.25	<	4.58	8.54	7.65	<	22.60
	②	N	L	F	2,156.81	29,024.42	211.29	1,354.92	5.37	>	1.5	0.07	<	4.58	7.97	7.72	<	22.60
	③	N	N	F	2,582.86	36,847.76	35.83	471.48	38.58	>	1.5	0.00	<	4.58	9.49	9.39	<	22.60
	④	N	F	A	2,227.05	11,135.25	24.28	358.93	48.41	>	1.5	0.18	<	1.67	8.95	7.24	<	22.60
	⑤	N	L	A	2,156.81	10,784.05	56.20	599.03	20.19	>	1.5	0.30	<	1.67	9.28	6.41	<	22.60
	⑥	N	N	A	2,582.86	12,914.30	83.54	750.97	16.53	>	1.5	0.31	<	1.67	11.16	7.62	<	22.60
Side pier	①	N	F	F	2,030.10	29,111.39	18.22	259.43	60.39	>	1.5	0.17	<	4.58	10.35	9.60	<	22.60
	②	N	L	F	2,119.27	30,377.74	115.97	759.94	9.93	>	1.5	0.70	<	4.58	12.00	8.83	<	22.60
	③	N	N	F	2,572.36	37,091.51	23.31	294.85	60.63	>	1.5	0.57	<	4.58	14.23	11.06	<	22.60
	④	N	F	A	2,030.10	5,300.37	571.69	2,793.94	1.92	>	1.5	0.36	<	1.23	12.87	7.09	<	22.60
	⑤	N	L	A	2,119.27	5,138.26	965.04	4,938.43	2.37	>	1.5	1.17	<	1.23	20.29	0.54	<	22.60
	⑥	N	N	A	2,572.36	6,272.13	803.16	3,893.74	1.76	>	1.5	0.30	<	1.23	15.76	9.52	<	22.60

Abbrev. N: normal, Q: quake in "Normal/quake"

F: at flood, L: at low water level, N: at no flow in "Water level"

F: flow direction, A: regulator axial direction in "Direction"

(8) Structural Analysis of Gate Pier

In general, a pier has enough length for loads to the flow direction, then structural analysis for the gate pier is not necessary in the flow direction. A reinforcement is arranged at minimum content, which is designed from examination in regulator axial direction, as additional bar. The most demanding load condition, which is gate-open and normal loads, is adopted for examination in the regulator axial direction.

① Loads

The pier weight that is worked from the bottom slab to upper parts of piers, the hoist weight, the reaction of regulator bridge and earth pressure are considered as load. And the gate is open on the safe side.

② Stress Calculation

The structure of the gate pier is calculated on assumption that the pier is a cantilever beam, which is fixed by the bottom slab. The axial load is excluded in the calculation of reinforcements, and an examination at the end of the pier, which is worked the most severe earth pressure, is adopted. The result of the calculation is shown in below.

1) Section size;

Width: b = 100.0cm, Section thickness: h = 140.0cm, Effective thickness: d = 130.0cm

2) Section force;

Bending moment: M = 118.98t_f-m/m, Axial force: N = 32.43t_f/m,

Sheering force: S = 41.60t_f/m

3) Arrangement plan of reinforcement bar

Required content of reinforcement bar: As' = 50.22cm^2/m

Diameter of reinforcement bar:		D 25mm	+	D 29mm
Pitch of reinforcement bar:		@ 200mm	+	@ 200mm
Proposed content of reinforcement bar:	As =	24.55cm^2/m	+	32.10cm^2/m = 56.65cm^2/m

4) Stress intensity;

Concrete compressive stress:	σ_c = 54kg_f/cm^2	<	σ_{ca} = 80kg_f/cm^2
Tensile stress of reinforce:	σ_s = 1,596kg_f/cm^2	<	σ_{sa} = 1,800 kg_f/cm^2
Sheering stress:	τ = 3.7kg_f/cm^2	<	τ_a= 8.0 kg_f/cm^2

2-2-2-2 **Protection Work for Canal Bed and Retaining Wall**

(1) Protection Work for Canal Bed

To prevent scour at downstream of the regulator, the energy of high-speed released water should be dissipated by the friction of the protection work sequentially, velocity at downstream on the protection work, shall be equal to the velocity of continued canal.

