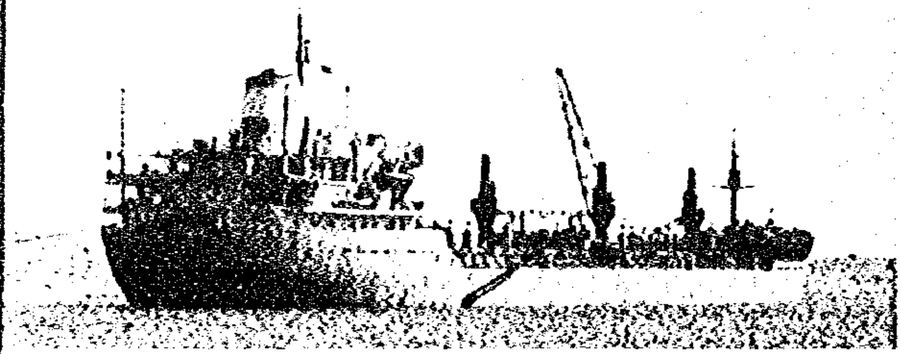
社会開発協力部報告書

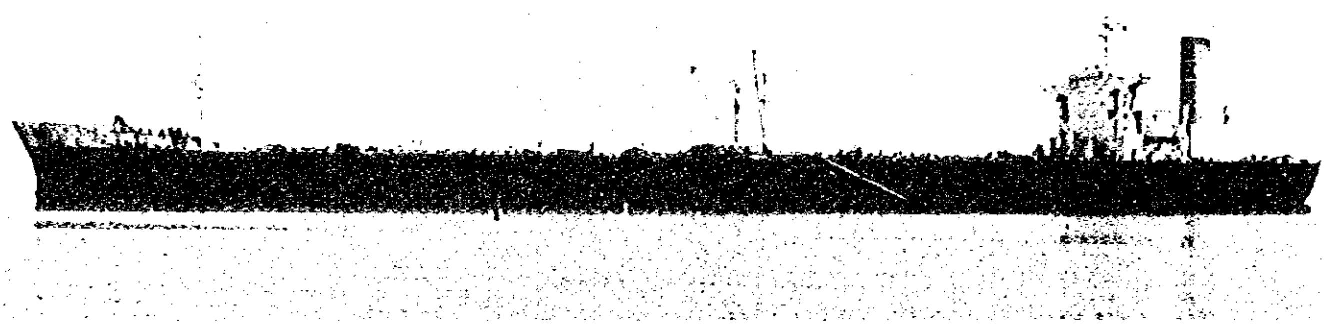
No. 7

THE STUDY ON THE SAFETY IMPROVEMENT OF THE SUEZ CANAL IN THE ARAB REPUBLIC OF EGYPT



FINAL REPORT

AUGUST 1985



JAPAN INTERNATIONAL COOPERATION AGENCY

SDF

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THE STUDY ON THE SAFETY IMPROVEMENT OF THE SUEZ CANAL IN THE ARAB REPUBLIC OF EGYPT

FINAL REPORT

AUGUST 1985

PREFACE

In response to the request of the Government of the Arab Republic of Egypt, the Government of Japan decided to conduct a feasibility study on the Safety Improvement of the Suez Canal and entrusted it to the Japan International Cooperation Agency (JICA).

The JICA sent to Egypt a survey team headed by Mr. Takashi Hazama, Senior Executive Director, the Overseas Coastal Area Development Institute of Japan (OCDI) for a field survey from Agusut, 1983 through October, 1983 and from October, 1984 through November, 1984.

The team exchanged views with the officials concerned of the Government of Egypt on the project and conducted a field survey in the region involved. After the team returned to Japan, further studies were made and the present feasibility 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 the Arab Republic of Egypt for their close cooperation extended to the team.

August, 1985

Keisuke Arita

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 Study Report on the Safety Improvement of the Suez Canal.

This report incorporates the results of studies which The Overseas Coastal Area Development Institute of Japan and The Japan Association for Preventing Marine Accidents have jointly carried out at the request of the Japan International Cooperation Agency.

Regarding this project, our study team has conducted field surveys in Egypt for the period of 61 days from 15 August, 1983, and of 30 days from 2 October, 1984. And, on the basis of the findings of these surveys as well as based on the data and information collected in Japan, we have made an evaluation of the current safety condition of the Suez Canal and formulated plans of countermeasures which need to be taken to improve the safety level of the Canal. Also, a study was made to examine the feasibility of the project from economic and financial viewpoints.

We believe that the safety improvement of the Suez Canal as proposed in this report is of an urgent necessity judging from the importance of the Canal as an international shipping route and at the same time feasible both economically and financially. We, therefore, 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 Japan Embassy in Cairo for their valuable advice and support given to us in the field survey and in the preparation of this study report.

August 1985

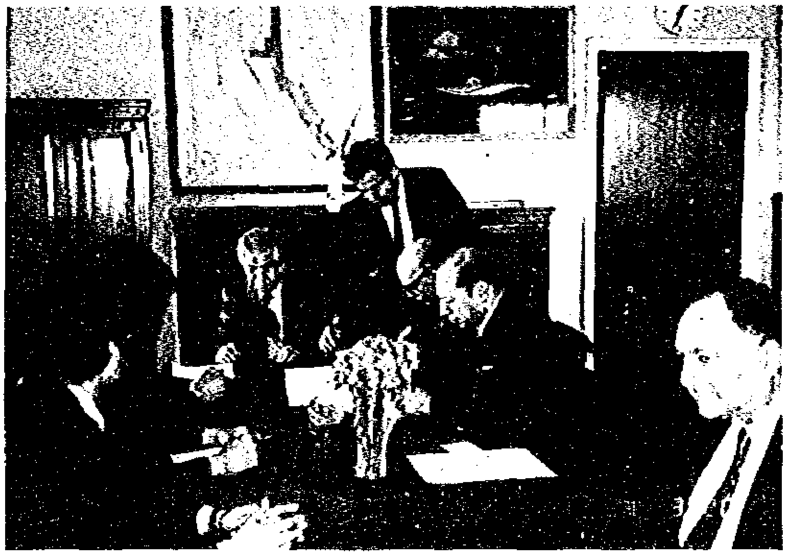
Yours faithfully,

T. Hazama

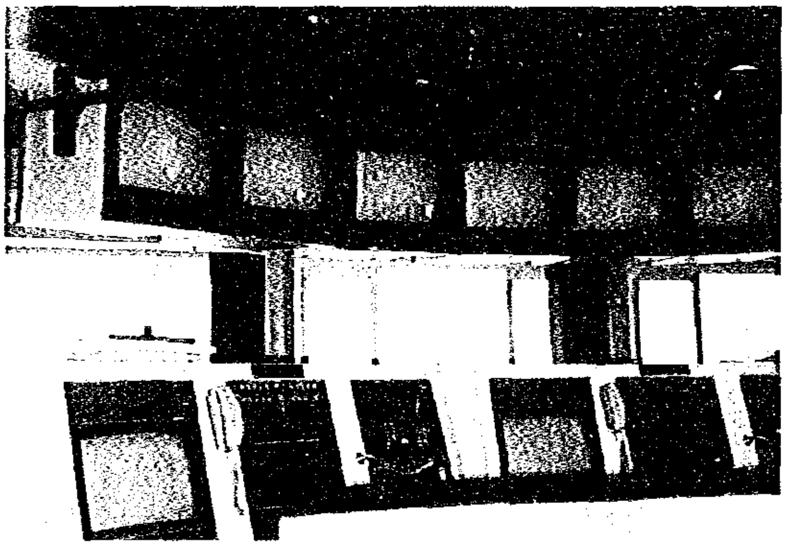
Takashi Hazama,
Head, Japanese Study Team
for the Safety Improvement
of the Suez Canal

