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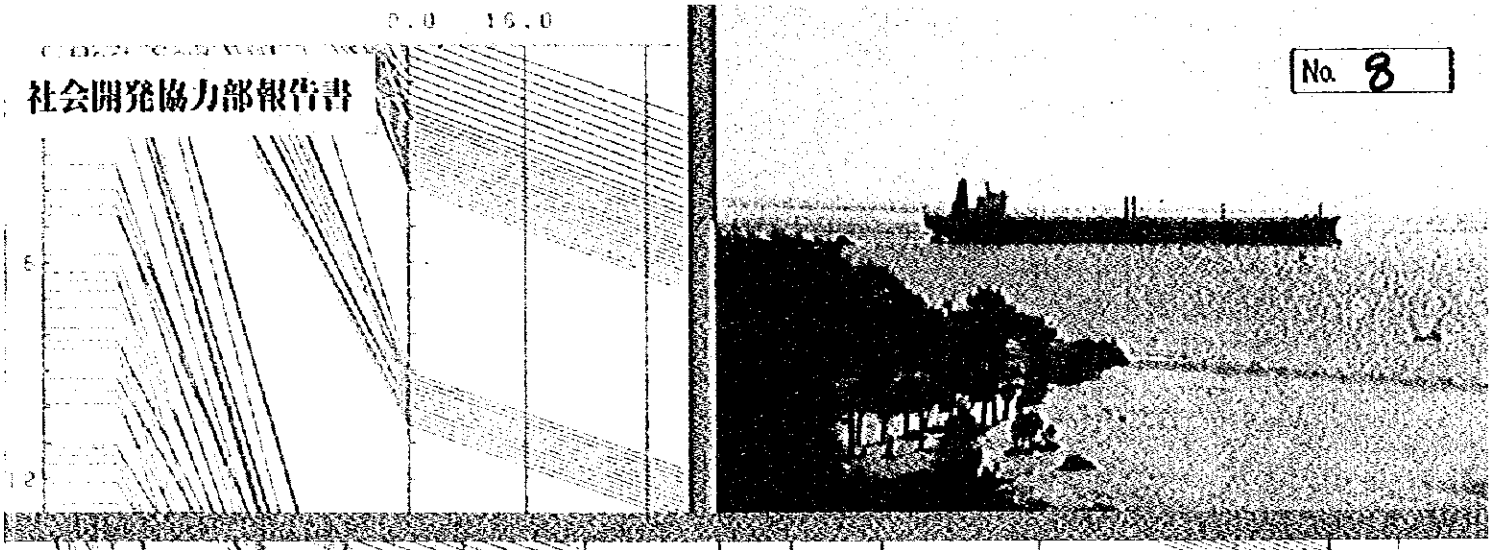
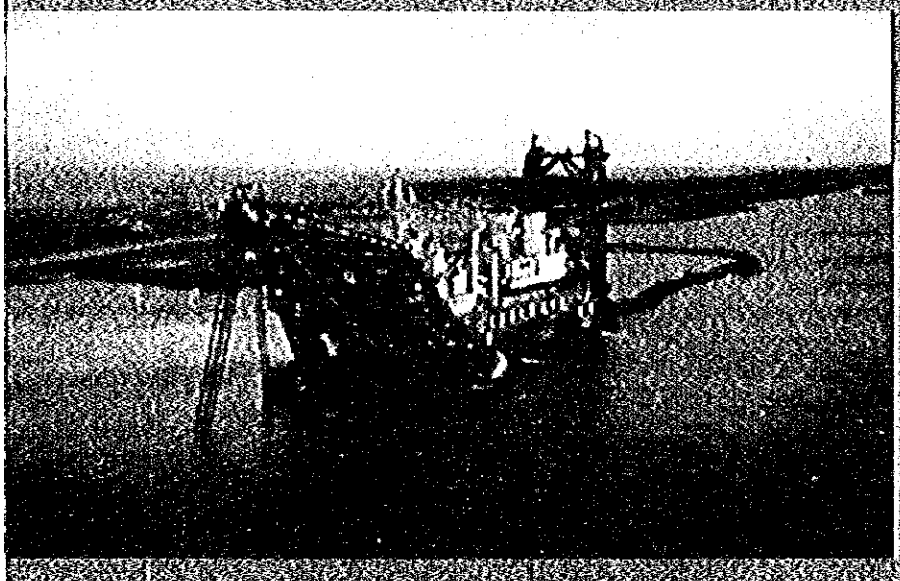
No. 8

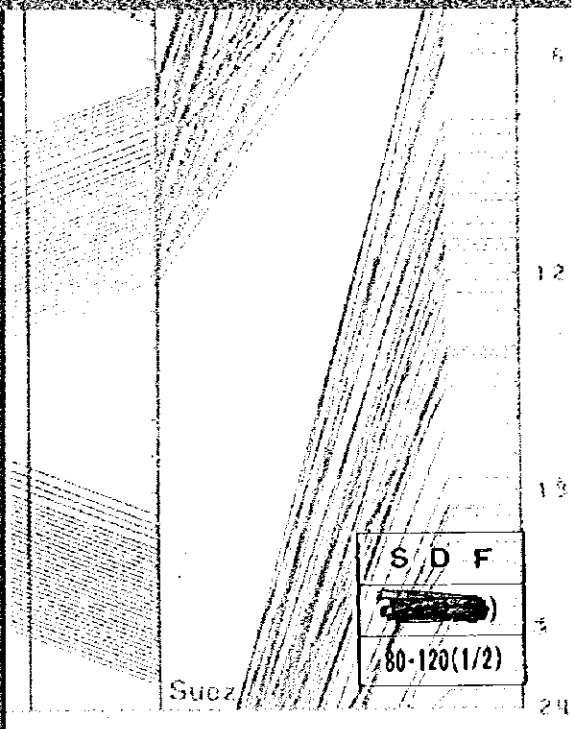


ARAB REPUBLIC OF EGYPT

FEASIBILITY STUDY REPORT ON THE SECOND STAGE DEVELOPMENT PROJECT OF THE SUEZ CANAL

JULY 1980



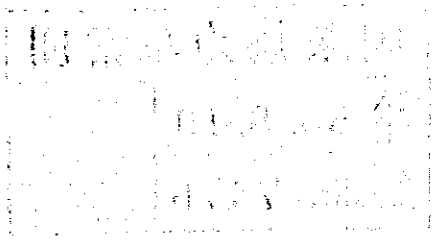


JAPAN INTERNATIONAL COOPERATION AGENCY

ARAB REPUBLIC OF EGYPT

FEASIBILITY STUDY REPORT ON THE SECOND STAGE DEVELOPMENT PROJECT OF THE SUEZ CANAL

JULY 1980



PREFACE

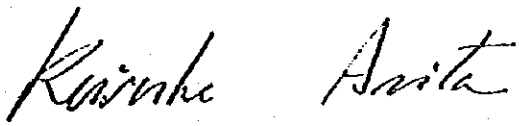
In response to the request of the Government of the Arab Republic of Egypt, the Japanese Government decided to conduct a feasibility study on the Second Stage Development Project of the Suez Canal and entrusted the Japan International Cooperation Agency with the study. The J.I.C.A. organized a steering committee headed by Mr. Susumu Maeda, Director, Construction Division, Bureau of Ports and Harbors, Ministry of Transport and a survey team headed by Mr. Takashi Hazama, Executive Director, The Overseas Coastal Area Development Institute of Japan. The survey team was dispatched to Egypt in December 1979.

The team, in consultation with the officials concerned of the Suez Canal Authority, conducted a field survey. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

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

July 1980



Keisuke Arita
President
Japan International Cooperation Agency

Letter of Transmittal

Mr. Keisuke Arita,
President, Japan International Cooperation Agency

Dear Sir,

It is my great pleasure to submit herewith to you the Feasibility Study Report on the Second Stage Development Project of the Suez Canal.

This report incorporates the results of studies which The Overseas Coastal Area Development Institute of Japan, Japan Maritime Research Institute and Mitsubishi Research Institute, Inc. have jointly carried out at the request of the Japan International Cooperation Agency.

Regarding this project, our study team has conducted a field survey in Egypt for the period of 15 days from 4 December, 1979, and on the basis of the findings of this survey as well as based on the data and information collected in Japan we have formulated plans for the development of the Suez Canal which are considered desirable to be implemented in succession to the First Stage Development Project. Also, a study was made to examine the feasibility of the project from technical, economic and financial viewpoints. As regards the questions raised after presentation of the draft report, an additional report was prepared to supplement the main study report.

We believe that the development project of the Suez Canal as proposed in this report is of an urgent necessity judging from the forcast of the Canal transits and at the same time feasible both technically, economically and financially. In the light of the importance of the Canal as an international shipping route we earnestly hope that measures will be taken to implement this project as early as possible.

On behalf of the study team, let me express my heartfelt thanks to the Suez Canal Authority and other related authorities of the Egyptian government for the generous cooperation, assistance and warm hospitality which our study team had the pleasure of enjoying during its stay in Egypt.

Our thanks are also due to the Japan International Cooperation Agency, the Ministry of Transport, the Ministry of Foreign Affairs and the Japanese Embassy in Cairo for their valuable advice and support given to us in the field survey and in the preparation of this study report.

July 1980

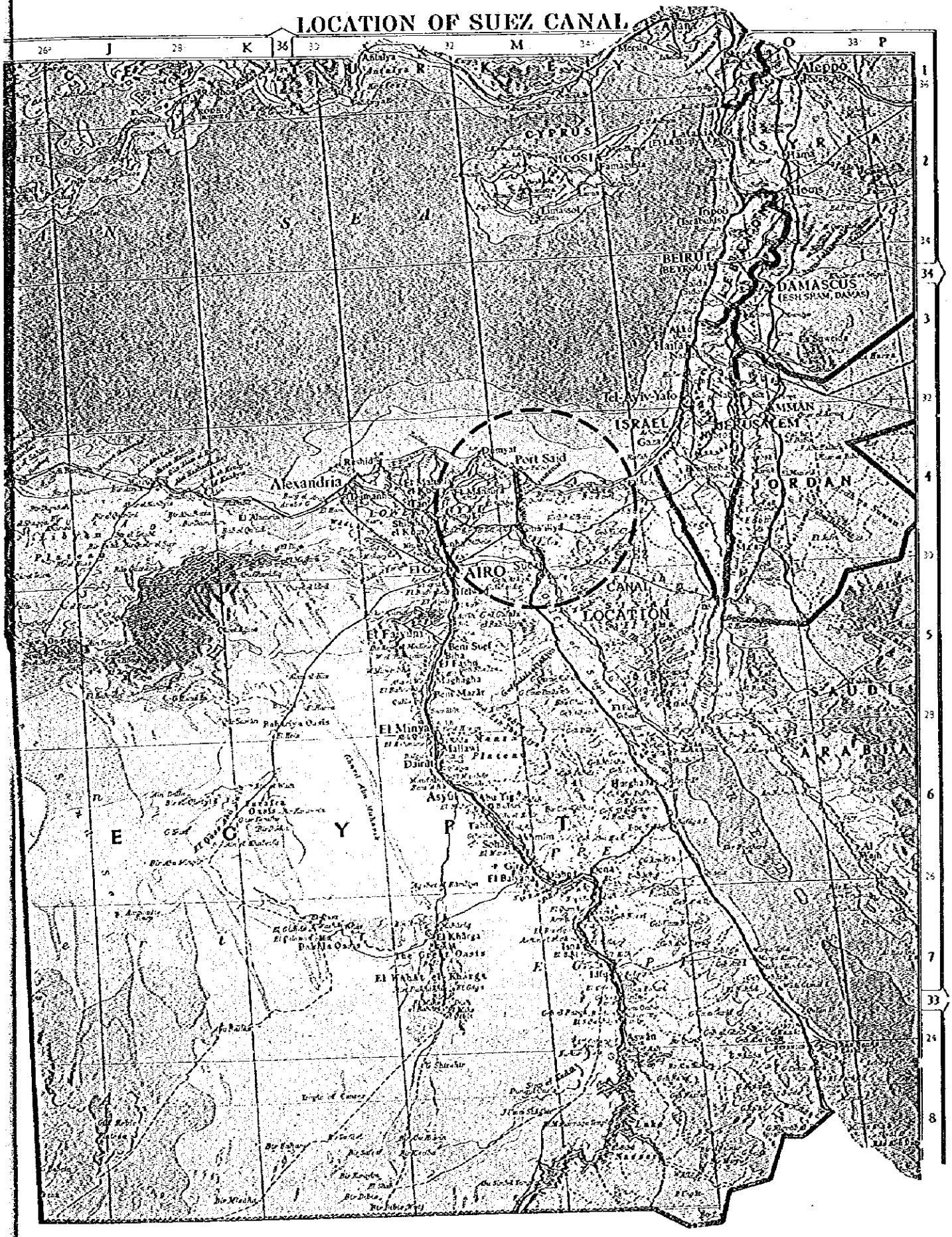
Yours faithfully,

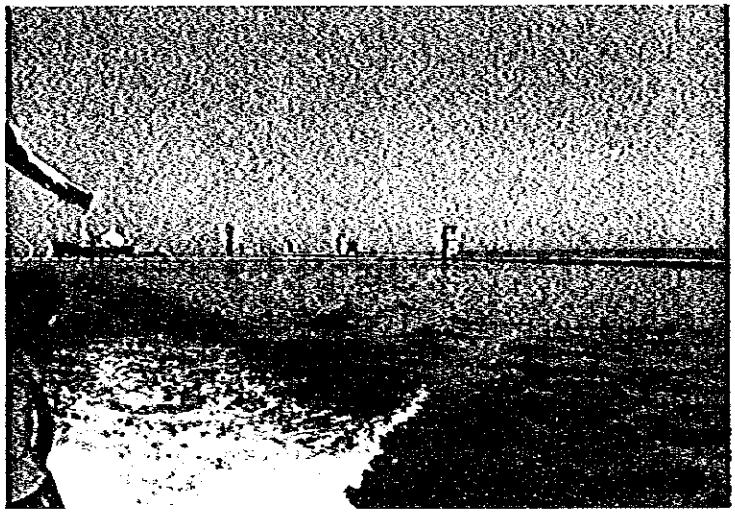
T. Hazama

Takashi Hazama,
Head, Japanese Study Team
for the Second Stage Development
Project of the Suez Canal

(Executive Director,
The Overseas Coastal Area
Development Institute of Japan)