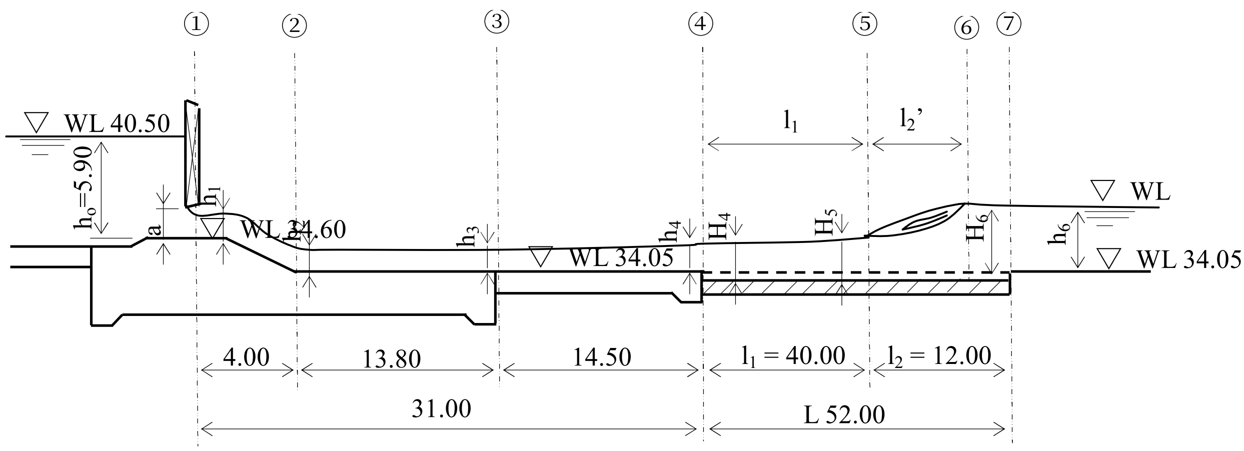
① Case A: Normal Case and Underflow Release

1) Underflow release

Released water at Dahab Regulator forms exposed jet flows when the canal depth at downstream is lower than the sub-critical flow side conjugate depth against the supercritical flow. When the head difference at up/downstream is the maximum before open gates, Dahab Regulator faces the worst case.

This examination of the protection work length is considered above hydraulic condition, and the length of the exposed jet flow and hydraulic jump is also examined at gate opening each 0.50m from 0.50 to 5.90m.

Figure 2-2-2.8 Examination of Length for Protection Work



2) Results

Results of the examination at underflow release are tabulated below.

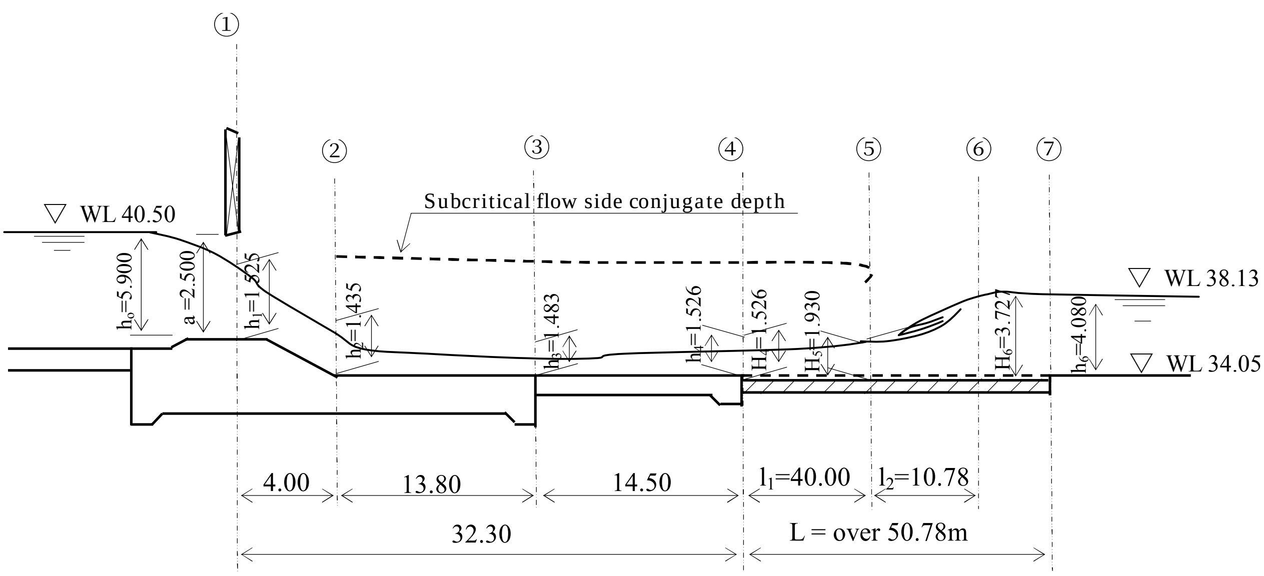
Table 2-2-2.9 Result of Examination of Underflow Release