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

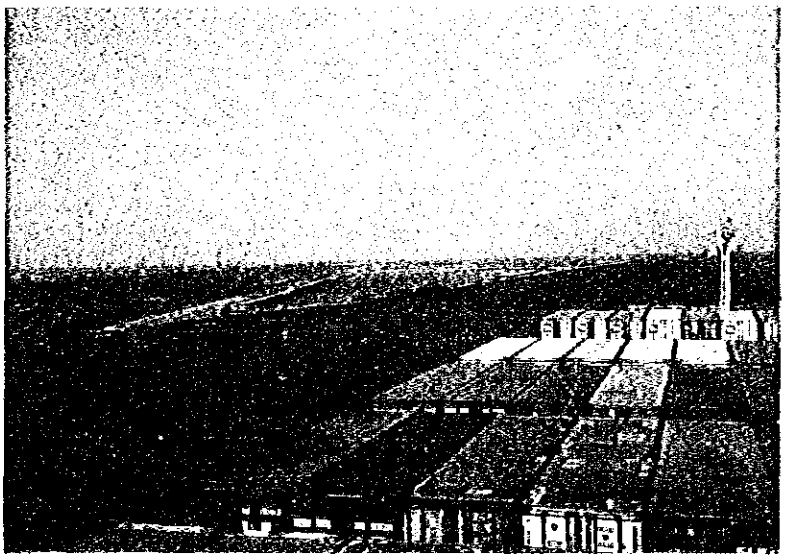
LOCATION OF SUEZ CANAL



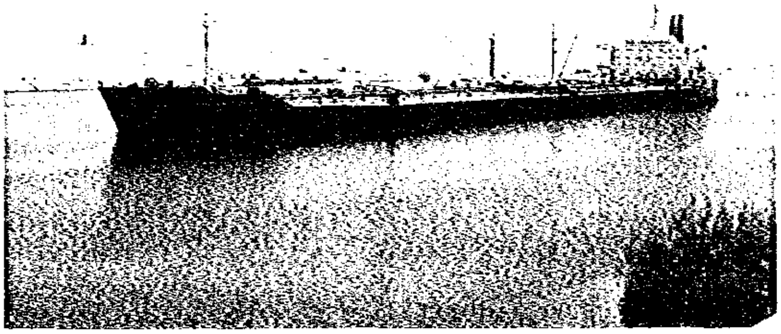
Exchange of Signature



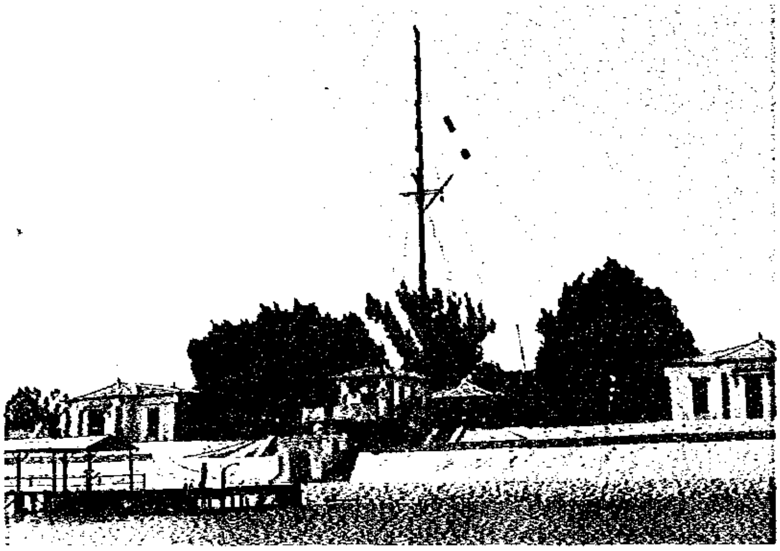
Instrument of SCVTMS



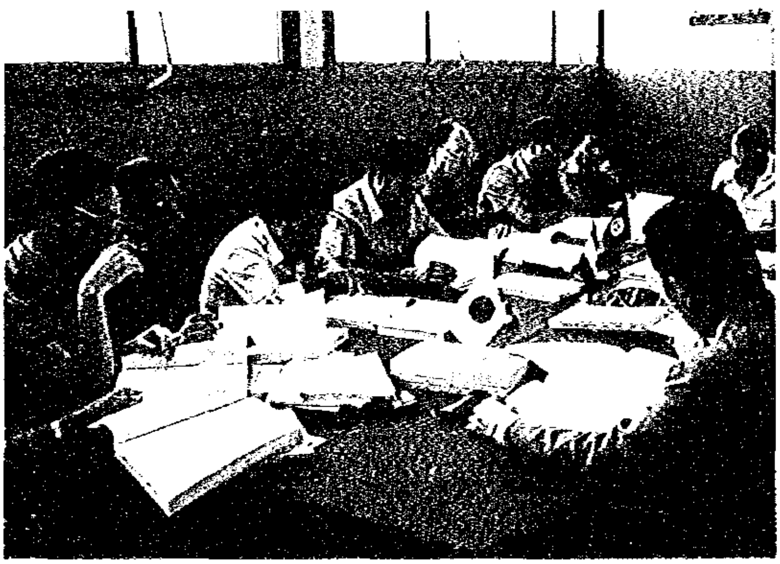
Port Said Junction (around Km 17)



Transit Tanker (around Km 75)



Shallufa Signal Station



Presentation of the Report

Exchange Rate

US$1.00 = LE 1.40 = ¥250.00

US$0.95 = SDR1.00

LIST OF ACRONYMS

B/C	:	Cost Benefit Ratio
BELVE	:	Boiling Liquid Expanding Vapour Explosion
CAROF	:	Computer Aided Operations Research Facility
Cl	:	Chloride Ion
COD	:	Chemical Oxygen Demand
CORT	:	Carry on Receiver Transmitter
CPP	:	Controllable Pitch Propeller
CRT	:	Cathode-Ray Tube
DM & M	:	Data Management and Display
DO	:	Dissolved Oxygen
DWT	:	Dead Weight Tonnage
ETA	:	Estimate Time of Arrival
FC	:	Foreign Currency
FRR	:	Financial Rate of Return
FTA	:	Fault Tree Analysis
GT	:	Gross Tonnage
HHWL	:	Highest High Water Level
HP	:	Horse Power
HWL	:	High Water Level
IPDS	:	Information Processing and Delivery System
IRR	:	Internal Rate of Return
JICA	:	The Japan International Cooperation Agency
JIS	:	Japan Industrial Standard
JAMPA	:	The Japan Association for Preventing Marine Accident
LC	:	Local Currency
LE	:	Egyptian Pound
LEL	:	Lower Explosive Limit
LFL	:	Lower Flammable Limit
LLWL	:	Lowest Low Water Level
LNG	:	Liquified Natural Gas
LPG	:	Liquified Petroleum Gas
MITAGS	:	Marine Institute of Technology and Graduate Study
MSI	:	Marine Safety International
MSL	:	Mean Sea Level
MWL	:	Mean Water Level

NK	:	Nippon Kaiji Kyokai
NPV	:	Net Present Value
NS	:	Nippon Standard
OCB	:	Temperature and Oily Matter
OCDI	:	The Overseas Coastal Area Development Institute of Japan
PCC	:	Pure Car Carrier
PH	:	Potential of Hydrogen
PIANC	:	Permanent International Association of Navigation Congresses
PPM	:	Parts per Million
SCA	:	The Suez Canal Authority
SCGT	:	Suez Canal Gross Tonnage
SCNT	:	Suez Canal Net Tonnage
SCVTMS	:	The Suez Canal Vessel Traffic Management System
SDR	:	Special Drawing Right
S/W	:	Scope of Work
UHF	:	Ultra High Frequency
ULCC	:	Ultra Large Crude Carrier
VHF	:	Very High Frequency
VLCC	:	Very Large Crude Carrier
VTMS	:	Vessel Traffic Management System
¥	:	Japanese Yen