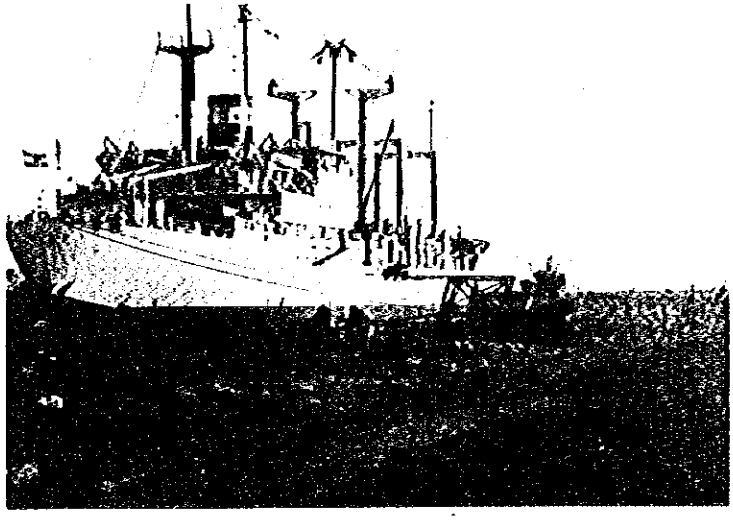
LOCATION OF SUEZ CANAL



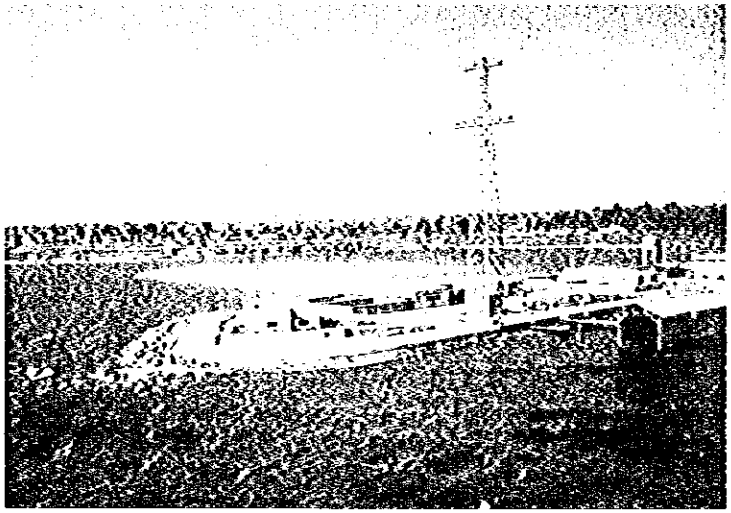


Port Said East Breakwater

New Port Said Bypass

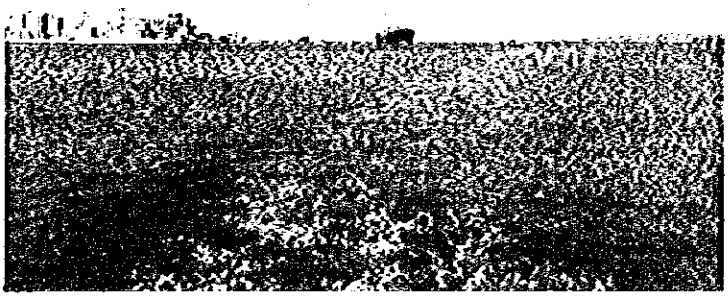


Ballah Bypass



Signal Station

Great Bitter Lake



Suez Entrance

Exchange Rate

US$1.00 = LE 0.69 = Yen 240

US$1.30 = SDR1.00

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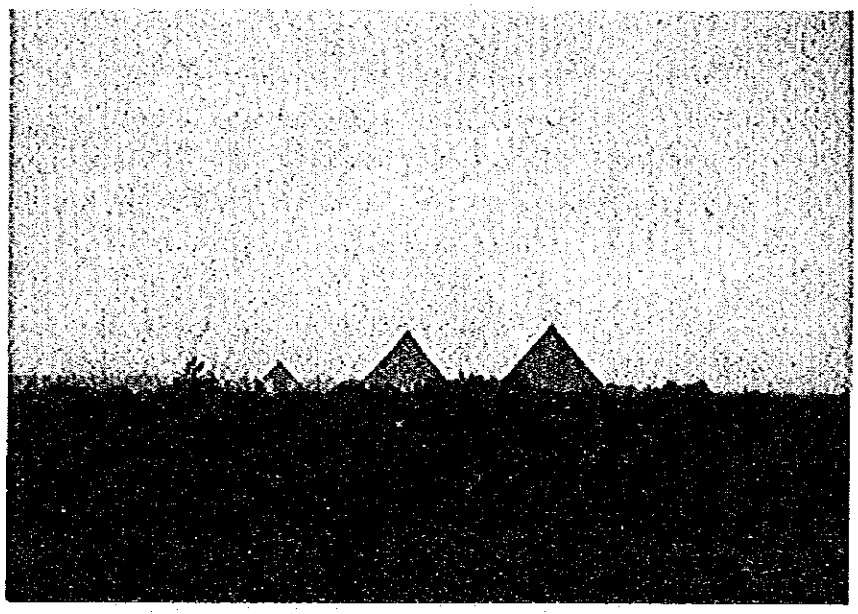


Conclusion

CONCLUSION

1) The two plans of the Second Stage Development Project of the Suez Canal to be implemented continuously after the First Stage Development Project are studied.: They are:
   (1) A Canal doubling plan geared to handle the increasing vessel traffic, and
   (2) A Canal doubling and widening plan not only to handle the increasing vessel traffic but also very large tankers in ballast up to 500,000 DWT by widening the west channel.

Doubling Plan

2) The purpose of the doubling plan, as different from a deepening or widening plan of the Canal to accommodate large tankers, is to increase the transit capacity of the Canal to meet the future increases. As this doubling will not modify the maximum possible size of transiting vessels, the vessels using the canal under the doubling plan alone are the same size as in the First Stage Development Project, that is, 150,000 DWT tankers fully laden and 350,000 DWT tankers in ballast.

3) The outline of the study on doubling the Canal is as follows:
   (1) Forecast of Traffic Demand

Year	Real Ships Ships/day	Standard Ships Ships/day
1978	58	53
1981	72	66
1985	84	75
1990	103	93
1995	120	107
2000	140	123

Note: Standard ships are converted from real ships in terms of a time interval of 10 minutes.

(2) Outline of the Second Stage Project

Phase	Section Doubled	Year of Completion	Transit Capacity* (Standard ships/day)
Phase I, Step 1	km 61–95 (Km 61–73.4 West channel) (Km 73.4–95 East channel)	1984 at the latest	87
Phase I, Step 2	Km 16–51 East channel Km 122–135 West channel	1987 at the latest	98
Phase II	km 135–162 (Km 135–144 West channel) (Km 144–162 East channel) Km 0–16 West channel West approach channels (Suez, Port Said)	1994 at the latest	248

* The transit capacity of existing Canal after the First Stage Project is 65 standard ships/day.

(3) Construction Cost of the Second Stage Project

Phase	Work Volume ($10^6 m^3$)		Construction Cost		
	Dredging	Dry Excavation	Local Currency 10^6 LE	Foreign Currencies 10^6 $	Total 10^6 $
Phase I, Step 1	141.8	99.0	157	183	411
Step 2	187.5	48.0	119	124	296
Total	329.3	147.0	276	307	707
Phase II	226.5	79.0	164	236	473
Total	555.8	226.0	440	543	1,180

Note: (1) The construction cost includes the cost of civil works and nagivation aids and tug boats.
(2) Cost as of September 1979.
(3) 1US$ = 0.69LE = 240 Yen
(4) No price escalation is included.

(4) Canal Revenue

(10^6 US$)

	1980	1985	1990	2000
a) Existing	785.2	833.1	833.1	833.1
b) Phase I	785.2	1,021.6	1,290.6	1,290.6
(Total doubling project)	(785.2)	(1,021.6)	(1,290.6)	1,730.3
c) Increase (b–a)				
Phase I	0	188.5	457.5	457.5
(Total doubling project)	(0)	(188.5)	(457.5)	(897.5)

(5) Evaluation of the Project

a) Economic evaluation

Internal rates of return expected by the doubling plan are as follows:

	National Economy	World Economy
(1) Phase I	24.2%	49.8%
(2) Total doubling project	23.8%	49.0%

b) Financial evaluation

A financial rate of return expected by Phase I is as follows:

FRR 17.3%

Doubling and Widening Plan

4) The doubling and widening plan combines doubling the Canal with widening the west channel of the Canal to accommodate up to 500,000 DWT tankers in ballast.

5) The outline of the doubling and widening plan is as follows:

(1) Traffic Forecast

Widening the west channel permits the southbound transit of up to 500,000 DWT tankers in ballast and increases the number of transiting ships by 0.16 ships/day in 1985, 0.24 ships/day in 1990, 0.28 ships/day in 1995 and 0.30 ships/day in 2000 compared with the doubling plan alone. The above values are the potential number of transiting ships.

(2) Outline of the Doubling and Widening Plan

The doubling and widening plan as the Second Stage Development Project is summarized as follows:

Under Phase I of the Second Stage Development Project, some sections of the existing channel which will become the west channel after the Canal is completely doubled are widened, however the other sections of the channel will not be widened until Phase II. Therefore, no large tankers over 350,000 DWT in ballast can transit, until the construction is completed in 1988.

Phase	Section Doubled	Section Widened	Year of Completion
Phase I, Step 1	Km 61–95 (Km 61–73.4 West channel) (Km 73.4–95 East channel)	Km 16–61 West channel Km 73–122 West channel Km 145–162 West channel	1984 at the latest
Step 2	Km 16–51 East channel Km 122–135 West channel		1987 at the latest
Phase II	Km 135–162 (Km 135–144 West channel) (Km 144–162 East channel) Km 0–16 West channel West approach channels (Suez, Port Said)	Approach channel (Suez)	1994 at the latest and the completion of widening the west channels in 1988

(3) Construction Cost of Second Stage Project

Phase	Work Volume ($10^6 m^3$)		Construction Cost		
	Dredging	Dry Excavation	Local Currency 10^6LE	Foreign Currencies $10^6$$	Total $10^6$$
Phase I, Step 1	175.8	99.0	161	217	450
Step 2	189.7	48.0	133	131	323
Total	365.5	147.0	294	348	773
Phase II	234.9	79.0	164	241	479
Total	600.4	226.0	458	589	1,252

Note: (1) The construction cost includes the cost of civil works and navigation aids and tug boats.
(2) Cost as of September 1979
(3) 1US$ = 0.69LE = 240 Yen
(4) No price escalation is included

(4) Canal Revenue

Additional revenue expected by over 350,000 DWT tankers in ballast is forecast to be 29 million US$ in 1989, 30 million US$ in 1990 and 38 million US$ in 2000.

(5) Evaluation of the Project

a) Economic evaluation

Internal rates of return expected by the doubling and widening plan are as as follows:

	Doubling and Widening Plan	Doubling Plan
Phase I	22.7%	24.2%
Total doubling project	23.4%	23.8%

b) Financial evaluation

A financial rate of return expected by Phase I is as follows:

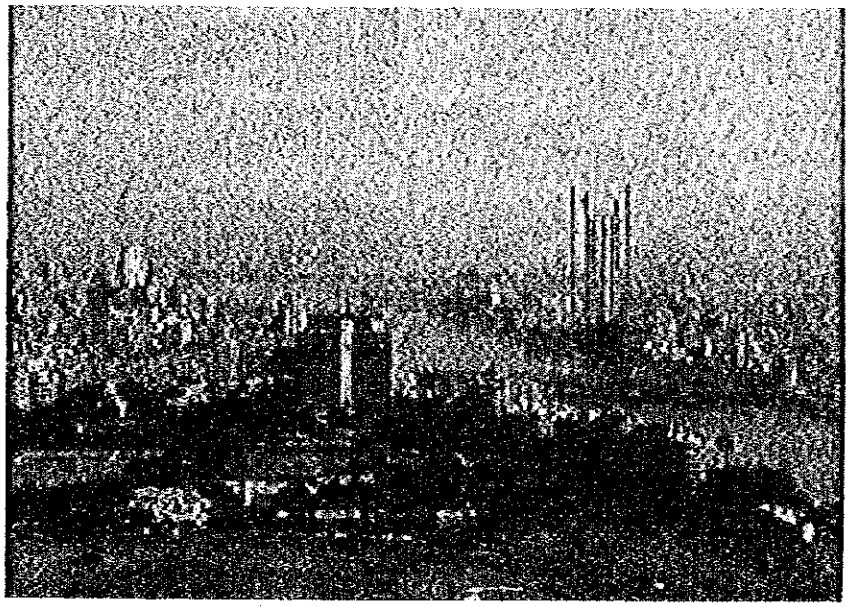
	Doubling and Widening Plan	Doubling Plan
FRR	15.8%	17.3%

6) Judging from the above, it is concluded that the doubling plan as well as the doubling and widening plan is, if they are implemented step by step, very feasible.

7) According to the traffic demand forecast, after the completion of the First Stage Development Project, some transiting ships will be required to wait from 1981, and delays in entering the Canal will reach a chronic state in 1984. Accordingly, it will be necessary to complete the doubling of the section Km 51–122 by 1984, and section Km 0–135 by 1987 at the latest. This shall be pursued as Phase I of the Second Stage Development Project.

If Phase I can be completed at an early stage for the unexpected increases of demand in the future, the occurrence of a ships waiting may be reduced or avoided and, at the same time, the risk of decline in the Canal revenue due to the diversion of large-sized vessels to the Cape route may also be prevented.

8) Good investment effects also may be expected from the plan to implement the total doubling scheme at the earliest possible time if the world economy grows in stable condition. Early implementation of the doubling will lead to the reduction in waiting hours at both ends of the Canal, and in addition will result in such uncalculated effects as the prevention of the Canal closure due to marine accidents.



Summary

Summary

Contents

CHAPTER 1 INTRODUCTION OF THE STUDY

In response to the request of the Government of the Arab Republic of Egypt, the Government of Japan has agreed to undertake the feasibility study of the Second Stage Development Project of the Suez Canal as a part of its technical cooperation program.

The study shall develop a master plan of the Suez Canal and prepare phased plans of the Second Stage Development Project to meet the increasing traffic demands after the completion of the First Stage Development Project, and evaluate the feasibility of these phased plans from technical, economic and financial viewpoints.

1. Objective of Study

The objective of the study is to prepare a feasibility report on the Second Stage Development Project of the Suez Canal to be implemented continuously after the completion of the First Stage Development Project.

2. Outline of the Study

1) Forecast of Canal Traffic
2) Formulation of Master Plan
3) Preparation of Phased Plans of the Second Stage Development Project
4) Study of Transit Capacity
5) Study of Technical Aspects
6) Construction Plan and Cost Estimates
7) Analysis of Canal Toll
8) Economic Analysis
9) Financial Analysis

3. Method and Organization

(1) Method of Study

A flow chart of the study is shown in Fig. 1.

(2) Organization of Study

Japan International Cooperation Agency consigned the study to the following three parties:
The Overseas Coastal Area Development Institute of Japan,
Japan Maritime Research Institute, and
Mitsubishi Research Institute, Inc.

This study is made jointly by the three parties.

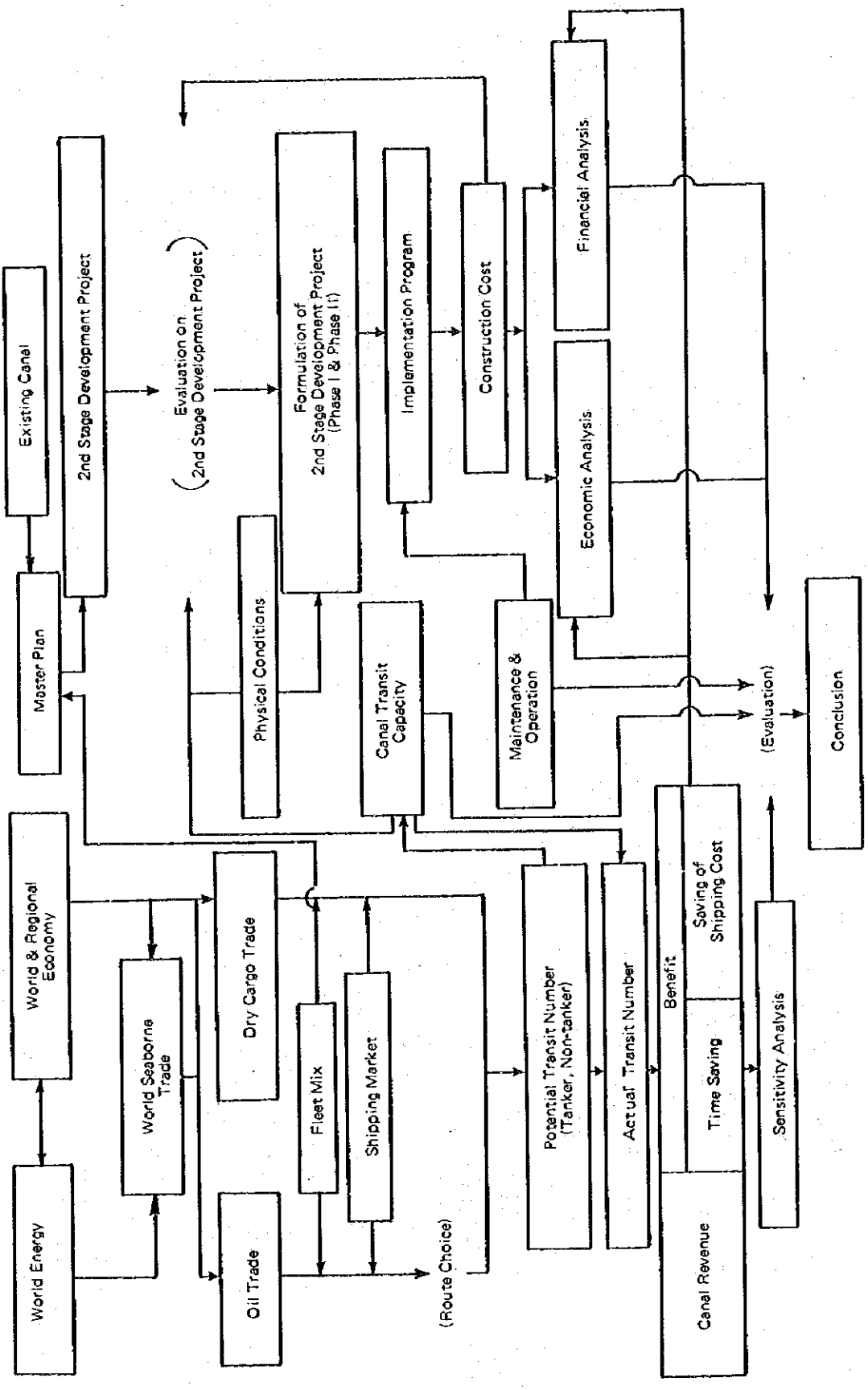


Fig. 1 Flow of Feasibility Study on The Second Stage Development Project

CHAPTER 2 PRESENT SITUATION OF THE CANAL

1 Present Situation

1) The Suez Canal is a waterway extending 162.5 km to join the Mediterranean and Red Seas, and its entrance to the Mediterranean Sea is located in Port Said and to the Red Sea is located in Port Tewfik of Suez.

2) The maximum sizes of ships which can transit the Canal are 60,000 DWT fully laden and over 200,000 DWT in ballast according to the past record. The theoretical daily transit capacity of the canal is considered to be about 80 ships.