Opening height	Discharge	Downstream Apron			Upstream end of rip-rap			Water depth of downstream	Flow Condition	Length of hydraulic jump
		Water depth	Veloc ity	Conjugate depth	Water depth	Velocity	Conjugate depth			
a (m)	Q (m^3/s)	h_4 (m)	V_4 (m/s)	H_{j5} (m)	H_5 (m)	V_5 (m/s)	H_{j5} (m)	H_6 (m/s)		l_2 (m)
0.50	25.55	0.407	7.85	2.067	1.711	0.34	-	< 1.711	Undulating jump	(1.95)
1.00	49.69	0.681	9.12	3.077	2.532	0.44	-	< 2.532	Undulating jump	(9.40)
1.50	72.36	0.964	9.38	3.707	1.400	6.65	2.823	< 3.153	Direct jump	8.54
2.00	93.48	1.247	9.37	4.144	1.660	7.30	3.350	< 3.658	Direct jump	10.14
2.50	112.97	1.526	9.25	4.457	1.930	7.58	3.727	< 4.080	Direct jump	10.78
3.00	130.76	1.803	9.07	4.671	2.205	7.72	3.991	< 4.436	Direct jump	10.71
3.50	146.72	2.070	8.86	4.816	2.480	7.68	4.165	< 4.738	Direct jump	10.11
4.00	160.75	2.325	8.64	4.903	4.990	0.64	-	< 4.990	Direct jump	(15.47)
4.50	172.69	5.197	0.66	-	5.197	0.66	-	< 5.197	Direct jump	(16.13)
5.00	182.36	5.360	0.67	-	5.360	0.67	-	< 5.360	Undulating jump	(14.85)
5.50	189.56	5.479	0.68	-	5.479	0.68	-	< 5.479	Undulating jump	(13.79)
5.90	193.36	5.540	0.68	-	5.540	0.68	-	< 5.540	Undulating jump	(13.19)

Accordingly, the required protection work length at underflow release is over $L = l_1 + l_2 = 40.00 + 10.78 = 50.78$m.

Figure 2-2-2.9 Hydraulic Conditions at Underflow Release

(Gate opening：a = 2.50m)



② Case B：Fully Gate Opening

If all gates are fully opened, the water level at downstream becomes higher than the critical depth at the regulator crest, submerged overflow is generated. The length of protection works is designed 10 to 15 times of water depth under gates at the maximum discharge.

$L_r = L - l_a$

$L = (10 \sim 15) \times H = (10 \sim 15) \times 5.90 = 59.00 \sim 88.50$m

where, L_r : Length of protection work (m)

L : Total length including length of apron (l_a) and length of protection (L_r) (m)

l_a : Length of downstream apron, l_a = 29.30m

H : Water depth under gates at maximum discharge (m)

H = U.H.H.W.L. 40.50m - EL. 34.60m = 5.90m

As above, the length of protection works is decided as follow.

$L_r = (59.00 \sim 88.50) - 32.30 = 26.70 \sim 56.20$m.

③ Case C：Empirical Equation

The length of protection works shall be examined from Bligh's equation.

$L_r = L - l_a$

$L = 0.67 \cdot C \cdot \sqrt{\Delta H \cdot q} \cdot f$

where, L_r : Length of protection work (m)

L : Total length including length of apron (l_a) and length of protection work (L_r), (m)

l_a : Length of downstream apron, l_a = 32.30m

ΔH : Maximum head difference at up/downstream (m)

ΔH = W.L. 40.50m - Min. D.W.L. 36.23m = 4.27m

q : Discharge per unit width at maximum discharge, (m^3/sec/m)

$q = 210.15 / (8.00 \times 4) = 6.57$ m^3/sec/m

$L = 0.67 \times 15 \times \sqrt{4.27 \times 6.57} \times 1.5 = 79.85$m

The length of protection works is decided on L_r = 79.85 – 32.30 = 47.55m.

④ Decision of Length of Protection Work

The result of each examination is shown in below.

Case	Required length of protection work	Designed length of protection work
Case A：Underflow release	Over 50.78m	52.00m
Case B：Fully gate open	26.70 ～ 56.20m	
Case C：Bligh's equation	47.55m	

Therefore, the length of protection work is designed 52.00m.