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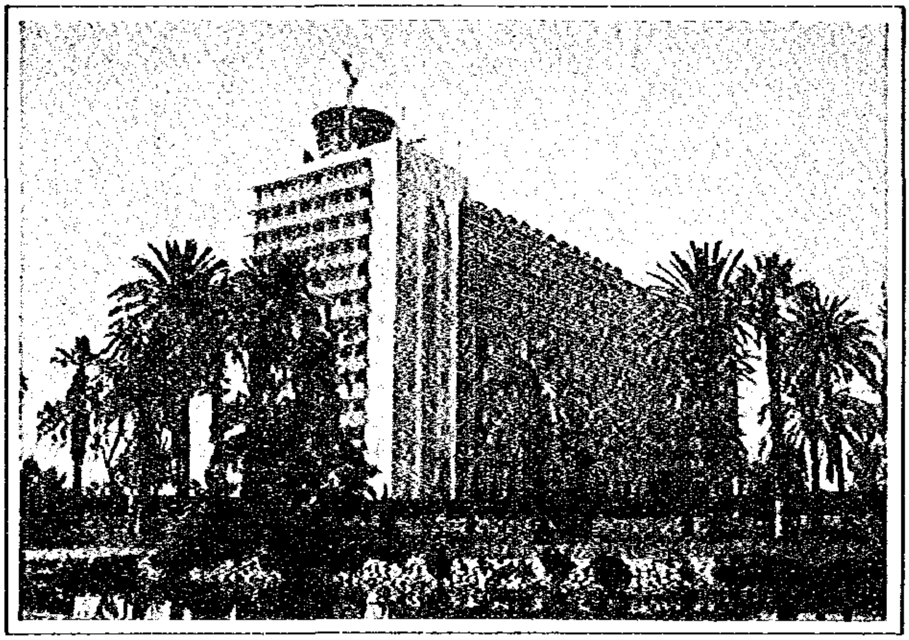


Headquater of SCA

CONCLUSION

1. Considering the overall evaluation of the current topography, navigation system, countermeasures against accidents, and frequency of accidents in the Canal, and compared with the frequency of accidents in other canals throughout the world, the Suez Canal can generally be judged safe. However, taking into account the important role of the Suez Canal in the world maritime economy, safety measures in the Canal should be improved and the level of risk reduced.

2. Considering the types, sizes, and traffic volume of transit vessels which pass through the Canal at present and are estimated to pass through in the future as well as the current SCA plan, risk levels in other waterways throughout the world, and the feasibility of implementing safety measures, we recommend that 0.40×10^{-3} be considered as the acceptable risk level in the study.

3. In order to clear the recommended acceptable risk level, all the following safety measures must be put into effect:

(1) The width of the Canal must be expanded between Km 85 and Km 88 and between Km 115 and Km 134 beyond the expansion which is part of the Second Stage Development Project currently being considered by the SCA.

(2) The navigation system must be improved through improvement of aids to navigation, establishment of an improved Canal traffic communication system, and through other necessary improvements.

(3) An efficient system to respond to accidents must be prepared including the construction of facilities, vessels, equipment, and appropriately located storage spaces to control oil spills and fires and to respond to other disasters. Furthermore, execution teams must be formed and trained to respond to various accidents which may occur.

I. Evaluation of Current Canal Conditions

1. Engineering Conditions

The current canal topography has been studied and evaluated through comparison with PIANC Recommendations and with the conditions in canals in other countries.

The present Suez Canal design depth of −19.5 m seems to be reasonable for navigation of 150,000 DWT class tankers.

However, the width of the greater part of the navigation way seems to be insufficient for navigation of 150,000 DWT class tankers, except for the fairway at the Port Said Approach Channel and at Great Bitter Lake. It is desirable to widen the Canal in certain areas to reduce risk and prevent fatal accidents.

2. Navigational Conditons

As the results of analysis and evaluation on the navigational conditions of the Canal, we wish to emphasize the following points:

(1) The actual speed of transit vessels exceeds the speed criteria established by SCA in most cases.

(2) The education and training of the Canal pilots seem to be insufficient.

(3) The arrangement of escort tugs is a prerequisite for large vessels; the reinforcement of them is desirable.

(4) The users of the Canal strongly request improved aids to navigation, better safety measures in Port Said and Suez, and improved communications.

(5) The controls over anchorages and meeting of transit vessels in areas such as Deversoir and Kabrit Junction are insufficient.

(6) The canal buoys are appropriate in terms of function and structure, but the buoys in the approaches must be reinforced.

(7) The SCVTMS is an extremely effective system for the efficient control and management of the Canal and for the safety of traffic in the Canal. The early placing of the system in operation for the actual control and management of the Canal is strongly desired.

(8) From the results of the analysis and evaluation of accident records, it may be concluded as follows:

1) The risk level of the Canal decreased sharply after the completion of the First Stage Development Project.

2) The occurrence of accidents in the Canal is closely linked to the occurrence of sandstorms.

3) Collision and contact accidents are heavily concentrated in Port Said, and many grounding and touching bank accidents occur at El Ballah.

4) The human caused accidents comprise the majority of the total accidents.

5) The risk levels are not closely related to the size of vessels. This may be attributable to

the effects of extra efforts dedicated to the safety measures in large vessels.

6) Collisions frequently take place during mooring and anchoring manoeuvres, whereas groundings often occur during passage.

7) Groundings often occur in many cases without the effects of other vessels, and mostly occur at the Canal banks.

3. Resources against Accidents

Though stockpiles of equipment and material are being build up gradually, however, there still remain room for improvement in their quantity and quality. Also, further improvement is necessary in the area of organization, manpower and facilities.

II. Risk Evaluation

1. Acceptable Risk Level

Considering the risk levels of other channels in the world, the improved level from the First Stage Development Project, the risk levels proposed by SCA and the feasibility of countermeasures, 80%, 60% and 20% reductions of the present risk levels are taken as alternatives for acceptable risk levels. By multiplying current levels by these decreasing ratios, the acceptable risk levels are calculated as follows:

Table 1 Acceptable Risk Levels

Locations	J-1	J-2	J-3	J-4
Port Said add Suez (Approach Channel and Harbour)	1.11×10^{-4} (1.39×10^{-5})	9.36×10^{-5} (1.17×10^{-5})	1.86×10^{-4} (2.34×10^{-5})	3.72×10^{-4} (4.66×10^{-5})
El-Ballah Bypass	3.05×10^{-6} (3.79×10^{-7})	3.23×10^{-6} (4.04×10^{-7})	6.46×10^{-6} (8.08×10^{-7})	1.29×10^{-5} (1.62×10^{-6})
Other parts of the Canal	1.15×10^{-4} (7.08×10^{-7})	3.11×10^{-4} (1.92×10^{-6})	6.20×10^{-4} (3.83×10^{-6})	1.24×10^{-3} (7.66×10^{-6})
Bitter Lakes	5.51×10^{-5} (–)	5.83×10^{-5} (–)	1.17×10^{-4} (–)	2.34×10^{-4} (–)

Note: Figures in parentheses are risk levels per km.

2. Risk Evaluation

Current risk levels in most parts of the Canal exceed all of the proposed alternative risk levels. Even after the Second Stage Development Project is completed, some portions of the Canal will still be unsatisfactory. The lengths of the Canal which must be widened are 152 km, 67 km, 38 km and 14 km to reduce risk levels to J-1, J-2, J-3, and J-4, respectively.

The areas to be widened are different for each proposed alternative. However, the section from Km 115 to 129 will have to be widened under all of the proposed plans.

III. Measures for Safety Improvement

1. Measures

(1) Engineering Measures

1) Canal Topography

According to the results of risk analysis, the additional widening widths in addition to the Second Stage Development Project of SCA are required for each level.

The additional widening widths and locations for each level are shown in Table 2.

2) The Work Volume of the Second Stage Development Project

As for the work volume of the Second Stage Development Project, the SCA plan would only involve dredging work, but each of the proposed alternative plans would also involve the removal and reconstruction of banks and/or mooring caissons.

The work volume involved in the SCA plan and the alternative plans is listed in Table 3.