2 Recent Transit Records

1) The Suez Canal that had remained closed since the Third Middle East War was reopened on June 5, 1975.

2) The transit record of 1978 shows that the number of transit ships is 58.3 per day and the volume of transit is 248 million NRT per year which have recovered to the level before the canal closure but the cargo volume of transit is 150 million tons which is only 62 percent of the level before the closure. (See Table 1.)

3) The number of transit tankers before the closing reached about 50% of the total number of transit ships but it is only 10% to 15% after the reopening, and the number of tankers is also only 1/4 of the number recorded immediately before the closure.

Table 1. Transit Record before Closing and after Reopening

Year	Number of transit ships	Ships volume of transit (10^3 NRT)	Cargo volume of transit (10^3 tons)	Number of transit ships per day
1966	21,250	274,250	241,893	58.2
1976	16,807	186,859	117,653	45.9
1977	19,703	220,471	128,699	54.0
1978	21,266	248,260	147,779	58.3
'78/'66	100.1%	90.5%	61.9%	100.1%

4) The decrease in the number of tankers is caused mainly because the size of tankers was increased during the canal closure so that the number of tankers with navigable sizes for the Canal was decreased, and the market for tankers dropped after the oil crisis.

5) On the other hand, the number of non-tankers increased very quickly after the reopening and, in 1978, this increase offset the decrease of tankers and the total number of ships already recovered to the level immediately before the closure.

6) The amount of oil transit by the northbound tankers was about 69% of whole cargoes before the closure but it was merely 20% in 1978. In 1977, the total oil flow from Middle East to Europe and U.S.A. was 650 million tons but the oil traffic through the Canal was only 28 million tons, 4.4% of the total oil flow.

3 Outline of the First Stage Development Project

1) The First Stage Development Project started in 1975 is being carried out to increase the width and depth of Suez Canal to allow the navigation of ships of 150,000 DWT class with full load instead of previous 60,000 DWT class. Specifications of the Canal for the First Stage Development Project are as indicated below.

	Present	First Stage Development
Water depth (m)	15.0	19.5
Area of standard canal cross section (m^2)	1,850	3,600
Maximum draught (ft.)	38	53
Maximum size of ship (thousand DWT)	60	150

2) The dredging volume for the First Stage Development Work is said to be 540 million m^3. The completion of work for whole section is expected to be in the middle of 1980.

CHAPTER 3 SUEZ CANAL AUTHORITY

1. Organization and Activities

1) The Suez Canal Authority (SCA) has its headquarters in Ismailia, field offices in Port Said and Port Tewfik (Suez) and a liaison office in Cairo.

2) The SCA is managed by a Board of Directors and Chairman appointed by the President of Egypt. The SCA Headquarters is composed of eight departments and the four sections directly responsible to the Chairman.

3) The SCA presently has a staff of 1,800 and 10,200 laborers.

4) The SCA not only controls Canal transit and handles the maintenance and improvement of the Canal and its harbors but also controls Port Said. As auxiliary ativities, it is charged with the control of Port Twefik, the control of waterworks in the three cities of Port Said, Ismailia and Suez, the management of schools and hospitals and the operation of ferry service facilities. It has eight subsidiaries engaged in such activities as ship building, ship repair and harbor services.

2. Facilities Owned by S C A

The S C A owns 14 dredgers, 19 salvage tugboats, 13 harbor tugboats and two pilot boats used for the maintenance and operation of the Canal. Besides, two more dredgers are on order.

3. Canal Tolls and Charges for Using Facilities

1) The SCA levies tolls from ships transiting the Canal in accordance with the provisions of the Rules of Navigation. Tolls are levied from ships of 300 gross tons or more. They are payable to toll rates set by category of tanker and combined carrier, bulk carrier, other ships, and according to ship tonnage. Tolls for empty ships are 80% of those for loaded ships.

Loaded Vessels

(i) Tanker and combined carrier
1.611 SDR/NRT

(ii) Bulk carrier
The first thousand tons .... 2.420 SDR/NRT
The following four thousand tons .... 2.000 SDR/NRT
The rest of the ship's net tonnage .... 1.611 SDR/NRT

(iii) Other vessels
The first thousand tons .... 2.660 SDR/NRT
The following four thousand tons .... 2.180 SDR/NRT
The rest of the ship's net tonnage .... 1.772 SDR/NRT

2) As charges for using canal-related facilities, there are wharfages, pilotages, berth change fees, towages, fees for using tugboat service etc. The rates are all prescribed by the Rules of

Navigation.

4. Financial Status

1) The 1978 operating earnings and operating expenditure of the S C A were 292.4 million LE and 22.3 million LE, respectively. The operating profit was 255.7 million LE: this figure is reached by subtracting the operating expenditures and a depreciation of 14.4 million LE from the operating earnings. Such payments as interest, patent fees and taxes were subtracted from the operating profit and a surplus of 107.2 million LE resulted.

2) Toll revenues represent about 97% of the operating earnings. Toll revenues have steadily increased since the reopening of the Canal in 1975. Since these tolls are on the SDR basis, toll revenues indicated by the pound are believed to have been greatly increasing since the devaluation of the Egyptian pound in January 1979.

3) Meanwhile, the amount of depreciation and the amount of interest to be paid will increase after the completion of the First Stage Project.

4) The following principal financial ratios of the past three years show that the present financial status of the SCA is satisfactory.

	(1976)	(1977)	(1978)
Operating ratio	16.8%	18.6%	12.6%
Return on net fixed assets	19.7%	16.1%	18.0%
Interest earned ratio	2,900%	2,490%	2,580%

CHAPTER 4 FORECAST OF SUEZ CANAL TRAFFIC

Although the forecast of Suez Canal traffic in Chapter 4 concerns the period up the year 2000, the emphasis is placed on forecasting the traffic in 1985 by destination and by ship size and type.

This forcast is made by analyzing the background of the world economy and trade with respect to a reasonable frame work of the world economy. The framework is based on world economic forecasts conducted by established international organizations for the period up to 2000.

The forecast of Suez Canal traffic is made according to the destination and the category of cargo transiting the Canal. Cargo is divided into ten categories, which are: crude oil, petroleum products, LNG, iron ore, coal, grain, fertilizer, fabricated metal, cement and general cargo.

The projection of ship tonnage through the Canal is based on the actual record in July 1978 of Canal traffic for each category of cargo, divided according to ship type and the ship loading ratio in each cargo category. At the same time, the trend towards larger ships and the shift from general cargo ships to specialized cargo ships such as container vessels are taken into account.

The most likely main cargo to transit the Canal after the completion of the First Stage Suez Canal Development Project is regarded as petroleum, iron ore and coal. The volumes of these potential traffics are included in the figures of the O/D (Origin/Destination) Table on the Suez Canal traffic by commodity and destination area.

The effect of the world market on large-sized ships, which influences the choice of route (either through the Canal or around the Cape), is studied by analyzing tonnage supply and demand and the transportation cost.

1. Method of Forecast

The canal transit volume is forecasted considering following items:

1) World energy supply and demand and oil trade;
2) Trends of world economy and dry cargo trade;
3) Selection of routes depending on the maritime transportation cost and outlook of the freight market;
4) The transit cargo volume of the Suez Canal by commodity and unloading area;
5) The net tonnage and number of transit vessels by type and direction; and
6) Canal revenue

The number of canal transit vessels is estimated for tankers, bulk carriers, general cargo ships and others.

For estimating the number of transit vessels, it is necessary to estimate the volume of transit cargoes. The volume of transit cargoes is forecasted according to the transit direction and commodity, and based on the outlook of the world and regional economy.

In estimating the number of the canal transit vessels, the capacity limit of the canal corresponding to the Second Stage Development Project should be taken into account.

First, the number of transit vessels (potential number of canal transit vessels) is forecasted assuming that there is no limit to the canal transit capacity and, again, the number of transit vessels is sought under the limited canal capacity. The canal revenue is calculated against the

obtained number of transit vessels (by type and size of vessel), according to current tariff structure.

2. Tonnage of Suez Canal Traffic

2-1 World Economy and Trade

The World economy today is in the so-called state of "stagflation" with the advanced market economy countries suffering from inflation stemming from the repeated crude oil price hikes in the midst of international monetary confusion. This problem is attended by continued depreciation of the US dollar's value. On the other hand, although the NICs are achieving remarkable economic progress, the economic situation of developing countries lacking petroleum resources is, in general, very serious.

The centralized economies of the East European countries are suffering from poor agricultural production because of unfavorable weather; their economic growth conspicuously levelled off in the latter half of the 1970s. China, which does not belong to any of the above groups, is modernizing on the basis of its revised 10-year Plan. However, China has had to depend to a large degree on other countries for technology and capital. The oil-producing countries, which hold huge petro-dollar funds, have been affected by steep inflation and the fall in the value of the dollar. In a vicious cycle, these nations repeatedly raise the price of crude oil to maintain their level of national revenue.

Under such a situation, it is extremely difficult to set up a framework for the world economy and trade up to the year 2000 for the purpose of forecasting Seuz Canal traffic.

For the purposes of this report, we review the forecasts made by established international institutions as a guide and use Scenario B of OECD Interfutures, which basically contends that the present framework of the world economy will continue. According to this scenario, the annual average economic growth rates up to year 2000 are 4.4% for the world as a whole, 3.5% for the OECD nations, 4.8% for the East European countries, and 6.0% for the remaining of the countries.

2-2 World Seaborne Trade and Cargoes Transiting the Suez Canal

The start of Section 3 is an overview of the world's economic situation and structure, and describes how world seaborne trade develops under this economy. Such an overview is indispensable for setting up a scenario for forecasting the volume of Suez Canal traffic.

In forecasting the volume of cargo transit through the Canal, we examine not only oil and the five major bulk cargoes, but also "Other goods", including general cargo, which compose of the main transit cargo with cement, fabricated metals and fertilizers. The OD table relating to the Canal is compiled for each cargo category, and the growth rate is set up for each, with the characteristics of the exporting and importing regions taken into consideration.

For crude oil and petroleum products, the three routes of Middle East/Northwest Europe, Mediterranean Europe and North America are picked up and the OD tables compiled by taking into consideration the recent consumption restraint structure in the advanced importing regions. Furthermore, estimates are made by taking into account the effect of pipelines. The volume of LNG is estimated by taking into account projects under planning and under consideration.

Northbound iron ore originates in Asia and Australia and is bound for Britain, Western Europe and other parts of Europe. Its growth rate is assumed to be 2.5%. Southbound iron ore

originates in the Soviet Union and Eastern Europe and is bound for Japan and Asian NICs, its growth rate is assumed as 3%.

On the coal trade, energy coal as a substitute for oil, is more important than metallurgical coal. This is why the growth rate of coal trade is estimated considerably high. The southbound growth rate of coal is taken as 3%. The Northbound growth rate, mainly derived from Australian coal, is taken as 18% up to 1985, 9.5% up to 1990, and 5% thereafter.

In the case of grain, the self-sufficiency degree of the importing region and the degree of dependence on imports is taken into consideration. For southbound grain, it is assumed that supply from the U.S. to Asia would increase by 6% up to 1985, by 6.5% up to 1990, and by 3.9% thereafter. The growth of grain bound for the Middle East is taken as 4.9% up to 1990 and 5% up to 2000. The growth rate of northbound grain for the entire period is assumed as 3%.

Of the main countries importing cement via the Canal, such as Iran, Saudi Arabia, UAE, Kuwait and Iraq, the consumption trend and the rapid increase in domestic production is taken into account and it is assumed that imports will peak in 1980 and decline thereafter.

India, China, iran and Pakistan are the major importers of fertilizer via the Canal. The growth rate of phosphate fertilizer consumption in these four countries in the past seven years is an annual 11%. It is expected that the growth rate will be 8% up to 1990 and 6% thereafter. Potassic fertilizer is exported mainly from the Soviet Union and East and West Germany via the Canal to the countries of Asia. Its growth rate will be slightly lower, or an annual 6% up to 1990 and 5% thereafter. The use of nitrogen fertilizer in the main Asian countries in recent years has been increasing at an annual rate of 10% while production has grown at 16%. Future consumption is expected to grow at 8% annually until 1990 and at 6% thereafter. Imports, however, are expected to decrease because the self-sufficiency rate will rise.

In the Arab countries, the present per capita consumption of fabricated metal is 160 kg per year, but is expected to rise rapidly to the 600 kg per year as same level as the industrially advanced countries. Thus, the expected growth is 10% up to 1980, 7% up to 1990, and 5% thereafter. It is believed that the self-sufficiency rate will rise to 20% in 1985 and to 50% in 2000. Export from Europe to Asian countries is expected to decline gradually because of the rise in the self-sufficiency rate of the area.

More than 60% of the dry cargo passing through the Canal account for "other goods" mainly consist of general cargo. Thus, great hopes are placed on the increase in southbound general cargo and other goods (the average annual growth rate for these goods from 1976 through 1978 was 36.2%). The Middle East is most promising in this respect because the region has both enormous oil funds and great development potential, both agricultural and industrial sectors (the average annual growth rate during the period described above was 35.5%). A future growth for other regions is predicted to be just about parallel with the GDP or slightly less.

2-3 Supply & Demand Balance of Ship Tonnage, Market and Maritime Transportation Cost

(1) Tankers

The tanker market deteriorated rapidly following the oil shock of the autumn of 1973. The Freight Index reflected this deterioration as follows, with 1973 as 100: 1973 = 32, 1978 = 35, and 1979 = 63. This shows the complete crumbling of the supply-demand balance resulting from sluggish growth of trade volume consequent to the recession and completion of more than 100 million dwt of ships, which were ordered during the boom period. The oil-producing countries

are regularly raising the crude oil price, and this is forcing the importing countries to restrain consumption and to turn their attention to the development of alternative energy.

In addition, the increase in petroleum output in the North Sea and Mexico has the effect of greatly reducing the ton-mile base of transportation for Western Europe and the United States. This is decreasing the voyage opportunities, particularly of large tankers. In 1978, signs finally began to appear of a relaxation of the tonnage supply pressure. Even so, surplus tonnage at the end of 1979, when the market began to look upward, still totaled 35 million dwt (comparrd with 100 million dwt in 1978). The major part of the surplus consists of large tankers. Furthermore, crude oil transactions in the form of DD and GG have been increasing, but the lot involved in such transaction is relatively small. Thus DD and GG deals have not resulted in stimulated demand for large tankers.

Aside from a few factors such as the IMCO regulations making compulsory the installation of SBT (which result in increasing tonnage demand), there are very few conditions which can lead to stabilization of the supply-demand balance of large tankers, leaving aside the question of small and medium size carriers. Consequently, it is expected that it will not be until after 1985 that a return to the previous supply-demand balance of large tankers will be seen.

(2) Bulk Carrier

The supply-demand balance of dry bulk carriers, did not crumble as severely or as quickly as the oil carriers after the oil shock of 1973. However, the balance gradually deteriorated, especially among the large carriers. Since 1974, cargo movement on a ton-mile base has been increasing, although very slowly. At the same time, however, bulk carrier tonnage has been increasing, and the difference between the shipment volume and the tonnage index has continued to widen from 0 in 1973 to 23 in 1976 and 40 in 1978. Considerable surplus tonnage is being absorbed by lay-up, slow-steaming, and part-cargo operation. However, the tonnage supply pressure has been rapidly lessening since 1978. Shipments of coal as an alternative to oil will increase from now, and the supply-demand imbalance will be rectified rapidly even in the field of large bulk carriers.

(3) Maritime Transportation Cost and Canal Traffic

In general, southbound VLCCs transit the Canal in ballast when the freight market rises above the following levels:

Arabian Gulf/Mediterranean	W29 (W22)
" " /N.W. Europe	W39 (W31)
" " /Caribbean Sea	W80 (W51)

Note: Figures in parenthesis are the world scale rates after January 1980.

The VLCC freight market in 1976, 1977 and 1978 was W28.8, W24.7 and W29.1 respectively. In other words, the market was roughly at the level of the Mediterranean-bound dividing point or below it. But in 1979, it had risen to 45.7, well above the N.W. Europe level. As a result, there was a sharp increase in VLCC traffic through the Canal from late 1978 into 1979.

In 1980 the market dropped again to the W 30 level. In view of the world petroleum supply-demand situation, a real market upswing, accompanied by a recovery of the supply-demand balance of VLCC and ULCC, cannot be expected until after 1985. Thus, much cannot be expected in the way of VLCC traffic through the Canal until then.

The large bulk carrier market recovered sharply in 1979. Coal shipments will expand in the future and the freight market will remain firm. A large portion of the iron ore and coal

from Australia to Europe will be transported via the Suez Canal.

As cargo transit through the Canal increases in the future, the ships passing through will become large in size. The actual number of transiting vessels will rise only moderately, however, because the larger vessels will carry more cargo per transit. Up to the year 2000, the effect on each type of ship will average an increase of 20%. The world trend towards larger ships seems to have levelled off at present.