(2) Retaining Wall

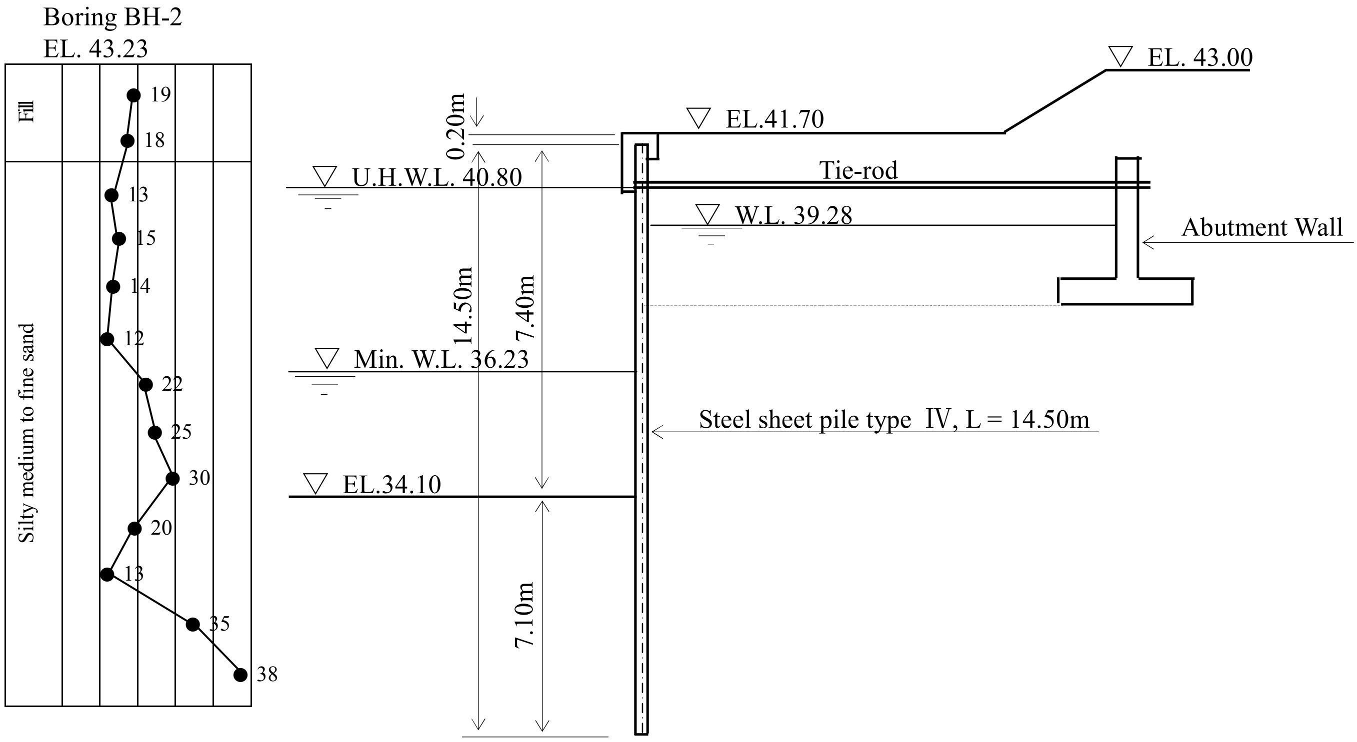
① Retaining Wall of Steel Sheet Pile

The steel sheet pile retaining wall is determined on tie-rod type taking account of shapes of structures, conditions of the foundation and workability etc. External force to steel sheet pile is earth pressure, residual water pressure and overburden pressure of back of sheet pile.

The length of the required penetration depth will be designed from the examination of a balance of "Overturn moment" and "Residence moment" and examination of boiling. The type of steel sheet piles will be adopted from the examination of the stress and the deflection, so the designed steel sheet piles are as follows.

Name of Retaining Wall	Unit	Upstream Retaining Wall on Left Bank	Downstream Retaining Wall on Left Bank
Crest elevation of wall	m	EL. 41.70	EL. 40.40
Bottom elevation of canal	m	EL. 34.10	EL. 33.35
Height of retaining wall	m	7.60	7.05
Required penetration depth (moment)	m	6.71	6.09
(boiling)	m	1.43	1.05
Required length of steel sheet pile	m	14.50	13.00
Maximum bending moment	tf-m	49.43	36.56
Maximum sheering force	tf	15.95	13.66
Type of steel sheet pile	-	Type-IV	Type-IV
Maximum bending stress	kgf/cm^2	1,794	1,327
Allowable bending stress	kgf/cm^2	1,800	1,800
Maximum sheering stress	kgf/cm^2	69	59
Allowable sheering stress	kgf/cm^2	1,000	1,000
Maximum deflection	cm	3.9	2.3
Allowable deflection	cm	5.0	5.0

Figure 2-2-2.10 Typical Cross-section of Upstream Retaining Wall of Steel Sheet Pile on Left Bank



② Rip-rap (slop protection)

The slope of Bahr Yusef Canal is planned to 1:1.5, however, the slope around the regulator is designed 1:2.0 considering flows disturbance by the Regulator.