Table 2 Additional Widening Widths (In Addition to the Second Stage Development Project Plan of SCA)

(Unit: meters)

Location	J-1		J-2		J-3		J-4	
	Results of Risk Analysis	Proposed Additional Width	Results of Risk Analysis	Proposed Additional Width	Results of Risk Analysis	Proposed Additional Width	Results of Risk Analysis	Proposed Additional Width
Hm 90^{E} ~ Hm 0^{E}	18	20	18	20				
Hm 0^{E} ~ Km 1^{E}	0	20						
Km 1^{E} ~ 15^{E}	15	15						
Km 15^{E} ~ 19	0	0						
Km 19 ~ 31	11	10						
Km 31 ~ 34	0	0						
Km 34 ~ 50	1	0						
Km 50 ~ 51^{E}	0	0						
Km 51^{E} ~ 60^{E}	0	0						
Km 50 ~ 52^{W}	15	15						
Km 52^{W} ~ 55^{W}	0	15						
Km 55^{W} ~ 59^{W}	35	35	12	10				
Km 59^{W} ~ 64	31	30	12	10				
Km 64 ~ 71	15	15						
Km 71 ~ 75	14	15						
Km 75 ~ 83	29	30	7	10				
Km 83 ~ 85	0	30						
Km 85 ~ 88	53	55	30	30	9	10		
Km 88 ~ 93	7	10						
Km 93 ~ 94	0	0						
Km 94 ~ 96	0	0						
Km 96 ~ 101^{E}	32	35	15	15	2	0		
Great Bitter Lake								
Km 115^{E} ~ 122^{E}	130	130	90	90	66	70	40	40
Km 122^{E} ~ 126	190	190	130	130	80	80	35	35
Km 126 ~ 129	54	55	35	35	20	20	5	5
Km 129 ~ 132	71	70	33	35	0	20		
Km 132 ~ 134	40	40	23	25	10	10		
Km 134 ~ 145	6	10						
Km 145 ~ 147	0	0						
Km 147 ~ 154	13	15						
Km 154 ~ 162	6	10						

Table 3 Work Volume of the Second Stage Development Project

km	SCA Plan	Alternative Plans									
		J-1			J-2			J-3		J-4	
	Dreding ($10^3 m^3$)	Dredging ($10^3 m^3$)	Bank Work (km)	Removal Caisson (Number)	Dredging ($10^3 m^3$)	Bank Work (km)	Removal Caisson (Number)	Dredging ($10^3 m^3$)	Removal Caisson (Number)	Dredging ($10^3 m^3$)	Removal Caisson (Number)
Port Said Approach Channel	61,400	65,300			64,800			61,400		61,400	
Km 1.5 ~ 61.0	42,700	55,300	9.5		43,900	0.2		42,700		42,700	
Km 61.0 ~ 79.0	30,200	39,200	16.9		31,900	3.5		30,200		30,200	
Km 79.0 ~ 94.5	21,300	31,300	13.7		24,300	6.2		21,900		21,300	
Km 94.5 ~ 101.0	11,700	16,000			13,300			12,300		11,700	
Km 101.0 ~ 115.0	19,000	20,400			19,600			19,400		19,200	
Km 115.0 ~ 122.0	4,300	24,300		16	18,200		16	14,900	16	10,300	
Km 122.0 ~ 145.0	36,600	67,600	10.5	36	54,900		36	47,300	36	40,200	13
Km 145.0 ~ 162.25	25,100	29,400	11.1	5	25,100			25,100		25,100	
Great Bitter Lake Anchorage	83,900	83,900			83,900			83,900		83,900	
Total	336,200	432,700	61.7	57	379,900	9.9	52	359,100	52	346,000	13

(2) Navigational Measures

1) For the enhancement of navigational safety and improvement of traffic control in the areas of the approaches and Great Bitter Lake etc., aids to navigation in those areas should be reinforced.

2) As for transit vessels, insufficient information and unsmooth communications reduce the safety of navigational operations. Therefore, instructions should be given to those engaged in the communication services to recognize the importance of communications, and the communication system should be reinforced.

3) For preventing undue disorders and disturbances at the time of the occurrence of accidents and for dealing with such emergency situations in a most organized and systematic manner, it is necessary to establish in advance an organization and system to respond to accidents with proper drill and training.

4) Sandstorms are a major culplit for a variety of accidents. Further investigations on the critical wind velocity and the visibility as the criteria to prohibit transiting is considered necessary.

5) A high frequency of grounding and contacting accidents to the Canal banks occurred in the Ballah West Branch by second southbound convoy vessels.

Proper guidance should be given to the pilots so that they pay better attention to the effects that bank suction and the inclined bottom of the Canal exert on manoeuvring there.

6) The controls over each anchorage are presently insufficient.
It is necessary to realize closely attended control practices.

7) The majority of the total accidents were caused by human error.

In recognition of the importance of the Suez Canal as an international waterway, it is the responsibility of the SCA to maintain the knowledge and skill of the pilots piloting the Canal at reasonably high levels.

(3) Structures and Equipment against Accidents

Proposed structures and equipment against fire and pollution are indicated in the following figure.

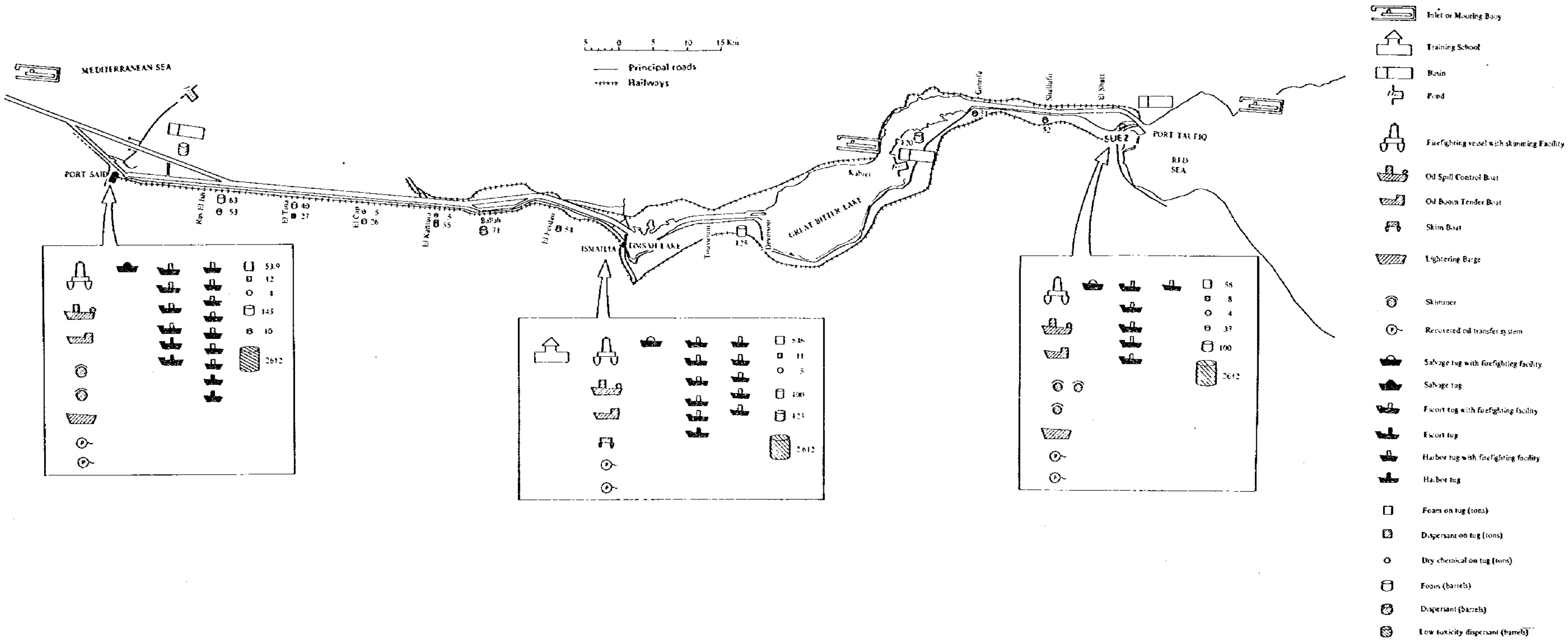


Fig. 1 Proposed Location of Structure and Equipment Against Fire and Pollution.

2. **Evaluation of Measures**

(1) The project cost of each alternative is estimated as shown in Table 4, and these are the additional cost necessary for achievement of each acceptable risk level to the cost of the Second Stage Development Project which will be carried out by SCA.