There are many uncertain factors with respect to the ratio of container ships used in the transport of sundries. In any case, it is expected that such containerships will roughly double by the year 2000, as there is a worldwide increase in port facilities to handle container cargo.

3. Potential Number of Transit Vessels and Potential Canal Revenue

The forecast of the number of canal transits was made for three cases, i.e., High Case, Base Case and Low Case. These three cases were determined by using as variables the timing of recovery of the tanker market and the economic growth rate of Middle East countries, the former being for tankers and the latter for non-tankers.

	Tanker	Non-tanker
High Case	The gap of supply and demand for tankers will be balanced around 1985 and the market will recover.	The economic growth of Middle East countries will be a little on the high side.
Base Case	The gap of supply and demand for tankers will be balanced around 1990.	The economic growth of Middle East countries will be on a moderate level.
Low Case	The gap of supply and demand for tankers will be balanced around 1995.	The economic growth of Middle East countries will be a little on the low side.

The potential number of transits for each case and corresponding canal revenues are shown in the following table.

The number of transit vessels is expected to increase steadily along with the increase of dry cargoes and the recovery of the tanker market, and it is forecasted that the number of transit vessels 68 in 1980 after the completion of the First Stage Project -- will almost double in 2000. The canal revenue in the Base Case will increase from $785 million in 1980 to $1,730 million in 2000.

The breakdowns of the number of transit vessels and the canal revenue in the Base Case are given below by ship's type and direction.

1) Tankers/LNG vessels will increase in number from 11.38/day in 1980 to 15.39/day in 2000; the growth rate is lower than that for non-tankers because of the lower growth of seaborne oil trade.
2) Non-tankers will double in 20 years, with an especially high growth in the number of general cargo vessels because of the expected increase of southbound cargoes due to increasing imports by Middle East countries.
3) In 1980, the revenue from tankers will be $130 million, or about 40% of the total, and the potential revenue from tankers in 2000 will increase to $550 million, or 32% of the total.

4) The potential revenue from non-tankers will increase from $457 million in 1980 to $1,180 million in 2000.

Potential Daily Traffic Number and
Potential Canal Revenue

	Case	1980	1885	1990	1995	2000
Potential Number (Ships/day)	High	70.3	91.8	118.1	141.5	170.8
	Base	68.3	83.9	103.3	120.1	139.6
	Low	66.2	76.5	92.5	107.9	125.3
Potential Revenue (millions of dollars/ year)	High	835.0	1126.4	1448.1	1723.9	2045.8
	Base	785.2	1021.6	1290.6	1506.7	1750.3
	Low	730.5	890.9	1125.5	1336.4	1548.4

4. Evaluation of the Forecast Results

(1) Demand forecasts were made mostly on the Base Case, followed by the High Case and Low Case.

Cargo movement through the Suez Canal is largely influenced by the increase of imports by Middle East countries from regions west of the Suez Canal.

In the Base Case, the increase in imports by Middle East countries is conservatively forecasted against the recent record. Consequently, the forecast values of the Base Case could be considered to be on the lower side for medium values.

In this sense, the Low Case is rather unlikely unless there is stagnation in both the imports to Middle East countries from Europe and the world economy.

(2) In the High Case, imports to Middle East countries increase at almost the same pace as that experienced in the 1970s. There is a possibility that the transit cargo volume of the Suez Canal will increase at the High Case rate, in light of the position which Middle East countries have held in the world economy in recent years.

(3) From the comprehensive analysis of the results of the forecast in the present study it will be concluded that, in general, the future volume of Suez transits will increase at the pace of the Base Case, but there is a high probability that it will increase at a higher rate near the High Case until 1990 and then at a pace approaching the value of the Base Case in 2000.

(4) Following are points which must be given consideration when applying the results of these forecasts to the development program of the Canal.

1) When making economic and financial analyses, the values of the Base Case should be used as the basis for evaluation, to ensure that the evaluation can be made on the safe side.

2) When the case of studying the development program of the Suez Canal, the forecast values in the High Case should be taken up with the view of avoiding congestion and preventing the diversion of large vessels to the Cape route or land transportation due to the congestion.

CHAPTER 5 MASTER PLAN

In order to give an ideal direction on the future development of the Suez Canal, a long-term Master Plan is formulated with 2000 as the target year.

It provides a complete doubling of the Canal, in response to the possible increase in the transit demand, with the east channel for northbound vessels and the west channel for southbound vessels.

1. Design of The Canal

In view of the size distribution of large vessels in the world and the scale of investment, the east channel was projected for 250,000 DWT tankers fully laden, while the west channel for all sizes of ballast tankers and 50,000 G/T container vessels, the largest vessels expected to make southbound transit fully laden. Draught and breadth of a ship on which the cross sections of the Canal are designed were determined as below.

	Draught	Breadth	
East Channel	68 feet	180 feet	250,000 DWT Tanker
West Channel	40 feet	203 feet	500,000 DWT Tanker
	43 feet	110 feet	50,000 G/T Container Vessel

Area ratio, lane ratio and the canal cross section are as shown below.

	Area Ratio	Lane Ratio	Depth	Width at −11m Depth
East Channel	4.8	2.6	−24.0m	240m
West Channel	4.6	2.7	−16.0m	200m

The underwater slope gradient of the canal is as shown below as in the case of the First Stage Project.

Km 0−61 1 in 4 Km 61−161 1 in 3

The layout of the canal was planned based on the following considerations:

1) For the purpose of navigational safety, the canal alignment should be planned in such a way that easy manoeuvring of transit vessels may be ensured.

2) From the viewpoint of efficiency of investment, the existing channel expanded under the First Stage Project should be utilized as much as possible as the channel for northbound traffic.

3) Account should be taken as fully as possible of the natural conditions and the state of land use around the Canal.

2. Work Volume and Construction Cost

Work quantities are estimated as below.

Dry Excavation	226 x 10^6 m^3
Bank Works	245.4 km
Demolition	13.5 km
Demolition and Construction	11.5 km
Construction	220.4 km
Dredging	1,028 x 10^6 m^3
km 1.5 – 161	816.5 x 10^6 m^3
Approach Cannel	211.5 x 10^6 m^3
Other Works	
Railway Relocation	26 km
Road Relocation	31 km
Sweet Water Channel Relocation	7 km

Approximate estimates of the construction cost for the Master Plan and the ratio of each category of works are as shown below.

	Local Currency 10^6 LEE	Foreign Currency 10^6 US$	Ratio %
Dry Excavation	202.4	25.5	16
Bank Works	96.2	40.3	9
Dredging (km 1.5 – 161)	260.0	944.9	66
Dredging (Approach Channels)	50.4	77.1	8
Other Works	12.5		1
Total	621.5	1,087.8	100

In terms of US dollar, the total cost will amount to approximately $2,000 million. Of the amount, 45% is for local currency and 55% for foreign currencies.

3. Evaluation

The order of implementation of this Master Plan should be decided through examination of both economic and technical aspects of the project. It should be noted that the priority must be given to the doubling scheme rather than to the deepening scheme. The reasons are as follows:

1) If the doubling scheme is preceded by the deepening scheme. Those sections of the existing channel which are to be used for the southbound traffic upon completion of the total doubling scheme will be so deepened as to accommodate fully loaded VLCCs. This is a waste of investments.

2) If the doubling scheme is implemented first, the canal capacity will increase or transit hours will be shortened with the completion of each doubled section of the canal. In the case of deepening, however, no benefit will come out until the entire route of the canal is opened for the navigation of deep-draught vessels.

3) Judging from the experience of the First Stage Development, it is certain that the doubling scheme can be implemented with no difficulty. As regards the deepening scheme, however, as the depth increases the degree of soil hardness will increase. Therefore it is most likely that the dredging works will meet with a difficulty and entail an unexpected cost increase and prolongation of work period.

In order to make the Master Plan even more satisfactory it is advisable to study and examine the following points:

1) Re-examination of the standard sea level following the expansion of the canal cross section.

2) Safety measures for navigation in the junctions of the dual channels.

3) Extension of the Port Said breakwater.

4) Dredging of hard soil.

CHAPTER 6 SECOND STAGE DEVELOPMENT PROJECT

As part of the Master Plan the Second Stage Development Project should be implemented following the First Stage Project. The objectives of the Second Stage Project are outlined as below:

1) The Second Stage Project is aimed at the complete doubling of the canal to obtain a marked increase of the transit capacity. The stage which should be immediately implemented is called Phase I of the Second Stage Project, with 1990 as the target year. Phase I is followed by Phase II to complete the doubling, as the transit demand increases.

2) The maximum size of transit vessel under the Second Stage Project is the same as that after the completion of the First Stage Project, i.e., around 150,000 DWT tankers fully laden for the east channel and around 300,000 DWT tankers in ballast and 50,000 GT container vessels for the west channel.

1. Phased Development Plan

1-1 Canal Design

(1) Canal

1) East channel

The east channel is designed for around 150,000 DWT tankers. The depth is determined taking account of the draught, squat and trim, underkeel clearance and clearance for siltation. The cross section was so designed as to achieve the area ratio (Ra) of 4.8 and the lane ratio (R1) of 2.6.

2) West channel

The west channel is designed for around 300,000 DWT tankers in ballast and the depth for 50,000 G/T container vessels. Factors to be taken into account in determining the depth are the same as in the case of the east channel. The cross section is so designed as to achieve the area ratio of 4.6 and the lane ratio of 2.7.

The design specifications of the cross section for the east and west channels are given below:

Name of Channel	Area (m^2)	Depth (m)	Width (m)		
			Surface	−11.0m level	Bed
East Channel					
0–60 km	3,510	19.5	258	170	102
60–162 km	3,461	19.5	236	170	119
West Channel					
0–60 km	3,503	15.5	288	200	164
60–162 km	3,313	15.0	266	200	176

(2) Approach Channels

The ocean channels at Port Said and Suez were designed taking account of the effects of wind, wave and current.

However, as the east channels are to be completed under the First Stage Project, only the west channels need to be dredged at both Port Said and Suez under the Second Stage Project.

Cross sections of the Port Said approach channel and the Suez entrance channel are outlined as below:

Name of Channel	Channel Direction	Depth (m)	Width (m)
Port Said Approach Channel	East Channel	20.0	max. 700
	West Channel	16.5	max. 840
Suez Entrance Channel	East Channel	19.5	289
	West Channel	16.0	417

In designing the cross sections under the Second Stage Project, the west line of the channels should coincide with that of the channels under the Master Plan.

There is no need to expand the anchorage area in the Great Bitter Lake in connection with the Second Stage Project, as the anchorage area at Suez has already ample space under the First Stage Project. At Port Said, however, a waiting space needs to be secured to the west of the Port Said approach channel.

1-2 Formulation of Phased Plan

Eight Phases were planned for the complete doubling project as shown in Fig. 2.

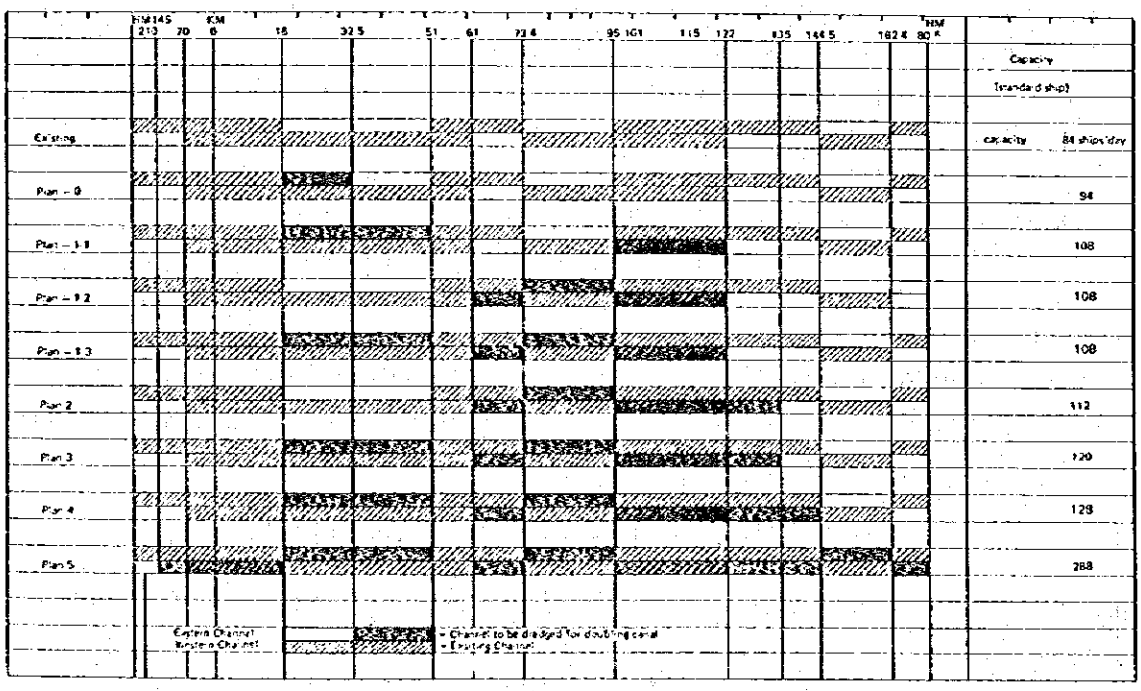


Fig. 2 Phased Development Plans

1-3 Comparison and Evaluation of Phased Plans

Various phased plans were compared in respect to economy and transit capacity in order to select a Phase I Programme which should be implemented first.

(1) Comparison in respect to economy

The internal rate of return of each phased plan was computed on the assumption that the phased plans will be implemented continuously after the completion of the First Stage Project.

The results of comparison in respect to economy are outlined as below:

1) Plan 0 offers high profitability with a short work period.

2) Profitability under Plan 1s is not much different among all plans. However, Plans 1-2 and 1-3, under which the reduction of transit hours can be expected, will have a bigger merit in view of the international role of the Canal.

3) Plans 1 – 3 do not vary a great deal in their merits, and as regards Plans 4 and 5, the unit dredging cost increases as the doubling works proceed to the southern part of the canal where hard soil prevails. It may be said that profitability decreases as the case number increases.

(2) Examination of transit capacity

On the basis of the traffic demand forecast and the increase in the Canal capacity in each plan (calculated in terms of the standard ship transiting at 10 minutes interval), studies were made on the saturation time of the Canal capacity under each of the phased plans. The study results are summarized as below.

1) As the canal capacity created by the First Stage Project will be saturated in 1981, measures ought to be taken to further increase the capacity by that time.

2) To overcome the capacity shortage expected after the First Stage Project, it may be desirable to start Plan 0 first. Even with this measure, however, the capacity will again be saturated at the end of 1984, making it necessary for the SCA to take the next step to increase the capaity.

3) Under Phase I of the Second Stage Project, doubling works need to be proceeded up to the stage of Plan 3 by 1987 at the latest.

4) Under Phase II, unless total doubling is completed by 1995 at the least, the canal capacity will be saturated.

5) Above observations are made on the assumption that the traffic will increase at the rate of the Base Case. If the demand increases at a higher rate, the Canal capacity may naturally be saturated earlier than the year under the Base Case. In such a case it is necessary to complete Phase I by the early 1980s.

(3) Evaluation of the proposed project

Judging from the results of the above study, it is advisable to increase the capacity of the Canal step by step keeping pace with the increase in traffic demand. Accordingly, if the Second Stage Project is to be implemented in Phases I and II, it may be divided as below:

	Doubled Section	Section Dredged for Doubling
First Phase Plan (Phase I)	Km 0 – 135	Km 16–51, Km 61–95, Km 122–135
Second Phase Plan (Phase II)	Km 0 – 162	Km 135–162, Km 0–16 Port Said Approach Channel Suez Entrance Channel

It is necessary to complete Phase I by 1987 at the latest. However, in view of the possibility of the demand increasing at a comparatively high rate, it is desirable to complete it in the first half of the 1980s.

Under Phase II, it may become necessary to complete the total doubling of the Canal by 1994. However, it is advisable that the work program for Phase II be adjusted, if necessary, by examining the transit situation prevailing after the completion of the First Stage Project as well as the trend of the world economy and also the situation of international shipping, particularly the condition of the tanker market.

2. Opening Program of Phase I

As regards the opening program for Phase I, it may be possible to implement Plan 0 to hasten the capacity increase. However, as the Canal capacity will expectedly reach its saturation point within one or two years, even after the completion of Plan 0, it is advisable to start with Plan 1-2 to be followed by Plan 3. Accordingly, the phase I should be implemented in accordance with the below mentioned schedule, taking into account the future trend of the traffic demand:

	Section Dredged for Doubling	Year of Completion
Step 1	Km 61–95	1984
Step 2	Km 16–51, Km 122–135	1987

The above schedule is based on the assumption that the demand increases at the rate forecast in the Base Case. However, there is a possibility that demand may increase at a comparatively high rate; therefore, it is advisable to implement Step 2 in the first half of the 1980s, so that the canal may provide sufficient capacity to meet the increase in traffic demand.