And, the required weight of rip-rap for the slope (weight per a stone) is determined considering wave height, slope and masonry type. Hadson's equation is adopted to calculations (refer to Agricultural civil engineering handbook).

$$W = (\gamma_r \cdot H^3) / [K_d \{(\gamma_r / \gamma_w) - 1\}^3 \cot\alpha]$$

where,
- W : Weight of rip-rap on slope, (t)
- γ_r : Unit weight of riprap, $\gamma_r = 1.8 tf/m^3$
- γ_w : Unit weight of water, $\gamma_w = 1.0 tf/m^3$
- α : Slope gradient, $\alpha = 1 : 2.0 = 26°34'$
- H : Wave height before slope, H = 0.50m
- Kd : A constant dependent of material, Kd = 4.0

$$W = (2.65 \times 0.50^3) / [4.0 \times \{(1.8/1.0) - 1\}^3 \times \cot 26°34']$$
$$= 0.331 / 4.096$$
$$= 0.081t = 81kg$$

Calibrating the weight into the size of round boulders, the volume becomes 31,200cm^3 by applying a unit weight of 2.6 and diameter becomes 19.53cm by assuming a sphere-shape.

$V = 4.189 R^3$

where, V: Volume of stone (t)

R: Mean radius (cm)

Therefore, $R = (31{,}200 / 4.189)^{1/3} = 19.53$cm. And the mean diameter of the stone for rip-rap is designed on 40cm (diameter: 30～50cm).

③ Closure Dike

During construction, required water is released by existing gates on right bank side, canal flow is delivered and existing one shall be closed after completion of new regulator. The shore protection for the closure dike shall be examined with following three (3) types.

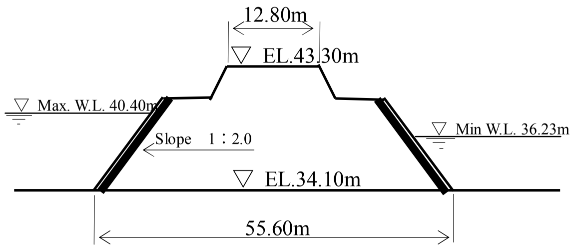
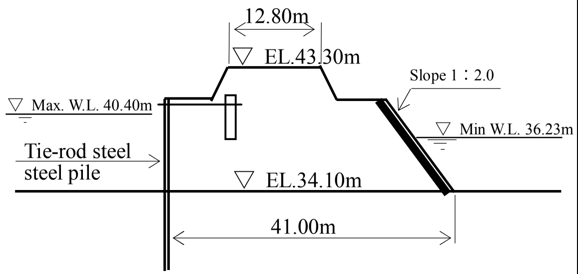
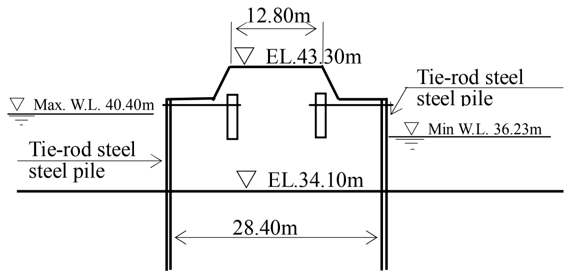
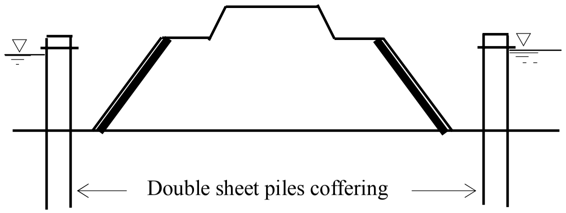
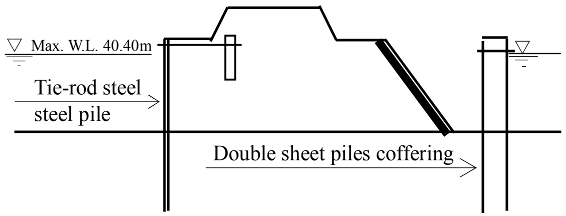
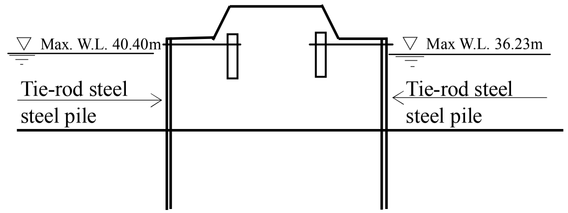
1) Rip-rap on both side of dike: Both slopes of dike are covered with rip-rap. The construction area for the dike shall be closed with double sheet pile coffering. A part of the existing regulator shall be demolished before backfilling and installation of rip-rap.