The cost of J-1 which represents a risk level of 0.25×10^{-3}, is US$327.4 million, the most expensive of the four alternatives.

Table 4 Project Cost

(Unit: LC in Million LE, FC and Totals in Million US$)

Item / Currency / Study Case	Canal Widening			Improvement of Aids to Navigation			Preparation for Disaster Treatment			Total		
	LC	FC	Total	LC	FC	Total	LC	FC	Total	LC	FC	Total
J-1 (0.25×10^{-3})	91.1	157.0	221.1	2.7	4.6	6.5	46.1	65.9	98.8	139.9	227.5	327.4
J-2 (0.40×10^{-3})	34.6	35.9	60.6	2.7	4.6	6.5	46.1	65.9	98.8	83.4	106.4	165.9
J-3 (0.79×10^{-3})	14.5	25.2	35.6	2.7	4.6	6.5	46.1	65.9	98.8	63.3	95.7	140.9
J-4 (1.58×10^{-3})	7.6	10.2	15.6	2.7	4.6	6.5	46.1	65.9	98.8	56.4	80.7	120.9

Note: An exchange rate of 1.40 LE per US$ is used in consideration of the shadow price.

(2) The results of the project evaluation show that alternative J-4 is not feasible because the B/C ratio is less than 1.0. J-1, J-2 and J-3 are all feasible alternatives. From the viewpoint of IRR, J-2 is clearly the best investment of the four alternatives.

Table 5 Results of IRR Calculation

	Alternative			
	J-1	J-2	J-3	J-4
IRR	6.6%	11.4%	3.5%	--

(3) The acceptable risk level is varied in accordance with discount ratio, and in the study it can be concluded that the optimum acceptable risk level is about 0.4×10^{-3} as shown in Fig. 2.

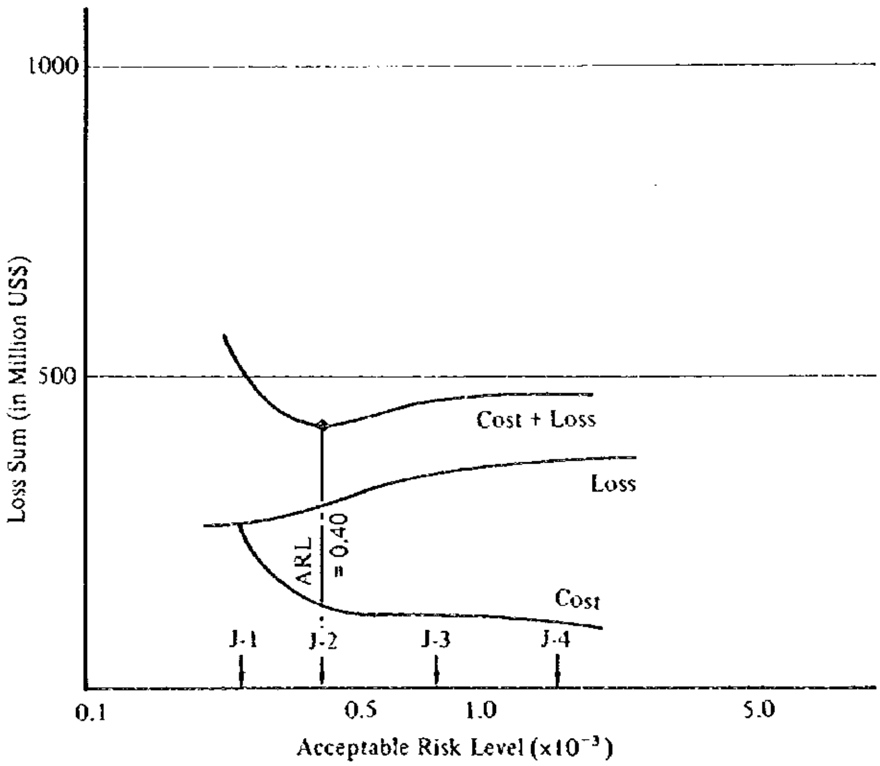


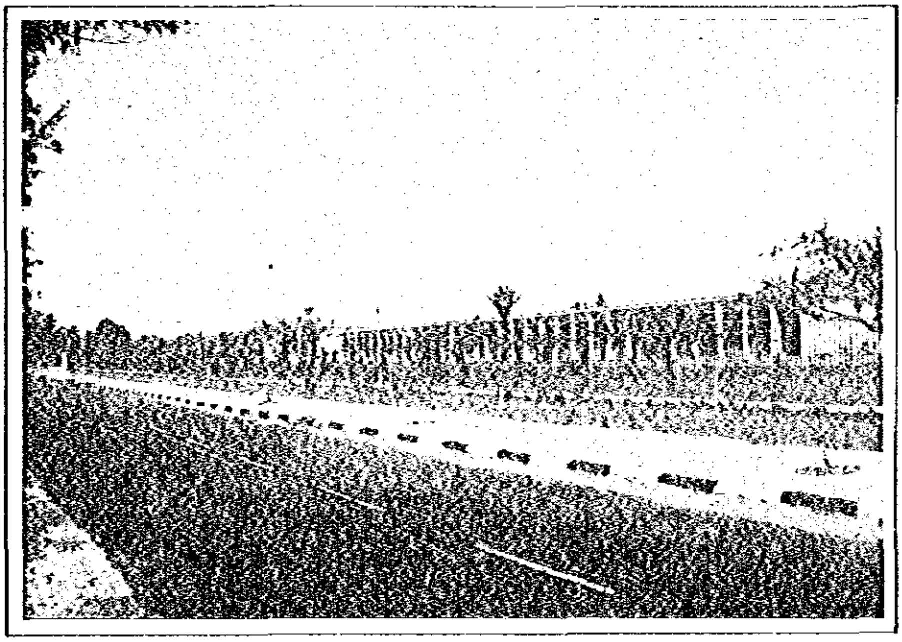
Fig. 2 Acceptable Risk Level (Discount Ratio: 15%)

(4) The results of the financial analysis show that J-1, J-2 and J-3 are feasible from the viewpoint of FRR, and that the FRR of J-4 is negative. The FRR of J-2 is the most profitable among the four alternatives.

Table 6 Results of FRR Calculation

	Alternative			
	J-1	J-2	J-3	J-4
FRR	4.6%	9.0%	1.4%	–

SUMMARY



Research Center of SCA

SUMMARY

PART I INTRODUCTION

In response to a request made by the Government of the Arab Republic of Egypt, the Government of Japan has decided to conduct a Study on the Safety Improvement of the Suez Canal in the Arab Republic of Egypt in accordance with laws and regulations in force in Japan.

I-1 Objective of the Study

The objective of this Study is to make some suggestions on measures to prevent Canal accidents which are likely to occur under the present situation of the Suez Canal, during the Second Stage Development Project of the Canal and after the completion of the Second Stage Development Project.

I-2 Outline of the Study

In order to achieve the objectives mentioned above, the Study covers the following:

(1) Review of Current Canal Conditions

1) Canal Topography
2) Natural Conditions
3) Traffic Flow
4) Traffic and Anchorage Conditions
5) Current Safety Measures
6) Survey of Canal Users
7) Environment in and around the Canal

(2) Analysis of Accidents

(3) Evaluation of Canal Conditions

1) Existing Risk Level
2) Topographical Conditions
3) Traffic and Anchorage Conditions
4) Aids to Navigation
5) Canal Traffic Control and Regulations
6) Canal Maintenance

7) Resources against Fire and Pollution

(4) Risk Analysis

(5) Risk Evaluation

(6) Measures for Safety Improvement

I-3 Method and Organization

(1) Method of Study

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

(2) Organization of the Study

The Japan International Cooperation Agency (JICA) consigned the Study to the Joint Venture, which consists of the Overseas Coastal Area Devlelopment Institute of Japan (OCDI) and the Japan Association for Preventing Marine Accidents (JAPMA), for the Study on the Safety Improvement of the Suez Canal.