CHAPTER 7 TRANSIT SCHEME AND TRANSIT CAPACITY

1. The Transit Scheme after The First Stage Development of The Canal

The present transit scheme is to be pursued after the completion of the First Stage Development Project with some modifications, as given below.

1) Northbound convoys will make non-stop transits to the Mediterranean passing through the newly created Deversoir Bypass and New Port Said Bypass.

2) Of the vessels in southbound convoys, those large vessels of over 38' in draught will enter directly from the Port Said outer waiting area to the New Port Said Bypass and proceed to the Great Bitter Lake.

3) Upon completion of the First Stage Development Project, the size of navigable vessel will be increased up to around 150,000 DWT class (fully laden) or around 300,000 DWT class (in ballast), though some of 350,000 DWT tankers may be able to make transits.

Further, the SCA is introducing the Suez Canal Vessel Traffic Management System (SCVTMS) to ensure navigational safety in the Canal.

2. Canal Transit Situation

According to the past record of transits, the distribution of ships' arrivals at Port Said and Suez shows a Poisson's distribution, as in the case of ordinary ports. No peak hours are seen in the distribution of arrival times, indicating that vessels arrive at random.

Waiting hours from arrival to departure, excluding those necessary for the transit clearance, are over 15 hours for northbound and over 11 hours for southbound.

The same record shows that the interval between vessels in a convoy is mostly 8 min. for general cargo vessels, 8–10 min. for container vessels (including RO/RO, LASH, car carriers and others), over 10 min. for bulk carries, 11 min. for tankers up to 30,000 DWT, 12 min. for those over 30,000 DWT (laden) and 16 min. for those in ballast.

The average transit speed computed from the actual convoy diagrams is 16–17 km/h, largely exceeding the speed prescribed in the Rules of Navigation.

3. Transit Simulation Test

A Canal transit simulation model was developed in order to ascertain what elements would affect the transit capacity and also to review the results of the study, which are described in Part VI, concerning the saturation points expected under the First and Second Stage Development Projects.

The study on the expected year of saturation after the completion of the First and Second Stage Development Projects is outlined below:

After the completion of the First Stage Project, ship waiting will begin to occur in 1981, and in 1984 the number of waiting vessels at Port Said and Suez will reach 21 in total, which means that waiting at both ports has come to a chronic state. These results are nearly identical to those of the study made in Part VI.

If the traffic demand increases at a higher rate, a chronic state of waiting may come in 1982, causing a serious situation.

The occurrence of chronic waiting is expected under the assumption that the traffic demand increases at the rate given in the Base Case and is shown below:

Step 1 (Plan 1–2)	1989	(Phase I)
Step 2 (Plan 3)	1993	(Phase I)
Plan 4	1995	(Phase II)

It will be pointed out that occurrence of waiting is expected to come a few years earlier than these years. Accordingly, it is necessary to make such arrangements that each step may be superseded by the next step a few years prior to the year planned. These findings are nearly identical to those in Part VI.

If the traffic demand increases at the rate of the High Case, waiting will increase at a high pace after 1986 even with the completion of Phase I of the Second Stage Project; it is therefore necessary to complete it by 1985.

4. Comments on the Transit Scheme

4-1 Problems connected with VLCC transits

Technical problems involved in the transit of large tankers after the completion of the First Stage Development Project were studied as follows:

In the event that an accident involving a large tanker travelling in the Canal or involving the vessel preceding the tanker it will be necessary for the large tanker to make an emergency stop. While it is impossible for a large tanker to come to a complete stop by its own propulsion without bringing the hull into contact with the bank of the Canal, it may be possible for a large tanker travelling at a speed of 7 kt to come to a stop within a distance between 4L and 6L if she can be assisted by tugboats with sufficient power. If the wind velocity is 12m/s and the current speed is over 2 kt, the number of tugboats required (at 3,000HP each) may be obtained as below.

Tanker	Laden	In Ballast
	number of tugboats	number of tugboats
– 60,000 DWT	1	1
–150,000 DWT	2	2
200,000 DWT –		3

The distance required for an emergency stop of a 150,000 DWT class tanker will be 12L = 3,480m with consideration of a safety allowance. For the transit interval of VLCCs, it might be convenient for the purposes of transit control and pilotage, if it is unified at 16 min. or a distance of 3.5 km, which is the same interval applicable to other tankers.

4-2 Transit Scheme

Various ways of increasing the Canal capacity are conceivable. They are:

1) Increasing convoy cycle time.
2) Allowing two-way traffic to small vessels
3) Increasing convoy speed.
4) Decreasing time intervals between ships.

Of these methods, the method of increasing convoy cycle time and that of decreasing ships' intervals are considered to some extent effective in increasing the Canal capacity.

The method of decreasing ships' intervals may be adopted, but it should be limited only to small-sized general cargo vessels whose speed control may be relatively easy, depending upon the reliability of SCVTMS which is scheduled to be put into operation after the completion of the First Stage Development Project.

If the convoy cycle time is extended from 24 to 36 hours, an increase of about 25% in capacity may be expected. However, it may be accompanied by some demerits such as the irregular departure time of convoy and night transits of large tankers. Further, it will incur an increase in the operating cost of Canal users because of a possible increase in waiting time at Port Said and Suez.

Judging from the above, the method of extending the span of the convoy cycle time is not recommended as a permanent measure; rather it should be employed on a tentative basis to cope with an emergency such as an occurrence of large number of waiting vessels which might be caused by accidents, bad weather, etc.

Accordingly, the transit scheme based on a 24-hour cycle accommodating 1 northbound convoy (non-stop) and 2 southbound convoys should be maintained after the First Stage Development of the Canal. The transit scheme under the Second Stage Development Project is outlined as below.

	Southbound	*Northbound*
Step 1 (Phase I)	S-1: Stop at Bitter Lake S-2: Non-stop	N-1: Non-stop
Step 2 (Phase I)	S-1: Non-stop	N-1: Non-stop

It will be noted that upon completion of the Step-1 of the Phase I Project some of the southbound vessels can make non-stop transit in addition to the northbound convoys. With the completion of the Phase I, it will no longer be necessary for southbound convoys to wait at the Great Bitter Lake, thus making it possible for both southbound and northbound convoys to make non-stop transits.

CHAPTER 8 TECHNICAL EXAMINATION

With regard to the development plan of the Suez Canal, extensive studies have already been made and almost all of the technical problems involved have been examined. For this reason an emphasis was placed in this study on checking the technical feasibility of the development plan and the proposed Canal cross-section which were presented on the basis of the traffic forecast newly conducted. In addition the tidal current and stability of the bank of the Canal were re-examined.

The results of the study are outlined as below:

1. Canal Section

For designing the cross sections, the following figures of area ratios and lane ratios were used in both the Second Stage Project and the Master Plan, taking into account the results of the past studies.

	Lane Ratio	Area Ratio	Ship Speed Max.
Laden Tanker	2.6	4.8	13 km/h
Ballast Tanker	2.7	4.6	14 km/h

For the area ratio for tankers in ballast, a higher value than the current one was chosen to account for the siltation. Other ratios correspond to the current figures.

Cross sections are ultimately determined by the area ratio. For instance, if the bank slope is 1/3, about 3.0 is taken for the lane ratio.

2. Tidal Current

The tidal current in the Canal was studied on the basis of numerical analysis. Though a more detailed analysis is required, qualitatively speaking, the following problems may be pointed out:

1) With the expanded cross section, the tidal range will increase in the Bitter Lake. This will affect the local datum along the Canal and increase the tidal current to the north of the Bitter Lake.

2) The implementation of the doubling scheme will produce a difference in the characteristics of current (water level, velocity and phase) between the two channels because of the different cross sectional areas, and the two currents will interfere with each other at the junctions of channels. In those junctions a complicated current is expected to occur when vessels pass through. Detailed study must be made on this phenomenon by means of a hydraulic model and mathematical analysis.

3. Stability of Canal Bank

To ensure the stability against circular slip of the bank, computations were made based on the results of soil exploration newly obtained. The table below shows the safety factors of four sections. In most places stability has been proven.

		Location			
		Km 5	Km 17.6	Km 25.2	Km 35.2
Canal Depth	–19.5 m	0.89 (1.70)	1.85	2.19	3.18
	–25.0	0.92 (1.68)	1.78	2.14	3.14
	C. t/m² (at ±0.0m)	0.25	2.235	2.0	2.5

Figures in brackets indicate toe failures of the sections with berm.

The soil test results at the point Km 5 are questionable because there is a possibility that the cohesion was underestimated.

4. Siltation

Siltation of the Canal is due to the return current caused by transit of vessels and tidal current in the Canal. As the mechanism of siltation has not yet been theoretically clarified, it is difficult to forecast the volume of siltation and it is therefore necessary to conduct periodical soundings along the Canal when formulating a plan for maintenance dredging.

CHAPTER 9 IMPLEMENTATION PLAN

1. Construction Work

The work volume for the entire Second Stage Project and it's Phase I and II are as shown below.

	Dry Excavation $10^6 m^3$	Bank Works Km	Dredging $10^6 m^3$
Phase I	147	143.2	329.3
Phase II	79	90.7	226.5
Second Stage Project	226	233.9	555.8

1-1 Dry Excavation

The total volume of dry excavation reaches $226 \times 10^6 m^3$, about 2.5 times are much as that of the First Stage Project. This is due to the following reasons:

Under the First Stage Project, dry excavation was limited mainly to the widened sections, while under the Second Stage Project, it must be carried out on the entire width of the new channel.

In dry excavation, the unit cost increases as the dumping distance increases. As the dumping distance under the Second Stage Project is increased by 1.5 -- 2.0 times, the unit cost increases accordingly. On the other hand, as the unit cost of dredging is hardly be affected by the dumping distance, it is likely that the unit dry excavation cost is higher than the unit dredging cost so far as the sections north of the point Km 52 are concerned. However, it cannot be concluded that dry excavation should be replaced with dredging on the sections north of the point Km 52. It is advisable that a decision be taken at the stage of implementation on the basis of the overall evaluation of the economic, technical and other aspects of the project.

Dry excavation is to be carried out by motor scraper (hereinafter referred to as MS). Calculations are made on the assumption that each MS (with capacity of 16 m^3) works 7 hours a day. This shows that about 230 MS are required if dry excavation is started all at once on the sections between Km 16 and Km 94.5 under Phase I.

1-2 Bank Works

The total length of new revetment is about 220 Km, or 1.5 times as long as that under the First Stage Project. The required annual performance of the work to complete the Phase I by 1986 should be nearly the same as at the First Stage Project. The monthly pace of a work unit comprising a bulldozer, a clamshell, a crawler-type pile driver, and a diesel hammer is estimated at about 200 m. As the monthly dredging speed is about 300–350 m, it is necessary to carry out revetment work at a higher pace than dredging. The revetment work should precede the dredging operation and be carried out on both sides of channel with two units each. As it is a difficult work to build a revetment on a slope of unfavourable soil condition, it is therefore necessary to intensify the supervision to ensure quality.

1-3 Dredging

The total dredging volume is approximately 555 x $10^6 m^3$; 490 x $10^6 m^3$ for the section Km 1.5–161 and 65 x $10^6 m^3$ for the approach channels. Dredging on the section Km 1.5–161 is mostly for the creation of a new channel. Dredging operation must be carried out from both ends of each work lot. The ideal number of dredgers operating on one end of each dredging section is two in view of work efficiency.

The monthly dredging capacity was calculated as follows:

First, the actual record of each dredger under the First Stage Project was studied to obtain the dredging volume per hour for each LOT. From this the monthly capacity of dredgers under the Second Stage Project was calculated taking into account of the work conditions under the project.

Assumption was further made that the SCA's dredgers are mainly used on the section north of the point Km 52 and the work on the section south of the point Km 58 is contracted out. In regard to the dredging of the approach channels at Port Said and Suez, the section outside Hm 50 of the Port Said Approach Channel is to be dredged by hopper dredger of the SCA and the remainder contracted out.

Table 2 Work Volume of Second Stage Project

Km	Dry Excavation	Bank Works		Dredging	Relocation		
	Volume	Removal	Construction	Volume	Railway	Road	Sweet water canal
	$10^3 m^3$	km	km	$10^3 m^3$	km	km	km
1.5 – 16.0		1.5	28.0	60,538			
16.0 – 32.5	14,000	1.5	28.0	67,913			
32.5 – 52.0	34,000	1.5	36.4	83,914			
58.0 – 73.5	37,000	2.4	31.0	54,669	19.0	19.0	
72.5 – 94.5	62,000	2.4	40.0	79,645			
94.5 – 134.5				43,182			
134.5 – 145.0	7,000	2.1	21.0	38,526	7.0	12.0	7.0
145.0 – 161.0	72,000	2.1	36.0	62,857			
Port Said Approach				46,109			
Suez Approach				18,475			
Total	226,000	13.5	220.4	555,828	26.0	31.0	7.0

2. Implementation Program

For the work schedule of the Second Stage Project, three programs were prepared: 1) the standard work schedule to carry out the doubling of the canal Section Km 51 – 122 by 1984 and Km 0 – 135 by 1987; 2) Work schedule to expand Km 0 – 135 by 1984, Km 0 – 145 by 1986 and the entire length by 1988 to meet the traffic demand forecast in the High Case forecast; and 3) shortened work schedule to expand Km 0 – 145 by 1984 and the entire length by 1986.

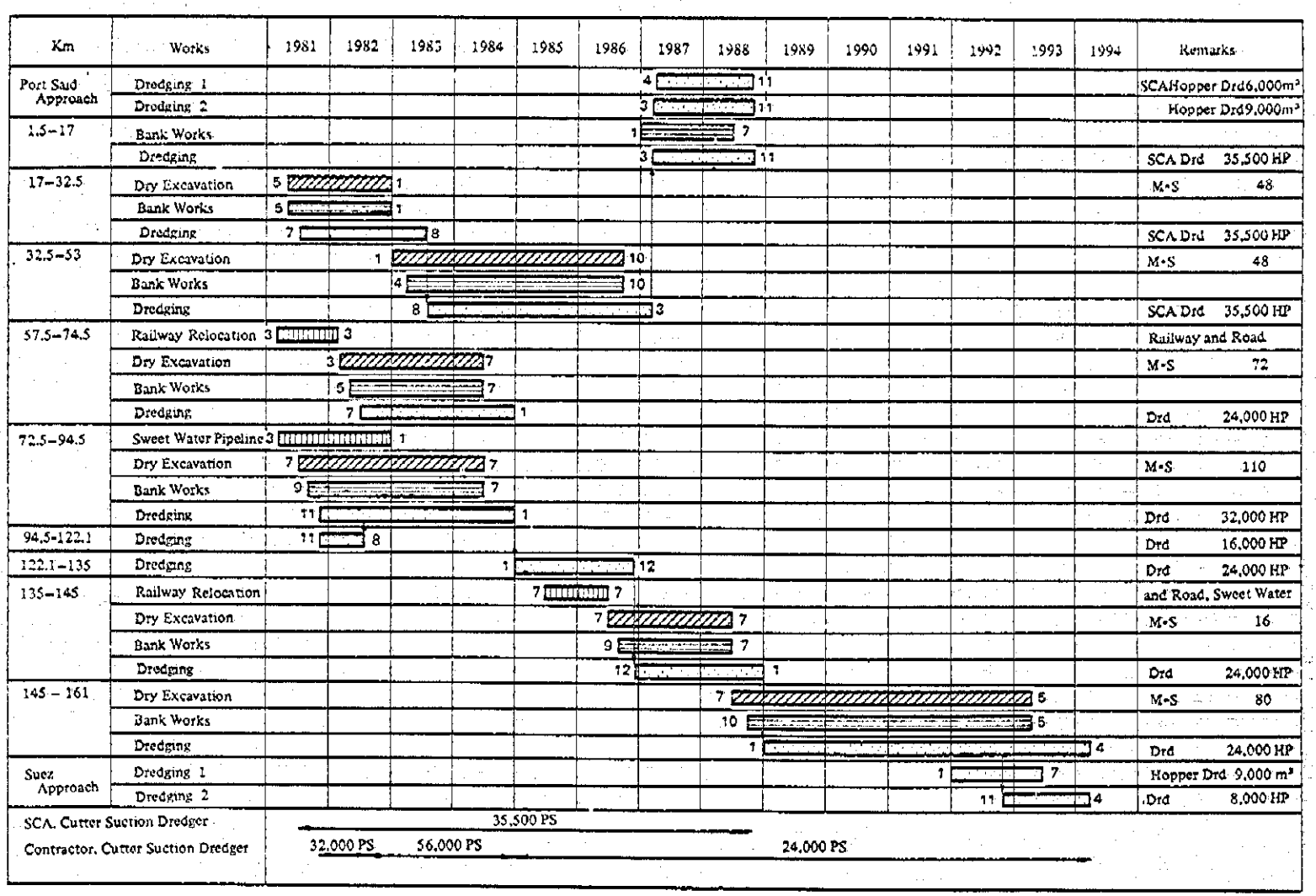


Fig. 3 Implementation Programme 1

3. Construction Cost

The unit cost of works was estimated on the basis of the prices in September 1979 with the exchange rate 0.69LE = 1 US$ = ¥240.