2) Steel sheet piles and rip-rap: Upstream shore of the dike shall be protected by the tie-rod type steel sheet piles which are used on temporary embankments. Downstream shore of the dike shall be protected by rip-rap. A canal flow is diverged after closing by tie-rod steel sheet piles and backfilling at upstream, and by double steel sheet piles at downstream. A part of the existing regulator shall be demolished before mentioned works.

3) Steel sheet piles on both side of dike: The both sides of the dike shall be protected by the tie-rod steel sheet piles, which are used on the temporary embankments. An installation of the sheet piles and diversion are carried out after banking for sheet piles works, and then abutment and tie-rod are installed. And the existing regulator shall be demolished and backfill is executed.

As a result of the examination, the steel sheet piles on both sides of the dike, which is no need the coffer dam, are selected taking economic, construction period, workability and environmental impact as shown in Table 2-2-2.10.

Table 2-2-2.10 Alternative Plan for Closure Dike Protection

Description	Plan 1: Riprap on Both Sides of Dike	Plan 2: Steel Sheet Pile on Upstream of Dike, Riprap on Downstream	Plan 3: Steel Sheet Piles on Both Sides of Dike
Structure			
Temporary closure work			
Direct construction cost	3.00 million L.E.	2.61 million L.E.	2.23 million L.E.
Work period	5.0 months	4.5 months	3.0 months
Safety and Workability	- Due to the height of riprap is 7.60m, it is unstable structurally. - Double sheet piles are required for the construction of both sides.	- Due to the height of riprap at downstream is 6.35m, it is unstable structurally. - Double sheet pile is required at downstream for banking work of closure dike.	- Tie-rod steel sheet pile has been used for long time. - Tie-rod steel pile for temporary closure is reused, and double sheet piles are not need.
Evaluation	×	△	○

2-2-2-3 Gate Section

(1) Gate Type

The overflow above upper gate types shall be selected due to delicate water level and discharge control. In the overflow gate type, a slide type of the double leaf roller gate is adopted due to release design maximum discharge of 210.15m^3/sec by overflow release.

(2) Hoisting Device for Gates

① Power Unit

With regard to power units of gate hoisting devices, the following prescript is in the hydraulic Gate and Penstock Standard of Japan.

Article 34 Gates have to be equipped with a power unit, which is able to operate gates quickly, absolutely and easily at any time. The power unit should be electric in principle.

Also, there are descriptions in the "Standard for Dam and Weir Equipment, 3-1-6 Power unit for operation machine", and they are following

1) Gates have to be equipped with a power unit that is able to open and close gates absolutely.
2) The power unit should be electric in principle.
3) Power units for gate operations have to fulfill required output, torque that is suited to purpose of gates and time rating etc.

Meanwhile, the buck-up power unit is defined in the "Gate and Penstock Standard of Japan".

Article 35: Gates that are needed to operate for water release at flood, have to be equipped with the buck-up power unit for gate operation. Buck-up power units have to be able to operate gates quickly, absolutely and easily when the main power unit would be gone down.

And, there are following descriptions in the "Standard for Dam and Weir Equipment, 3-1-7 Buck-up power unit for operation machine".

1) Gates have to be equipped with a buck-up power unit in principle.
2) Buck-up power unit must have a capacity and structure that are able to operate gates quickly, absolutely and easily when the main power unit would have troubles.
3) Buck-up power unit must be adopted the most suitable type considering the importance of gates, conditions of the installation and maintenance system.

Based on these descriptions, the power unit for hoisting device is employed the low cost public electric power. A diesel generator is installed for buck-up power units. A hand hoisting device is planned in the preparation for accidents of the electric system, however, the diesel generator is not suitable for long gate operations, therefore, it is for water level adjustments at emergency and for fine adjustments at maintenance.

(3) Design Specification of Gates

Design specifications of gates are as follows.