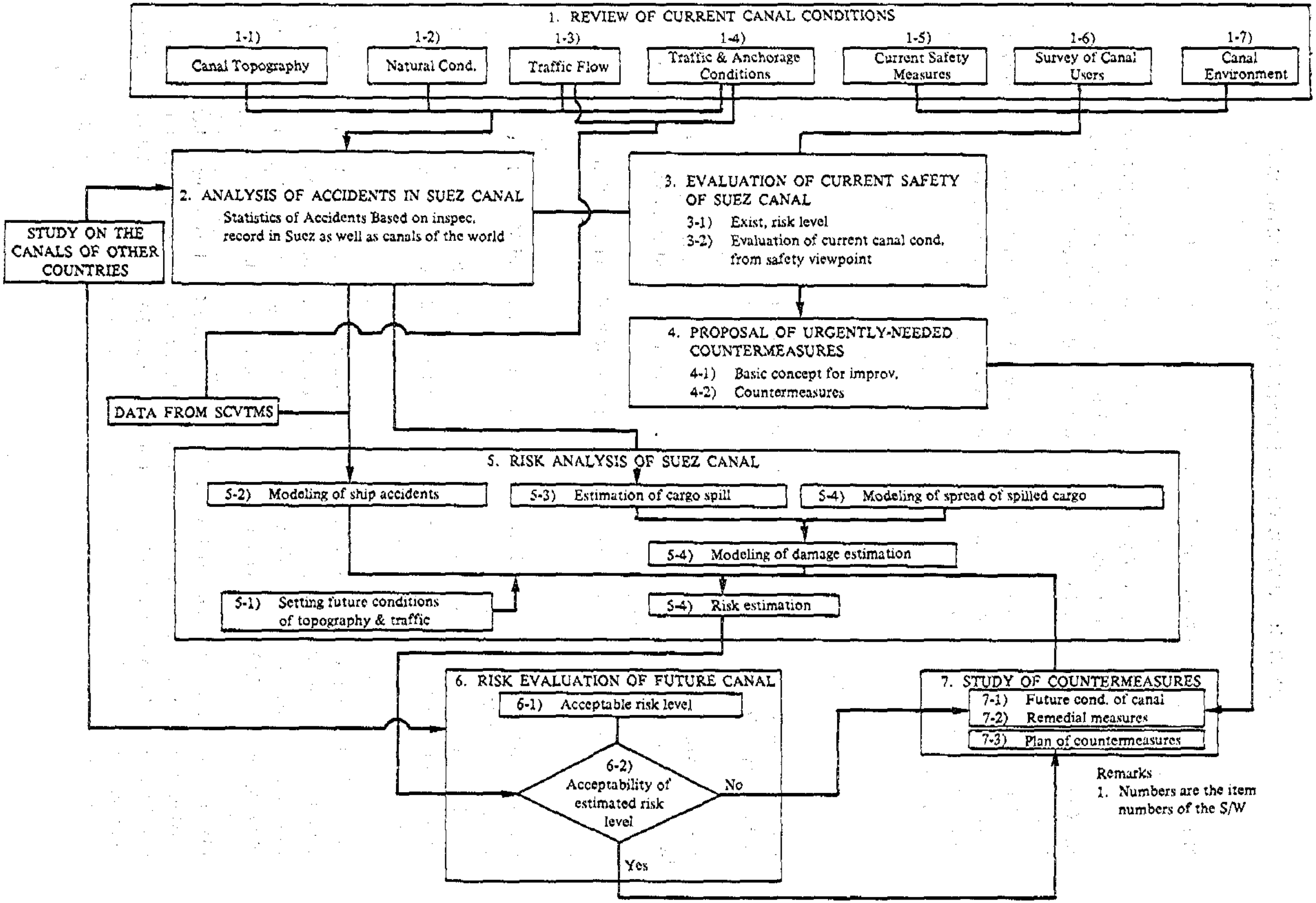


Fig. I-1 The Study Flow for the Safety Improvement of The Suez Canal

PART II REVIEW OF CURRENT CANAL CONDITIONS

II-1 Canal Topography (Refer to II-1)

The current Canal topography was reviewed based mainly on "Suez Canal Plan and Cross Section", "Development of the Suez Canal – Widening and Deepening of the Canal", "Depth of the Canal", "Measured Canal Cross Section", and other data and published charts provided by SCA.

Such fundamental dimensions of the Canal as width, depth and curvature are studied at intervals of 1 Km along the "Kilometer Base Line" fixed by SCA and between Hms 0 and 195 in the Mediterranean Sea, and between Hms 0 and 80.5 in the Red Sea.

The results of the review are shown all-inclusively in Table II-1-(1)-1.

II-2 Natural Conditions (Refer to II-2)

(1) The number of rainy days increases from November to March at Port Said and from January to February at Ismailia.

(2) Poor visibility occurs due to fog and sandstorms. The occurrence of poor visibility (under one kilometer) increases from January to March at Port Said, and from October to April at Ismailia. Poor visibility rarely occurs at Suez.

The duration of poor visibility caused by fog is usually shorter than that caused by sandstorms.

(3) The occurrence of strong winds increases between January and May at Port Said, and between April and May at Suez.

However, strong winds rarely occur at Ismailia. Wind velocity of 11 ~ 16 knots in the direction of west to north occurs most frequently at Port Said and Suez. Wind velocity of 1 ~ 3 knots occurs most frequently at Ismailia.

(4) At Port Taufiq, the current velocity is very high and it reaches about 2 knots. The current velocity is relatively high at Tousson and El Kabrit and low at Port Said. From the results of current simulation, the current often runs across the waterway at the points near the junction of the bypasses and El Kabrit, and in the Port Said approach channel.

(5) The difference of Mean Sea Level at both ends of the Canal varies periodically, with a maximum range of about 40 cm. The maximum tidal range owing to astronomical tide throughout the year is estimated at about 60 cm at Port Said, about 30 cm at Ismailia and about 150 cm at Suez.

(6) The wave height is high at Port Said, reaching about 6 ~ 7.5 meters.
The sea area is very calm at Suez.

(7) At Port Said, the volume of sediment deposited in and nearby the east and west approach channels is estimated at about 4 ~ 5 x 10^6 m^3/year. At Suez, sedimentation has not become an issue in the Canal and its approach channel.

II-3 Traffic Flow (Refer to II-3)

Before the closure of the Canal, tankers accounted for about 75% of the SCNT volume. When the Canal reopened, the percent of transiting tankers accounting for only 30 ~ 40% of all the transits. The percentage of tankers had dropped drastically. However, it has shown as increasing trend recently.

On the other hand, the size of vessels transiting the Canal has been increasing markedly since 1982. Specifically, the number of tankers of 100,000 DWT or more transiting northbound has increased greatly.

As for the cargo volume, in 1982 the total is still below the 1966 level. In 1966, tankers transported as much as 73% of the total cargo volume via the Canal, whereas recently this percentage dropped as low as 22 ~ 24%. However, after the completion of the First Stage Development Project, the percentage of cargo volume carried by tankers has begun to recover somewhat to about 28% in 1981 and 36 ~ 38% in 1982 ~ 1983 but has been still far below the level before the closure.

II-4 Traffic and Anchorage Conditions (Refer to II-4)

(1) Traffic Conditions

1) Canal Traffic

Transit of vessels through the Canal is controlled by the Main Office coordinating the Port Offices, signal stations and pilots serving on board each vessel.

2) Present Conditions of Canal Traffic

(i) Convoy Transit System

For transiting through the Canal, a system of two southbound convoys and one northbound convoy a day has been in practice.

(ii) Southbound Vessels

Vessels with a maximum draught of 42 ft in the southbound convoy are transitable at present though it depends on the ship's breadth. Note, however, that by taking a course through the East Channel, arrangement can be made to transit vessels with draught more than 42 feet.

(iii) Northbound Vessels

Although it depends on vessel's breadth as in the case of the southbound vessels, vessels of the northbound convoy with a maximum draught up to 53 ft can transit the Canal.