The unit cost of dry excavation was estimated on the basis of the actual cost under the First Stage Project with adjustment for the rate of price increase and for the difference in the dumping distance of soil. The unit cost of revetment work was estimated by computing the quantities of materials and the work volume from the designed cross sectional area.

The unit dredging cost on contract was obtained for each LOT from the monthly dredging volume and expenses at Sept. 1979 prices and a mobilization expense of dredger is not included. The unit dredging cost of SCA's dredgers was calculated considering the actual cost at the First Stage Project, a rate of increased price up to 1979, and the working efficiencies for each LOT.

The unit dredging cost for the approach channel was obtained from the actual work volume under the First Stage Project and the rate of price increases.

The construction costs for the Second Stage Project is outlined as shown Table 3.

Table 3 Cost of Second Stage Project

Km	Dry Excavation		Bank Works		Dredging		Others	Remarks
	L·C	F·C	L·C	F·C	L·C	F·C	L·C	
	10^6LE	$10^6$$	10^6LE	$10^6$$	10^6LE	$10^6$$	10^6LE	
1.5 – 16			11.1	4.6	15.1	8.5		
16 – 32.5	12.4	1.5	11.8	5.0	21.3	12.0		
32.5 – 52	31.2	4.0	15.3	6.4	33.6	18.9		
52 – 58								
58 – 73.5	29.4	3.7	12.3	5.2	8.3	59.2	8.4	
72.5 – 94 5	57.0	7.2	15.8	6.6	11.9	84.2		
94.5 – 134.5					7.9	56.7		
134.5 – 145	5.6	.7	12.2	5.1	6.8	48.2	4.1	
145 – 161	66.8	8.4	14.2	5.9	16.0	119.8		
Port Said Approach					6.5	15.7		
Suez Approach					4.8	19.4		
Total	202.4	25.5	92.7	38.8	120.9* / 11.3**	407.5* / 35.1**	12.5	* Km 1.5 – 161 Total **Approach Channel Total
Grand Total	L·C 439.8 x 10^6LE + 506.9 x $10^6$$				F·C			≒ 1,150 x $10^6$$

The total cost will be $1,150 million with the local currency accounting for 56% and foreign currencies 44%.

Further, divided into Phase I and Phase II, the costs will be as follows:

	Local Currency	Foreign Currency	Percentage
Phase I	276.6 million LE	270.6 million US$	59%
Phase II	163.2 " "	236.3 " "	41 "
	439.8 " "	506.9 " "	100%

In addition to the above, tugboats and navigation aids shall be financed by foreign currency of 35.6 million US$.

In the cost mentioned above, 10% of estimated cost is included as physical contingency.

CHAPTER 10. ADMINISTRATION AND OPERATION

There exists no particular problem in the control and management of the Canal after the completion of the Second Stage Development Project, so long as there is no qualitative change in the utilization of the Canal and measures are taken to strengthen the control and management system.

In this chapter, from the experience of navigation control in Japan, the safe management of canal traffic is discussed.

1. Suez Canal Vessel Traffic Management System (SCVTMS)

The SCA is introducing the SCVTMS by the end of 1980 and it is most timely that this system is installed for the navigational safety of large tankers expected to increase after the completion of the First Stage Development Project. However, followings should be given an account for a smooth and efficient operation of SCVTMS.

1) Training of control officers and maintenance personnel.
2) Combined use of existing signal stations.
3) Adoption of a position reporting system.
4) Preparation of a manual for control officers.
5) Measures to be taken to solve the problems connected with radar and radar data processing.
6) Supply of equipment and materials necessary for the control room.
7) Provision to the users of the system (ship's masters) with thorough information of the system.

2. Disaster prevention measures

In preparation for the accidents involving large tankers and their emergency stops, the following system must be established:

1) Reinforcement of tugboats and fire fighting facilities.
2) Provision for oil recovery equipment.
3) Improved maintenance and control of navigation aids and provision of equipment and materials thereof.

Further, in preparation for the outbreak of fire or of oil spills on or from a large tanker navigating the Canal a program of measures for combating disasters must be formulated.

The followings are measures to be included in the program:

1) Measures to prevent the outbreak of fire and oil spill.
2) Measures to combat accidents (manuals for combating accidents and conducting rescue operations).
3) System for combating accidents.
4) Emergency communications.
5) Provision of equipment and materials.
6) Training of personnel for combating disasters.

CHAPTER 11. ECONOMIC ANALYSIS

In this analysis, economic feasibility of Phase I Project and that of the whole project of the Second Stage Development were studied. In view of the nature of the Suez Canal, the economic analysis was made not only from the standpoint of the national economy of Egypt but also from the viewpoint of the world economy. Evaluation was made by means of the internal rate of return of the project.

For the purpose of this analysis, initial investment, administrative expenses, operational expenses, and maintenance dredging expenses are taken as the costs, while, the increased portion of canal revenue derived from the Second Stage Development Project is regarded as benefit for the national economy, and the saving of operation cost of vessels which might be obliged to take the Cape route if the Second Stage Project is not implemented and also the cost saving which will be achieved by the shortening of transit time due to the doubling of the Canal are considered as the benefits for the world economy.

The project life is, as a rule, set at 20 years after the completion of the works.

1. Evaluation of First Phase Plan (Phase I)

1-1 Evaluation from the viewpoint of national economy.

The internal rate of return of Phase I from the viewpoint of national economy is at least 24%, if the project is implemented in accordance with the program of Schedule-1 (Base Case). IRR obtained from the results of sensitivity analyses is shown below:

Case where traffic demand fluctuates:

Low Case:	18.1%
High Case:	28.0%

Case where work cost increases (Base Case):

10% increase:	22.9%
20% increase:	21.5%
30% increase:	20.3%

Case where earlier completion of work is selected: (Schedule-2)

Base Case:	22.1%
High Case:	25.3%

In either case, the economic feasibility of the project is maintained. If demand increases at a higher rate than expected, IRR becomes higher than that of the standard Schedule-1. Earlier completion of work (Schedule-2) is also justified and is desirable since the Canal will be able to respond to the demand more flexibly.

1-2 Evaluation from the viewpoint of world economy

From the viewpoint of world economy, IRR is at least 50% for Phase I. About one-half of this, or 24%, is enjoyed by the Egyptian economy and remaining one-half directly by the world shipping.

2. Evaluation of Second Stage Development Project

If the Phase II is implemented keeping pace with the increase in demand (Schedule-1), the IRR for the national economy is, 23% which is similar to that of Phase I. However, about 20% is obtained even in the case where the work is carried out in accordance with the program of Schedule-2 or Schedule-3 so that the canal capacity may be increased in advance of the increase in traffic, thus making it possible for the Canal to flexibly respond to the transit demand. If the demand increases at a high rate, higher IRR is expected.

In addition, if the work is carried out in accordance with Schedule-1, IRR similar to that of Phase I is expected for the world economy. If the work is carried out in accordance with Schedule-2 or Schedule-3, IRR exceeding 40% can be expected.

From the above analyses, it is concluded that Phase II which aims at the total doubling of the Canal is economically feasible.

In addition, the early implementation of the total doubling scheme will bring about additional favourable effects such as the reduction in waiting time of convoys at the both ends of the Canal and the avoidance of canal closure which might be caused by accidents.

3. Overall Evaluation based on the Economic Analysis

From the results of economic analysis the following conclusions can be drawn:

1) From the viewpoint of national economy, an IRR of at least 24% can be expected for Phase I. Since IRR of transport projects in Egypt is about 15%, it may be said that Phase I is capable of producing considerably high profitability for the national economy.

2) At the same time, the world economy is also able to enjoy the saving of transportation cost which might be derived from the avoidance of Cape routing and the shortening of transit time through the Canal. World economic IRR of this project is at least 50%. Of this 50%, about a half will be shared by the Egyptian economy through the increase in the toll revenue, and remaining a half by shippers and shipowners in the world through the saving of transportation expenses.

3) Sufficient IRR can be expected even if Phase I is completed earlier than the scheduled time and the traffic demand increases at the rate of Base Case. If the demand increases at the rate of the High Case, nearly the same IRR is obtained as in the case the works are implemented according to the standard schedule. Waiting for transits attributable to the shortage of canal capacity will possibly be avoided with earlier completion of the works even if the traffic increases at a higher rate (High Case).

4) Various kinds of sensitivity analysis proved high internal rates of return of this project and, therefore, from a viewpoint of economic profitability there is no problem which will obstruct the implementation of the project.

5) Sufficient effects of investment may be expected, even if the total doubling of the Canal is carried out to eliminate the waiting time for transit at the both ends of the Canal which, before the completion of the total doubling, is normally needed for the formation of convoys and to meet unexpected increase of traffic. Further, early implementation of the doubling results in such uncalculated effects as the prevention of the Canal closure due to accidents.

CHAPTER 12 SENSITIVITY ANALYSIS OF CANAL REVENUE

The forecast of Canal revenue under capacity constraint is made, and the effects of the capacity constraint on the global shipping cost is analyzed.

1. Canal Revenue under Capacity Constraint

The Canal capacity depends on the distance of a single lane passage, convoy diagram and type of transit vessels etc.

The Canal revenue in each year is the same as the potential Canal revenue, until the number of ships reaches the Canal capacity, but after saturation of the capacity the revenue is calculated according to the daily average capacity.

According to the Canal capacity examined in Parts VI and VII, the Canal is expected to reach the saturation point in 1981 under the First Stage Project and in 1992 under Phase I of the Second Stage Project. The number of daily transit vessels in 1981 and 1992 forecast as shown below:

	Standard ships	Real ships
	ships/day	ships/day
1981	65.0	71.2
1992	98.3	109.6

These above figures are considered to be the daily average transit capacity of the Canal. (See Part VI). Accordingly, the number of transit vessels stays dormant after it reaches the daily average capacity. The potential number of transit vessels will be about 123 standard ships (140 real ships) in 2000, and under such a large demand many vessels will be diverted to the Cape route.

The Canal revenue, as a result, will vary according to the number of vessels diverted from the Canal to the Cape route and also to kind and type of vessels diverted.

A forecast was made on the Canal revenue for the following two cases.

Case 1: Overflowed vessels will have the same configuration in types and size (obtained from the forecast) after the capacity is saturated.

Case 2: Overflow will begin with larger vessels under the forecast of vessel types after the capacity is saturated.

The Canal revenues for each case are as follows:

Canal Revenue Constrained by Capacity

(10^6 US$)

Case		1980	1985	1990	1995	2000
Potential Revenue		785.2	1021.6	1290.6	1506.7	1730.5
Case 1 (R-1)	First Stage	785.2	833.1	833.1	833.1	833.1
	Second Stage	785.2	1021.6	1290.6	1373.3	1373.3
Case 2 (R-2)	First Stage	785.2	692.3	586.3	520.5	473.6
	Second Stage	785.2	1021.6	1290.6	1213.7	1015.7

1) In the case 1, the Canal revenue remains the same after reaching its capacity. The revenue is 833 million US dollars under the First Stage Development of the Canal and 1,373 million US dollars under the Second Stage Development of the Canal.

2) In the case 2, when the large-sized vessels are diverted to the Cape route, the Canal revenue will sharply decrease after reaching its capacity.

In reality, there is a great possibility that the larger vessels (tankers, bulk carriers) having little cost differential between the routes of Suez and Cape, will be diverted to the Cape route, this reducing the Canal revenue due to capacity constraint.

2. Effect of Capacity Constraint upon Global Shipping Cost

The capacity constraint not only affects the Canal revenue but also increases the shipping cost by diverting many vessels to the Cape route. The increase of shipping cost is calculated for each case in the same way as given in the preceding chapter.

The increase of the shipping cost is obtained by multiplying the increased cost of each diverted vessel by the number of those vessels.

Notes that the capacity constraint will bring a large increase in shipping costs. The result is as shown in the following table. It will be noted that the capacity constaint will bring a large amount of increase of shipping cost.

Increase in Global Shipping Cost by the Constraints of Canal Capacity

(10^6 US$)

Case		1980	1985	1990	1995	2000
Case 1 (B-1)	First Stage	0	608.4	1,523.7	2,309.3	3,195.1
	Second Stage	0	0	0	489.9	1,375.7
Case 2 (B-2)	First Stage	0	875.1	2,008.9	2,935.3	3,941.2
	Second Stage	0	0	0	758.4	2,032.9

CHAPTER 13 FINANCIAL ANALYSIS

Financial analysis is made by the following two methods:

(1) Analysis and evaluation of Phase I are carried out by computing FRR on the various cases instituted in respect to the canal revenues and work costs of the project.

(2) The investment effect for Phase I is analysed and evaluated using the financial ratios based on Financial Statements.

1. Analysis and Evaluation by FRR

Case No.	FRR %	Case
Case 1	17.3	Base Case
Case 6	9.8	Low Case
Case 7	23.4	High Case
Case 8	16.3	Earlier completion work for Base Case
Case 9	23.0	Earlier completion work for High Case

As FRR is high in all cases (about 17% for Base Case) it is concluded that Phase I is a favorable project from the viewpoint of the SCA's financial management.

This is particularly so when Phase I is completed at an earlier date than scheduled and when the traffic increases at a high rate, since the waiting of vessels for transit attributable to the shortage of capacity can be avoided and, at the same time, improvement in the rate of return on investment will be expected. Further, there is hardly a difference between the FRR (Case 8) of Phase I completed earlier than the scheduled time and the FRR (Case 1) for the standard scheduled time. In addition, the total investments can be cut down by approximately LE 16 million (2.4% decrease) because the price contingency is included in the work cost. Thus, the merits of the early completion of Phase I are worthy of special mention from the viewpoint of the rate of return on investment.

2. Analysis and Evaluation by Financial Ratio

Main Financial Indexes after Phase I

(10^6 LE)

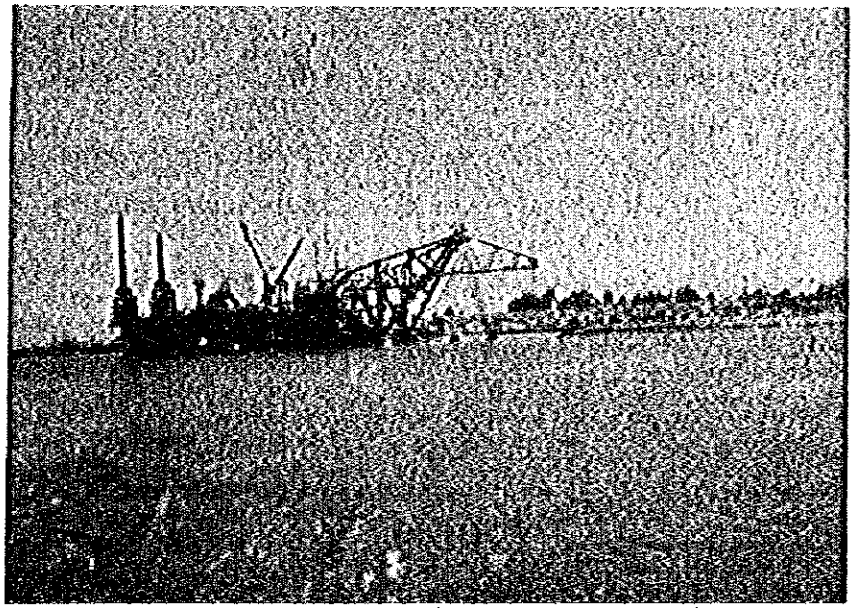
	1981	1985	1987	1992	1987~1996
Operating Revenue	584 (584)	716 (584)	785 (584)	958 (584)	908 (584)
Profit before Tax	456 (457)	592 (483)	656 (486)	840 (491)	789 (491)
Surplus	258 (258)	336 (274)	372 (276)	478 (279)	449 (279)
Operating Ratio	16 (16)	12 (14)	12 (14)	10 (14)	11 (14)
Return on Net Fixed Asset	45 (45)	42 (50)	42 (49)	52 (47)	49 (49)
Debt Service Coverage	692 (700)	530 (756)	660 (1147)	1415 (1383)	1149 (1167)

Analysis and evaluation were made on the effects of investment under Phase I by using financial ratio for both cases, having implemented the Phase I project and of having not implemented the same project.

Financial soundness is maintained after the implementation of Phase I; in fact it will show a tendency to improve.

No problem is anticipated in raising funds for the investment and adequate financial viability is expected judging from other financial statements.

The earning capacity on investment under Phase I was compared in terms of the return on net fixed assets ratio, with not implemented the project. It is worthy of note that a higher ratio is obtained when the investments were made. Further, with an earlier completion of work for Phase I, the ratios will increase due to the reduction in the total investments, and other ratios will likewise improve.



I . Introduction

PART I. INTRODUCTION

In response to a request of the Government of the Arab Republic of Egypt, the Government of Japan has agreed to undertake the necessary study for the Master Plan and the Second Stage Development Project, as a part of its technical cooperation program.