Table 2-2-2.11 Design Specifications of Gates of Dahab Regulator

Type		Steel double leaf roller gate
Number of gate		4 gates
Clear span		8.00m
Gate height		Upper leaf：2.80m + Lower leaf：3.10m Total height：5.90m
Design water level	Front	U.H.H.W.L. 41.00m
	Rear	EL. 34.60m
Operation water level	Front	U.H.W.L. 40.80m
	Rear	EL. 34.60m
Control water level	Front	Max. U.W.L. 40.40m
	Rear	Min. D.W.L. 36.23m
Gate sill		EL. 34.60m
Lifting height		EL. 41.70m – EL. 34.60m = 7.10m
Water seal method		Three way, rubber seal
Hoisting type		Electric powered wire rope winding type（1M-2D）
Operation speed		over 0.3m/min.
Operation type		Local and remote control

2-2-2-4 Regulator Bridge

(1) Design Condition

① Width of Regulator Bridge

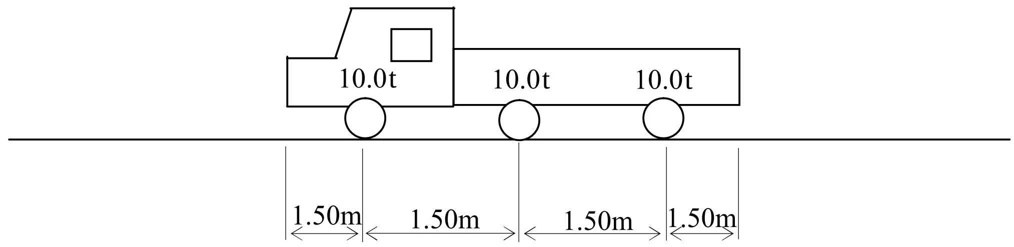
The width of the bridge is as follows,

For vehicles:	2.5m x 2 lines	=	5.0m
For carriage and bicycle:	1.5m x 2 lines	=	3.0m
For side-walk:	1.0m x 2 lines	=	2.0m
For guardrail:	0.4m x 2 lines	=	0.8m
Total width:		=	10.8m

② Live Loads on the Bridge

Thanks to the discussion with ISS, the live load of the regulator bridge is determined on 60 ton, and it is the standard load for a main local road, according to " Egyptian Code for Loading in Construction of Building, Roadway Bridge and Railway Bridge ". Above live load condition is shown in below.

Figure 2-2-2.11 Live Load Condition at Regulator Bridge



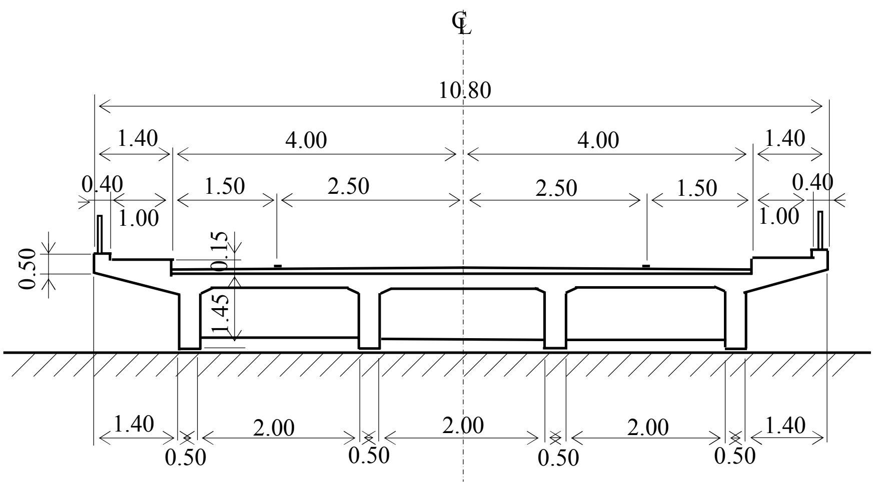
(2) Regulator Bridge Type

The dimension of the regulator bridge is span: 10.0m x width: 10.8m x 4 spans. The type of beams shall be adopted reinforced concrete T-beam, which is time-proven in Japan

(3) Standard Cross-section of Regulator Bridge

Standard cross-section of the regulator bridge is decided as follow.

Figure 2-2-2.12 Standard Cross-Section of Regulator Bridge



2-2-2-5 Control House

The control house will be constructed by undertaking of Egyptian side. The control system for remote control of gates and emergency generator will be installed in the control house. Therefore, the control house should be designed carefully under responsibility of Egyptian side to against above mentioned additional load. Required design condition of control house will be proposed as follows.

(1) Design Condition

① Components of Control House

Components of the control house and space are designed as below.

Structure	Space	Remarks
1) Remote operation room	6.0m x 6.5m (approx.)	
2) Emergency generator	6.0m x 3.0m (approx.)	
3) Stock room	6.0m x 3.5m (approx.)	
4) Kitchen and bathroom	3.6m x 1.1m (approx.)	A part of remote operation room

(2) Structure of Control House

The control house is designed to one-stored, RC piers and block wall structure, which has been adopted for a long time in Egypt.