(iv) Transit Speed

1st and 2nd southbound convoys:	14 km/h (7.56 kt)
Loaded VLCCs etc. of northbound convoy:	13 km/h (7.02 kt)
Other vessels of northbound convoy:	14 km/h (7.56 kt)

(v) Time intervals between Vessels

DWT	Minimum Time Intervals in Minutes
Up to 30,000	6
30,000 to 60,000	10
60,000 to 140,000	16
140,000 to 250,000	20
Over 250,000	25
VLCC in Ballast	16

(vi) Results of Analysis on Traffic Diagrams

i) One-month period in August, 1983

	Southbound	Northbound	Mean
Transit Speed	8.51 kt	8.63 kt	8.57 kt
Time Intervals between Vessels	10.75 min	11.37 min	11.06 min
Anchored or Tied up Time	5 hr 30 min	2 hr 50 min	4 hr 10 min
Transit Time	15 hr 05 min	11 hr 22 min	13 hr 14 min

ii) The Most Congested Day in 1982

	Southbound	Northbound	Mean
Transit Speed	8.78 kt	9.02 kt	8.90 kt
Time Intervals between Vessels	10.92 min	11.30 min	11.11 min
Anchored or Tied up Time	6 hr 44 min	3 hr 04 min	4 hr 54 min
Transit Time	15 hr 11 min	12 hr 31 min	13 hr 51 min

(vii) Arrival and Waiting Conditions

We obtained the following distributions of arrival vessels and waiting vessels from the records for the period from 12th September to 2nd October, 1983.

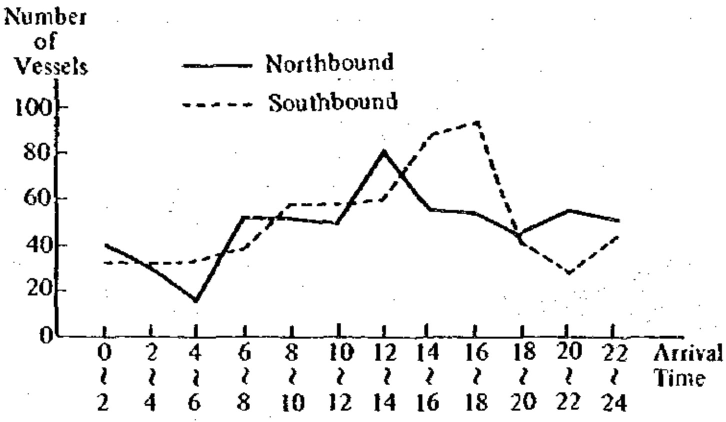


Fig. II-1 Distribution of Arrival Vessels

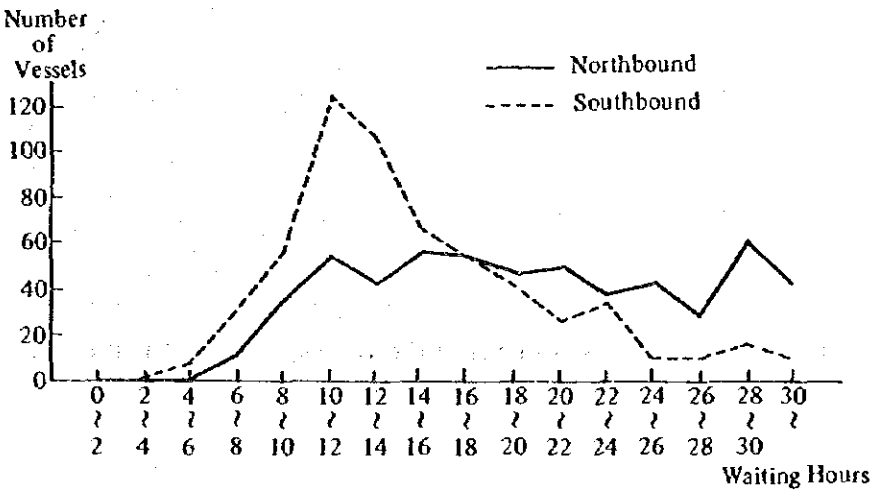


Fig. II-2 Distribution of Waiting Vessels

(viii) Analysis of Magnetic Tapes of the SCVTMS

The magnetic tapes of the SCVTMS including the record of a total of 224 vessels which transited the Canal during the period from 10th September, 1983 to 27th November of the same year were computer processed for analysis whereby track charts, distribution of the number of vessels passed the gate lines, and distribution of vessels' breadths occupying water at the gate line were obtained. Representative examples are presented below.

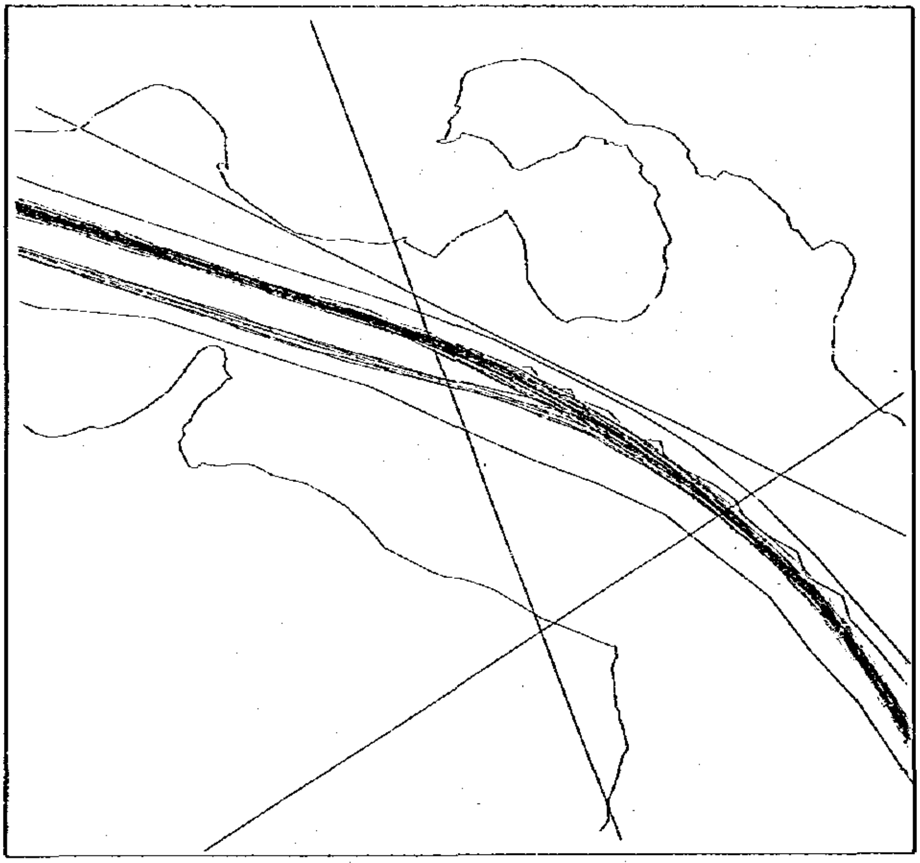


Fig. II-3 Track Chart at El Kabrit (76 vessels, less than 50,000 tons)

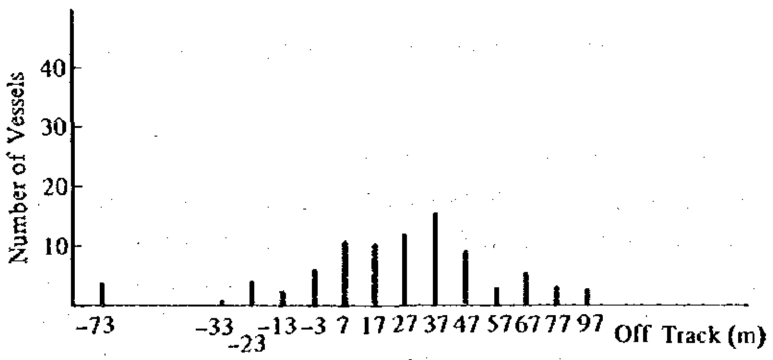


Fig. II-4 Distribution of Number of Vessels Passed Gate Line at Km 32 (89 vessels, less than 50,000 tons)