The study shall develop a Master Plan of the Suez Canal, and prepare a phased development plan as part of the Second Stage Development Project, to meet the increasing traffic demand of trade flow after completion of the First Stage Development Project.

1. Background

The use of Suez Canal, closed from 1967 to June, 1975, has been growing steadily since its reopening. The transit volume through the Canal in 1978 exceeded the flow preceding the 1967 closure.

The Suez Canal Authority (SCA), in the meantime, started the First Stage Development Project in 1975, which would allow the passage of loaded 150,000 DWT class tankers. The work is expected to be completed in 1980.

In October, 1978, the Arab Republic of Egypt requested the Japanese government to carry out a feasibility study for the Second Stage Development Project which is to be implemented following the completion of the First Stage Development Project.

Accordingly, the Japan International Cooperation Agency (JICA) dispatched in March, 1979 to Egypt "The Japanese Contact Mission for the Technical Cooperation Program to Planning and Research Department of the Suez Canal Authority". After the discussion with the Suez Canal Authority, the Japanese mission agreed to undertake immediately a rough study of the effects of the delay of the Second Stage Development Project, as part of the system analysis of the "Technical Cooperation Program to Planning and Research Department of the Suez Canal Authority".

In response to the request, JICA made its study and prepared the Progress Report "Study on the Second Phase Expansion Project of the Suez Canal".

The Japanese Preliminary Study Team organized by JICA explained the Progress Report to the Suez Canal Authority in Ismailia and finalized the Scope of Work for the feasibility study on the Second Stage Development Project, in October, 1979.

Immediately after signing the Scope of Work in October, the first phase of the preliminary survey in Egypt was made by the Japanese Study Team of four experts.

In accordance with the Scope of Work, the second phase survey team of six experts, organized by JICA, visited Egypt in December, 1979, for the purpose of conducting an in depth field survey and for meeting the authorities concerned for discussion and data collection.

With the accumulated information and its research, the Draft Final Report was submitted to the Suez Canal Authority.

2. Objective of Study

The objective of study is to prepare a feasibility report on the Second Stage Development

Project of the Suez Canal to be implemented continuously after the completion of the First Stage Development Project.

3. Outline of Study

1) Forecasting of Canal Traffic
   a) Seaborne cargo movements and fleet
   b) Maritime transportation cost by type and size of vessel
   c) Canal traffic forecasting by type and size of vessel and direction

2) Formulation of Master Plan

From a long range viewpoint, the Master Plan is formulated for the completely doubled channel giving consideration to the maximum anticipated size of transit vessel.

3) Evaluation of Phased Development Plans for the Second Stage Development Project

For the Second Stage Development Project, phased plans for doubling the Canal are prepared and evaluated.

The dimension and alignment of the channel are designed with due consideration of the safety of navigation, hydraulic phenomena in the Canal and so forth.

4) Study of Transit Capacity

Using a simulation model, the transit capacity is studied for the Canal after completion of the First and Second Stage Development Projects with consideration of different convoy systems.

5) Review on Technical Aspects

Based on the past reports and data supplied by SCA, a review on technical matters of developing the Canal is made.

6) Construction Plan and Cost Estimation
   a) The overall plan of constructon is made with consideration of the appropriate work schedule, the required capacity and number of dredgers, the construction equipment and others.
   b) The construction cost is estimated for land excavation, dredging, revetment work and others.

7) Analysis of Canal Toll

An analysis is made of how the Canal revenue and toll will be affected by circumstances surrounding the Canal.

8) Economic Analysis

The economic analysis is made on the cost and benefits induced by the Second Stage Development Project.

In this case, the share of benefits to the SCA, to the Egypt and to the World Economy

is examined.

9) Financial Analysis

Based on the present financial situation of the SCA, a financial analysis for the Second Stage Development Project is made. Financial statements based on business accounting principles are prepared.

4. Method and Organization

4-1 Flow of Study

A flow chart of the study is shown in Fig. 1-4-1.

4-2 Organization of the Study

Japan International Cooperation Agency consigned this study to the following three parties;

Overseas Coastal Area Development Institute of Japan (OCDI)
Japan Maritime Research Institute (JMRI)
Mitsubishi Reseach Institute, Inc. (MRI)

This stdy is made jointly by the three parties.

4-3 The Project Personnel

Title and Duties	Name and Position
1) Economist Project Manager	Takashi Hazama Executive Director, OCDI
2) Civil Engineer Canal Development Plan	Masahiko Matsuyama Director of Engineering, OCDI
3) Civil Engineer Canal Transit Analysis & Economic Analysis	Takashi Hashikawa Deputy Director of Engineering, OCDI
4) Economist Canal Administration & Financial Analysis	Kozo Tanaka Senior Economist, OCDI
5) Civil Engineer Technical Examination	Hisanori Kato Civil Engineer, OCDI
6) Civil Engineer Construction Plan & Cost Estimation	Ryosuke Komine Civil Engineer, OCDI
7) Maritime Economist Maritime Transportation Cost, Shipping Market & Canal Traffic	Katsumi Akiba Chief Maritime Economist, JMRI

8) Maritime Economist World Economy, Seaborne Trade & Fleet	Shojiro Miyanaga Senior Researcher, JMRI
9) System Engineer Transit Forecasting	Yoichi Aoki Manager, Social Systems Sec. II, MRI
10) Transportation System Analyst Transit Toll Analysis	Akira Tani Deputy Manager, Social Systems Sec. I, MRI
11) System Engineer Modeling and Forecasting of the Canal Traffic	Nobuharu Miyatake Chief Researcher, Social Systems Sec. II, MRI

4-4 Survey Schedules

(1) Preliminary Survey	October, 1979
(2) Secondary Survey	December, 1979
(3) The First Final Draft Report	March, 1980
(4) The Second Final Draft Report	May, 1980

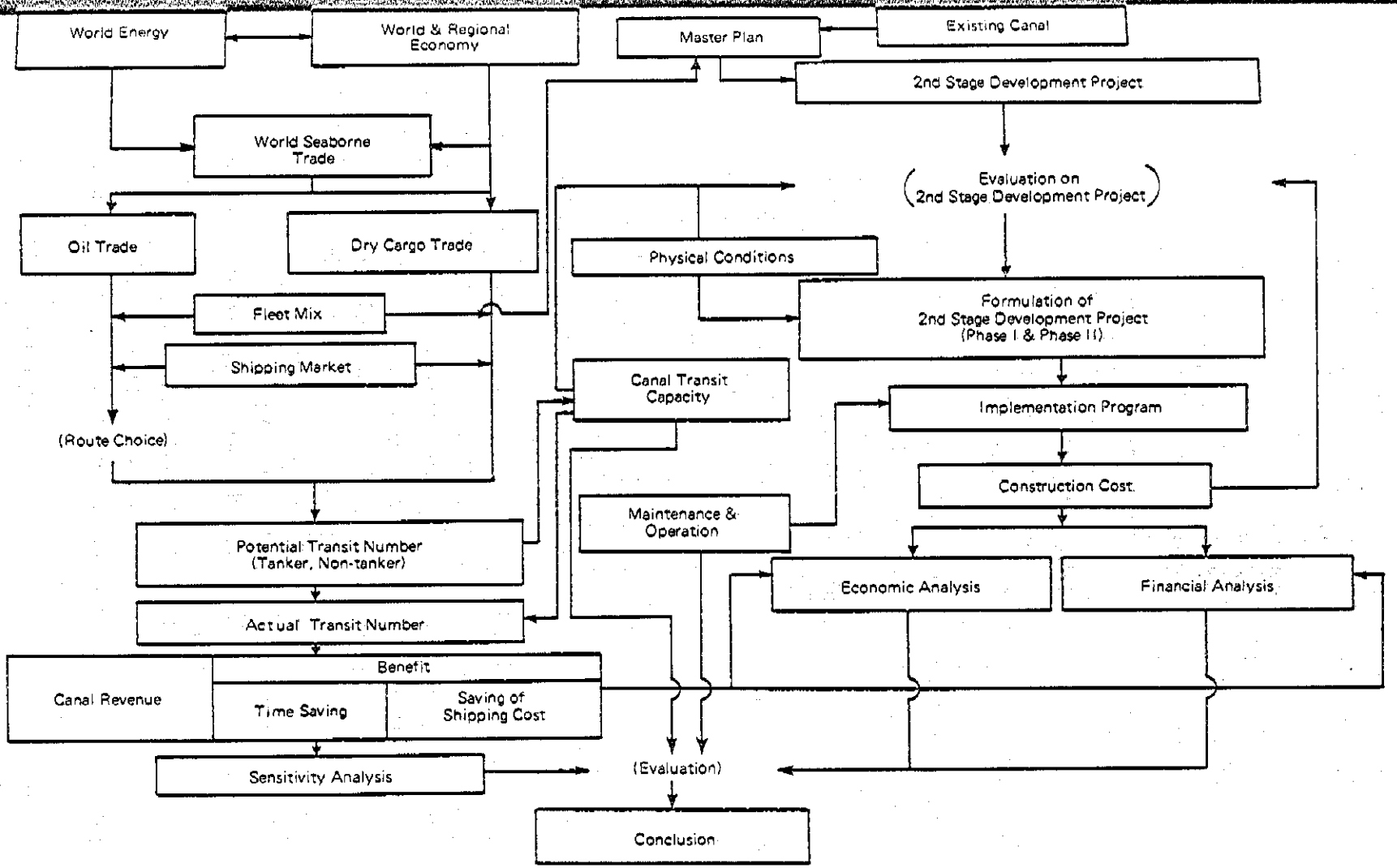


Fig. 1-4-1 Flow of Feasibility Study on The 2nd Stage Development Project

(1) Preliminary Survey (October, 1979)

Member:

S. Maeda	(Head – Japanese Government)
K. Matsumoto	(Japanese Government)
H. Nishijima	(JICA)
T. Hazama	(OCDI)
M. Matsuyama	(OCDI)
T. Hashikawa	(OCDI)
K. Akiba	(JMRI)

Date	Itinerary	Activities
Oct. 16 Tue.	Tokyo – Cairo	Tokyo – Cairo
17 Wed.	Cairo – Ismailia	Courtesy call to the Japanese Ambassador
18 Thu.	Ismailia	Courtesy call to SCA Discussion on the schedule with officials of SCA
19 Fri.	Ismailia – Port Said	Observation of the Canal and Port Said Harbour (by car)
20 Sat.	Ismailia	Reporting and discussion on the progress report
21 Sun.		Discussion on the progress report and explanation of S/W
22 Mon.		(Group 1) Observation of the Canal and Suez Port (by boat on the Canal) (Group 2) Meeting with officials of Transit Dept. on the transit system
23 Tue.		(Group 1) Final discussion on S/W and preparation of R/D (Group 2) Meeting with officials of Engineering Dept. on construction methods, etc.
24 Wed.	(Group 1) Ismailia – Cairo	(Group 1) Agreement of S/W and R/D (Group 2) Meeting with officials of Planning and Research Dept. on the Second Stage Project
25 Thu.	(Group 1) Cairo	(Group 1) Courtesy call to the Japanese Ambassador (Group 2) Meeting with officials of Planning and Research Dept. on the Second Stage Project
26 Fri.	(Group 1) Cairo – Tokyo	(Group 1) Cairo – Tokyo (Group 2) Data analysis
27 Sat.	(Group 2) Ismailia – Port Said	Survey and data collection in Port Said and Ismailia
28 Sun.	Ismailia	Final meeting with officials of Planning and Research Dept. on the Second Stage Project
29 Mon.	(Group 2) Ismailia – Suez	Survey and data collection in Suez and Ismailia
30 Tue.	Ismailia – Cairo	Survey and data collection in Ismailia
31 Wed.	Cairo	Courtesy call to the Japanese Ambassador
Nov. 1 Thu.	Cairo – Tokyo	Cairo – Tokyo

(2) Secondary Survey (December, 1979)

Member:	T. Hazama	(Head – OCDI)
	T. Okimoto	(Japanese Government)
	S. Miyanaga	(JMRI)
	K. Tanaka	(OCDI)
	H. Kato	(OCDI)
	A. Tani	(MRI)

Date	Itinerary	Activities
Dec. 4 Tue.	Tokyo – Cairo	Tokyo – Cairo
5 Wed.		Courtesy call to Japanese Embassy & JICA
		Data collection in Cairo
6 Thu.	Cairo – Ismailia	Meeting with officials of Planning & Research Dept.
7 Fri.	Ismailia – Port Said	Survey and data collection in Port Said
8 Sat.		Meeting with officials of Planning & Research Dept.
		on Inception Report and Questionnaire
9 Sun.		Data collection in SCA
10 Mon.		"
11 Tue.		"
12 Wed.		"
		Courtesy call to the Chairman of SCA
		Observation of the construction site of siphon
13 Thu.		Data collection in SCA
		Observation of the Canal by a container ship
		(Ismailia – Suez)
14 Fri.		Data collection in Ismailia
15 Sat.	Ismailia – Cairo	Final meeting with officials of Planning & Research
		Dept.
16 Sun.		Courtesy call to Japanese Embassy & JICA
		Data collection in Cairo
17 Mon.		Data collection in Institute of National Planning and
		others
18 Tue.	Cairo – Tokyo	Cairo – Tokyo

(3) The 1st Final Draft Report (March, 1980)

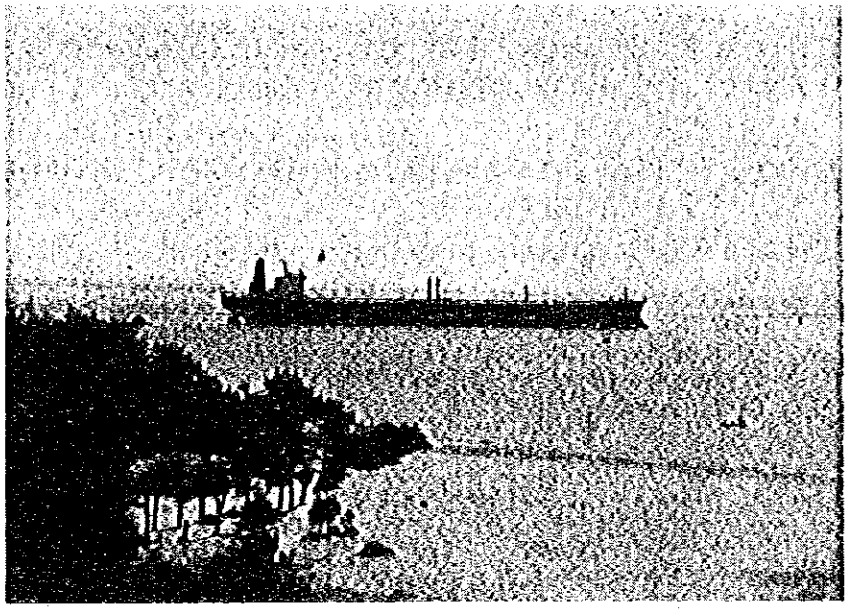
Member: S. Maeda (Head – Japanese Government)
T. Kaibara (JICA)
T. Hazama (OCDI)
M. Matsuyama (OCDI)
T. Hashikawa (OCDI)
K. Akiba (JMRI)

Date	Itinerary	Activities
Mar. 18 Tue.	Tokyo – Cairo	Tokyo – Cairo
19 Wed.		Courtesy call to Japanese Embassy & JICA
20 Thu.	Cairo – Ismailia	Courtesy call to SCA and Submission of Draft Final Report
21 Fri.		Preparation and data collection
22 Sat.		Explanation of Draft Final Report
23 Sun.		"
24 Mon.		"
25 Tue.	Ismailia – Cairo	Meeting with the Chairman of SCA
26 Wed.		Reporting to Japanese Embassy
27 Thu.	Cairo – Tokyo	Cairo – Tokyo

(4) The 2nd Final Draft Report (May, 1980)

Member: S. Maeda (Head – Japanese Government)
H. Ohta (Japanese Government)
T. Hashikawa (OCDI)
K. Akiba (JMRI)

Date	Itinerary	Activities
May 24 Sat.	Tokyo – Cairo	Tokyo – Cairo
25 Sun.		Courtesy call to Japanese Embassy & JICA
26 Mon.	Cairo – Ismailia	
27 Tue.		Explanation of the Draft Final Report
28 Wed.		"
29 Thu.		"
30 Fri.	Ismailia – Cairo	
31 Sat.		Reporting to Japanese Embassy & JICA
Jun. 1 Sun.	Cairo	Cairo
2 Mon.	– Tokyo	– Tokyo



II. Present Situation of The Suez Canal

PART II PRESENT SITUATION OF THE SUEZ CANAL

1. Present Situation of the Canal

The Suez Canal is a waterway connecting the Mediterranean and the Red seas. The Canal extends 162.5 km between Port Said in the north and Port Tewfik in the south, or 173.5 km if it is measured from the entrance of the approach channel north of Port Said (referred to Fig. 2-1-1).