Continuously, a direct reinforced concrete foundation (width: 1.50m x height: 2.50m) is employed for foundation works, because the foundation of the control house is Nile deposit (silty medium to fine sand) which N-value is 12.

The structure of the control house is indicated in Figure-8, 9 in 2-3 Basic Design Drawing.

2-2-2-6 Control Panel

(1) Remote Control Panel

Configurations of the remote control panel are shown in below.

Item	Specification	Remarks
1) Upper gate operation button	Button for up, stop and down operation	For No.1～No.4 gate
2) Lower gate operation button	Button for up, stop and down operation	For No.1～No.4 gate
3) Buzzer stop button		
4) Lump test button		
5) Upper gate opening indicator	Digital display (unit: cm)	For No.1～No.4 gate
6) Upper gate opening indicator	Analog display (unit: 50 cm)	For No.1～No.4 gate
7) Lower gate opening indicator	Digital display (unit: cm)	For No.1～No.4 gate
8) Lower gate opening indicator	Analog display (unit: 50 cm)	For No.1～No.4 gate
9) Upstream water level gauge	Digital display (unit: cm)	
10) Downstream water level gauge	Digital display (unit: cm)	

11) Release discharge meter	Digital display (unit: m^3/sec)	Total of No.1～4 gate
12) Accumulative release discharge meter	Digital display (unit: m^3/sec)	
13) Automatic recorder	For water level, gate opening & discharge	
14) Emergency stop button		
15) Local telecommunication		

(2) Local Control Panel

If four local control panels are packed into one cabinet, it would become oversize. Panels for No1 and No.2 are installed to one cabinet, and No.3 and No.4 are done to one another.

The configuration of a local control panel is shown in below.

Item	Specification	Remarks
1)Upper gate operation button	Button for up, stop and down operation	For No.1～No.4 gate
2)Lower gate operation button	Button for up, stop and down operation	For No.1～No.4 gate
3)Buzzer stop button		
4)Lump test button		
5)Upper gate opening indicator	Digital display (unit：cm)	For No.1～No.4 gate
6)Upper gate opening indicator	Analog display (unit：50 cm)	For No.1～No.4 gate
7)Lower gate opening indicator	Digital display (unit：cm)	For No.1～No.4 gate
8)Lower gate opening indicator	Analog display (unit：50 cm)	For No.1～No.4 gate
9)Upstream water level gauge	Analog display (unit：50 cm)	
10) Downstream water level gauge	Analog display (unit：50 cm)	
11) Voltage indicator	Analog display (unit：50 V)	
12) Ampere meter	Analog display (unit：5 A)	For No.1～No.4 gate
13) Operation location selection button	Choice between Local operation and Remote operation	
14) Operation mode button	Choice between Normal and Emergency	
15) Emergency stop button		
16) Reset button		
17) Local telecommunication		

2-2-2-7 Specification and Quantity of Miscellaneous Equipments

(1) Side Frame and Sill Beam of Spare Gates (Stop Logs)

It considers as a plan to divert the spare gate of Lahoun Regulator, which is already rehabilitated, so that Main Gate is recoated by the frequency of a grade at once at ten years. The side frames and sill beams of spare gates (stop logs) shall be installed for Dahab Regulator.

The specification and quantity of spare gates (stop logs) are as follows.

Table 2-2-2.12 Design Specifications of Side Frame and Sill Beam of Spare Gates (Stop Logs)

Item		Specification & quantity	Remarks
1) Type		Steel stop log	
2) Number of gate		4 gates	Eight (8) parts
3) Clear span		4.00m x 2 spans	
4) Gate height		5.90m	1.25m x 1 leaf + 1.55m x 3 leaves
5) Design water level	Front	U.H.W.L. 40.80m	
	Rear	EL. 34.60m	
6) Operation water level	Front	U.H.W.L. 40.80m	
	Rear	EL. 34.60m	
7) Control water level	Front	Max. U.W.L. 40.40m	
	Rear	Min. D.W.L. 36.23m	
8) Gate sill		EL. 34.60m	
9) Operation type		Electric chain hoist	at gate pier

(2) Emergency Generator

The specification and quantity of the emergency generator and its engine are as follows.

Item	Specification & quantity	Remarks
1) Type	Indoor Soundproof Type	
2) No. of generator	1 unit	
3) Output rating	65 kVA	
4) No. of Phase	3-phase, 4-wire system	
5) Voltage	380V/220V, 50Hz	
6) Rated Speed	1,500rpm	
7) Power Factor	0.8 (Lagging)	
8) Voltage Regulation	within ± 1.5%	
9) Dimensions	1,300H x 2,630W x 1,000D	