The distance table with the Port Said lighthouse is normally used to give the locations of various points along the canal. According to the table, Timsah Lake is 76 – 81 km, Great Bitter Lake 97 – 120 km and Little Bitter Lake 120 – 134 km. The Canal is provided with three By-passes: Port Said By-pass at 3 – 17 km, Ballah By-pass at 50 – 62 km and Kabret By-pass at 114 – 123 km.

Fig. 2-1-1 shows the section of the present Canal. The section varies depending upon the position. The depth of the Canal is 13.5 – 16.0 m throughout the entire reach with the grade of slope varying between 1/3 and 1/4. In the north where the soil is loose and soft, the grade of slope is taken as 1/4, while 1/3 in the south where the soil condition is more favorable.

With the given section, the Canal is navigable for up to 60,000 DWT class tankers fully laden, though tankers of about 250,000 DWT class have made transits in ballast.

A system of convoys is in operation on a 24-hour cycle basis for the Canal transit. On entering at Suez, northbound vessels are organized into two types of convoys: Group A consisting of loaded tankers and Group B consisting of tankers in ballast and general freighters. Group A makes a direct transit to Port Said, whereas Group B leaving Suez after Group A, is reorganized at North Anchorage of Great Bitter Lake into the Port Said-bound convoy and the direct transit convoy. Proceeding with the direct transit convoy to sea, the Port Said-bound convoy leaves for Port Said.

Southbound ships are organized in two convoys. After leaving Port Said, the first convoy awaits at South Anchorage of Great Bitter Lake for the passing of northbound convoy. With the last ships of the northbound convoy entering the lake, the first convoy proceeds to Suez.

The second convoy leaves Port Said seven hours after the departure of the first convoy and awaits at Ballah By-pass for the passing of northbound convoy. With the last ship of the northbound convoy passing the km 60 point, the second convoy proceeds to Suez.

Canal transits are conducted according to the Rules of Navigation of the Suez Canal Authority.

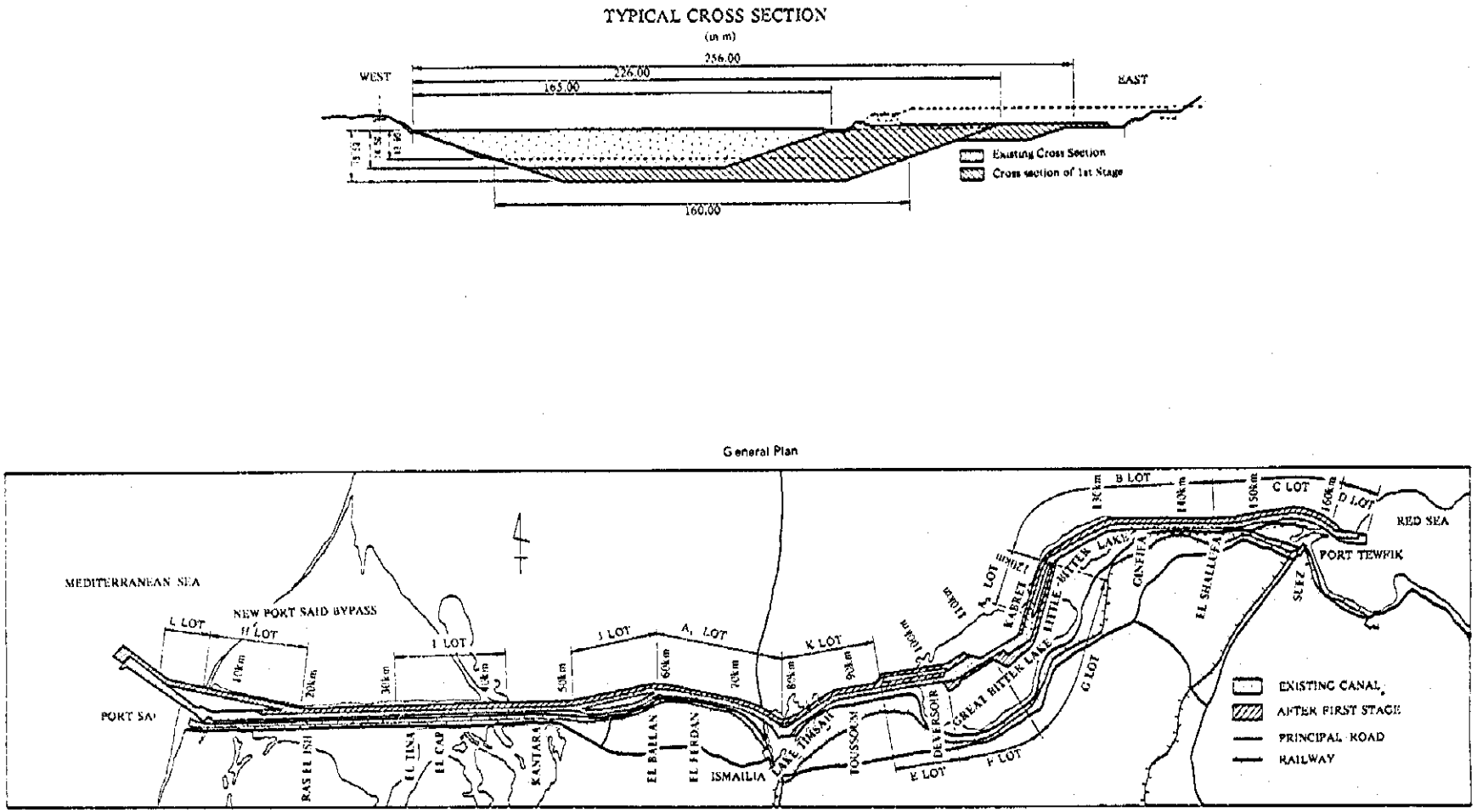


Fig. 2-1-1 Existing Conditions of the Canal

2. Canal Transit Record

2-1 Movements in transit volume

The Suez Canal was reopened on June 5, 1975, after it had been closed for eight years due to the Third Mid-East War. Except for 1975, when the Canal was reopened, the transit volume has been increasing steadily since 1976. The number of transits in 1978 has thus exceeded the level of 1966, before the closure. Accordingly, net registered tonnage (NRT) is also recovering the pre-1966 level; but the cargo traffic volume has recovered only about 60% of the 1966 level. Table 2-2-1 shows the number of transit ships, NRT and the cargo traffic volume from 1950 to 1966 and from 1976 to 1978.

Table 2-2-1 Traffic Volume before Closure and after Reopening

Year	Number of transit ships	Net tonnage (10^3 NRT)	Cargo traffic volume (10^3 ton)	No. of transit ships per day	Remarks
1950	11,750	81,796	72,609	32.2	
55	14,666	115,756	107,508	40.2	
60	18,734	185,322	168,883	51.3	
66	21,250	274,250	241,893	58.2	
76	16,807	186,859	117,653	45.9	
77	19,703	220,471	128,699	54.0	
78	21,266	248,260	149,779	58.3	
'78/'66	100.1%	90.5%	61.9%	100.1%	

Notes: 1. Derived from the Suez Canal Report.
2. NRT stands for Net Registered Tonnage which forms the basis for computing the transit tariff rates.

Table 2-2-2 shows the movements in the number of transits classified by tanker and non-tanker.

The table shows that prior to the reopening of the Canal, tankers had accounted for around 50% of the total transits; the ratio fell to 10 – 15% of the total after the reopening, with the number of tankers decreasing to about 1/4.

This shows that the size of tankers had increased during the closure and that the oil traffic between the Middle East and western countries was rerouted via the Cape of Good Hope after the reopening, due to the unfavorable tanker market following the oil crisis.

Oil traffic was almost balanced between northbound and southbound ships prior to the reopening of the Canal, but there have been more southbound ships than northbound ones after the reopening. This shows that loaded tankers take the route via the Cape of Good Hope, while ships in ballast use the Canal.

Classified by size, northbound traffic included tankers of over 60,000 DWT, although it is normally limited to those under 60,000 DWT if they are fully loaded. This is due to tankers of 60,000 – 150,000 DWT making transits with partial loads (see Table 2-2-3).

Table 2-2-2 Transit Number by Ship Type

Year	No. of transits	Tanker			Non-tanker		
		North-bound	South-bound	Total	North-bound	South-bound	Total
1958	17,842	4,761	4,827	9,588			8,254
59	17,731	4,526	4,685	9,211			8,520
60	(100%) 18,734	4,811	4,944	(52.1%) 9,755			(47.9%) 8,979
61	18,148	4,526	4,604	9,130			9,018
62	18,518	4,723	4,707	9,430			9,088
63							
64	19,943	4,856	4,910	9,766			10,177
65	(100%) 20,289	4,762	4,901	(47.6%) 9,663			(52.4%) 10,626
66	(100%) 21,250	4,759	5,171	(46.7%) 9,930			(53.3%) 11,320
76	(100%) 16,807	1,010	1,600	(15.5%) 2,610	6,834	7,363	(84.5%) 14,197
77	(100%) 19,703	1,083	1,537	(13.3%) 2,620	8,459	8,624	(86.7%) 17,083
78	(100%) 21,266	1,041	1,448	(11.7%) 2,489	9,790	8,987	(88.3%) 18,777

Table 2-2-3 Tanker Transits by Size and Direction

Size	1976			1977			1978		
	South-bound	North-bound	Total	South-bound	North-bound	Total	South-bound	North-bound	Total
under 20,000	213	179	392	246	207	453	230	219	449
20,001–40,000	452	450	902	435	495	930	390	429	819
40,001–60,000	202	178	380	150	154	304	181	162	343
60,001–80,000	136	87	223	126	98	224	116	98	214
80,001–100,000	215	103	318	196	109	305	176	119	295
100,001–150,000	201	13	214	241	20	261	163	13	175
150,001–200,000	35	–	35	42	–	42	43	1	44
over 200,000	146	–	146	100	–	100	149	–	149
Total	1,600	1,010	2,610	1,187	1,083	2,270	1,488	1,041	2,489

Large tankers naturally take the southbound route. The number of ships over 200,000 DWT, however, showed a decrease in 1977, probably due to their being rerouted via the Cape of Good Hope because of the depression in the tanker market.

In the meantime, non-tankers have shown a rapid increase after the reopening. Thus, the total number of transits has regained the level prior to the reopening with non-tankers making up for the decrease in tankers.

For the number of transits, cargo traffic has also shown a drastic decrease in oil traffic, while dry cargo has shown a relatively steady increase. Prior to the closure, oil accounted for 84.5% of northbound traffic and 68.8% of the total Canal traffic in 1966; in 1978 the ratio fell to 40.8% and 18.9% respectively.

On a quantity basis, oil traffic is only 17.0% of the 1966 level. In contrast, the dry cargo traffic in 1978 was 1.84 times the 1966 figure with the annual rate of increase of 5.2%, approximately 80% of that of world dry cargo movement, which was 6.5% (1966 – 77 average obtained from the United Nations Statistics). Movements in cargo traffic by commodity are given in Table 2-2-4.

Table 2-2-4 Traffic Volume by Commodity

(10^3 ton)

Year	Crude oil (including petroleum products)			Dry cargo			Total		
	North-bound	South-bound	Total	North-bound	South-bound	Total	North-bound	South-bound	Total
1965	(84.5%) 155,086	(18.8%) 7,908	(72.3%) 162,994	(15.5%) 28,355	(81.2%) 34,093	(27.7%) 62,448	(100%) 183,441	(100%) 42,001	(100%) 225,442
66	(34.4%) 166,718	(18.8%) 8,953	(72.6%) 175,671	(65.5%) 27,440	(81.2%) 38,772	(27.4%) 66,212	(100%) 194,158	(100%) 47,725	(100%) 241,883
76	(41.5%) 29,855	(8.7%) 3,969	(27.8%) 33,824	(58.5%) 42,165	(91.3%) 45,633	(72.2%) 87,798	(100%) 72,020	(100%) 45,633	(100%) 117,653
77	(42.5%) 30,878	(7.3%) 4,068	(27.2%) 34,946	(57.5%) 41,758	(92.7%) 56,036	(72.8%) 97,794	(100%) 72,636	(100%) 56,036	(100%) 128,672
78	(40.8%) 28,363	(6.0%) 4,816	(22.1%) 33,179	(59.2%) 41,234	(94.0%) 80,812	(77.9%) 122,046	(100%) 69,597	(100%) 80,182	(100%) 149,779

According to the Fearnley and Egers data, the total oil flow from the Middle East to Europe and U.S. in 1970 was 650 million tons. However, according to the Canal Report of Suez Canal Authority, the oil traffic through the Canal was only 28.4 million tons, or 4.4% of the total oil flow. As has been described, this is because oil flow from the Middle East to Europe and U.S. has been rerouted via the Cape of Good Hope due to the increase in the size of tankers.

2-2 Canal revenue

Suez Canal Authority collects tolls from transit ships in accordance with the Rules of Navigation.

Revenue from tolls after the reopening has shown a steady increase. The revenue in 1975

when the Canal was reopened was 39 million LE ($91 million), but this figure increased to 139 million LE ($323 million) in 1976 to 167 million LE ($388 million) in 1977 and 285 million LE ($662 million) in 1978. (Conversion of the old rate, US$1 = 0.43 LE.)

3. First Stage Development Project, Stage of Progress

The First Stage Development Project has been in progress since 1975. The purpose of the project is to widen the Canal and increase the depth to accommodate ships up to around 150,000 DWT instead of the present 60,000 DWT class fully loaded. Present and enlarged dimensions of the Canal after the First Stage Development Project are given below:

	Present	First stage Development Project
Depth (m)	15.0	19.5
Standard cross sectional area of the canal (m^2)	1,850	3,400 – 3,600
Maximum draft (ft)	38	53
Maximum ship size (thousand DWT)	60	150

Fig. 2-1-1 is a plan for the expanded Canal. The total extension of the Canal consists of the Canal section extending 162.5 km from Port Said to Suez, Port Said Approach Channel of 18 km and the Suez Entrance Channel of approx. 8 km. The canal section is to be enlarged both in width and in depth according to the specifications given above, Port Said By-pass, Deversoir By-pass and Kabret By-pass are also to be improved to increase transit capacity, and anchorage is to be improved in Great Bitter Lake for southbound convoys.

The scope of the First Stage Project includes five major works, and listed below.

1) Dredging: expansion of the Canal in width and depth, and dredging of By-pass
2) Dry excavation: land excavation of the east bank.
3) Revetment: removal of the east bank revetment and installation at the widened position (removal and transfer of bollards included)
4) Mooring caissons: removal and installation of caissons
5) Breakwater and groin: protection of the north section of port Said By-pass

Table 2-3-1 gives the constructor and the volume of work for each secton. Dredging volume, including By-passes is about 600 million m^3.

When the work commenced, it was to be completed in 3.5 years, from mid 1975 to the end of 1978. However, due to the delays with the contract and the rock excavation in the south of Bitter Lake, the work period is expected to be extended by two years. Accordingly, work on all sections will be completed in mid 1980; and with the period of inspection the final completion of the First Stage Development Project will be at the end of 1980.

Table 2-3-1 Contractor, and Work Volume of Each Section

Works classified	Work lot	Canal section	Constructor	Work volume required	Remarks
				10^6 m^3	
Dredging	A_1	61.00 – 78.00	Penta-Ocean Construction Co., Ltd.	39.45	
	A_2	114.80 – 122.10	Penta-Ocean Construction Co., Ltd.	9.20	
	B	122.10 – 145.00	Penta-Ocean Construction Co., Ltd.	36.00	
	C	145.00 – 161.05	Penta-Ocean Construction Co., Ltd.	30.30	
	D	161.05 – Hm 77	Vianini (Italy)	13.00	
	E	94.50 – 101.05	Penta-Ocean Construction Co., Ltd.	31.80	
	F	101.05 – 109.00	U.M.D. (France)	28.55	
	G	109.00 – 122.10	Penta-Ocean Construction Co., Ltd.	28.35	
	H	1.50^E – 16.00^E	Mitsui Harbour and Urban Construction Co., Ltd.	49.50	
	I	29.50 – 42.00	Toa Harbour Works Co., Ltd.	27.20	
	J	50.50 – 61.00	Penta-Ocean Construction Co., Ltd.	31.60	
	K	78.00 – 94.50	Dredging International (Dutch)	42.60	
	L	1.50 – Hm 110	Vianini, Mitsui Harbour and Urban Construction Co., Ltd.	52.00	
	M	-19.00 – Hm 0	SCA	31.37	
	N	0 – 3.60	SCA	4.10	
	O	3.60 – 16.275	SCA	25.38	
	P	16.275 – 30.00	SCA	29.75	
	Q	42.00 – 50.50	SCA	18.38	
	R	53.51 – 56.87	SCA	7.00	
		Total		535.5	
Excavation			6 Local constructors	93.3 10^6 m^3	
Revetment			Arab contractors	144 km	
Breakwater/ jetty			Local constructors	2,400 m	
Others					

Note: Compiled from the data supplied by OECF.