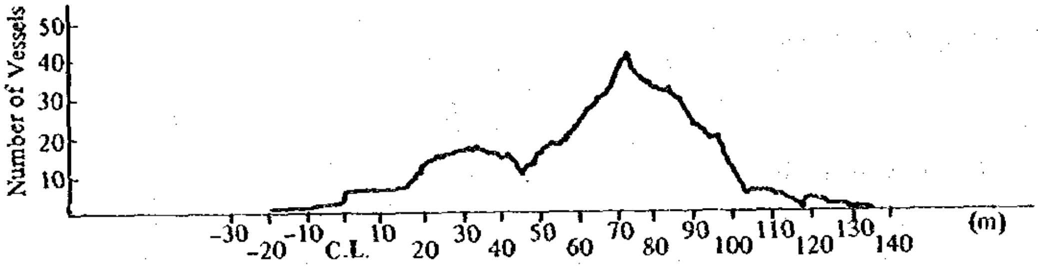


Fig. II-5 Distribution of Vessels' Breadths Occupying Water at the Km 78 Gate Line (101 vessels, less than 50,000 tons)

3) Manoeuvrability

(i) Stopping Distance in the Canal

The results of the stopping experiment conducted by the SCA in July, 1978 using a 71,000 DWT tanker within the Canal are as below:

Table II-1 Summary of Stopping Trials in the Canal

Trial No.	1	2	3	4	5	Average
Stopping Distance	1,069	575	1,260	975	1,255	1,026.8
Initial Speed	6.98 kt	5.68 kt	6.78 kt	5.03 kt	7.01 kt	6.296 kt
No. of Tugs	2	2	2	1	1	

(ii) Analysis of Data on the "KAMAKURA MARU"

By analyzing the magnetic tapes recorded through the use of two CORTs placed on board the "KAMAKURA MARU" a northbound vessel on 27th September, 1983, ship manoeuvring charts were drawn.

Following is an example:

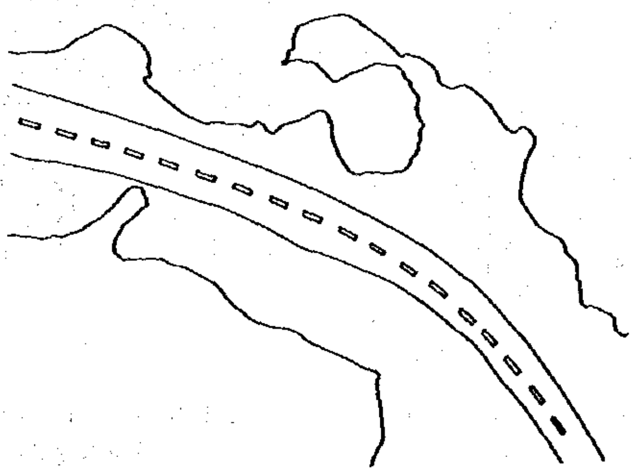


Fig. II-6 Manoeuvring Chart of Kamakura Maru

(2) Anchorage Conditions

1) Anchorage

(i) Capacity of Anchorage

Port Said Waiting Area	23 vessels
Lake Timsah Anchorage	5 vessels
Great Bitter Lake Anchorage	60 vessels
Suez Waiting Area	38 vessels
Suez Inner Anchorage	39 vessels

(ii) Bottom Soil of Anchorages

The bottom soil of all anchorages is muddy or sandy silt.

2) Analysis of Anchoring Conditions

(i) Analysis Based on Magnetic Tapes and Other Records

For analyzing anchoring condition at each anchorage, attempts were made to analyze the magnetic tapes of the SCVTMS and records of movements of vessels at anchors and the points of anchorage but the data were insufficient.

(ii) Analysis of Video Taped Radar Images

Based on the records of video taped radar images in Great Bitter Lake and the Port Said Waiting Area, anchoring conditions, density of vessels at anchor and track charts were drawn.

Shown below are part of them.

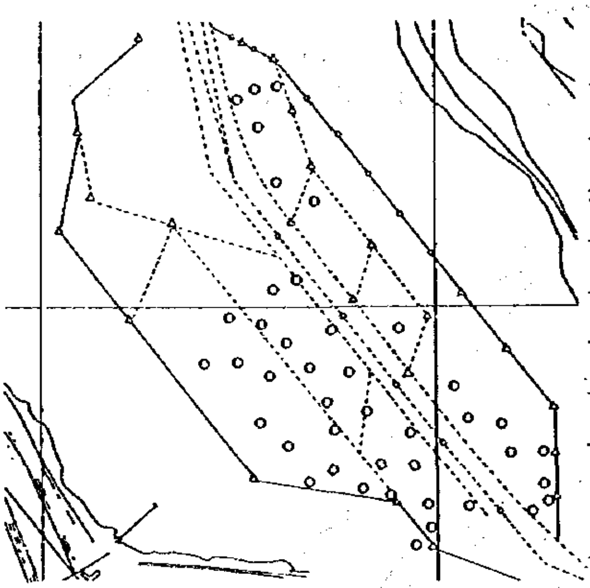


Fig. II-7 Anchoring Condition in Great Bitter Lake Anchorage

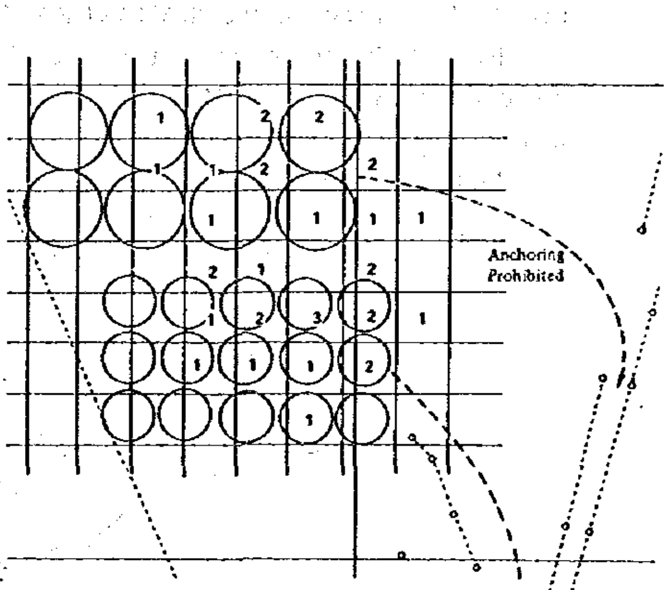


Fig. II-8 Density of Vessels at Port Said Waiting Area

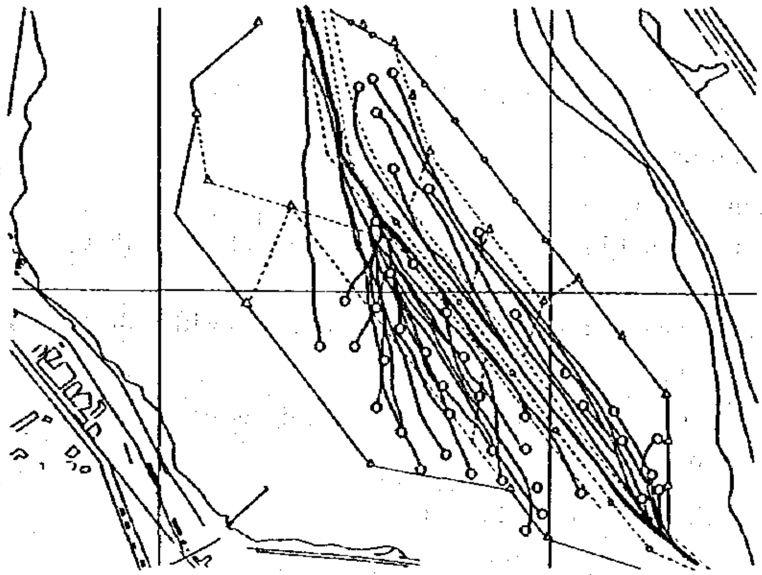


Fig. II-9 Track Chart at Great Bitter Lake Anchorage

3) Mooring Facilities

(i) Port Said

Isolated Berths	3
Outer Harbour Basin	15
Red Berths	5
Black Berths	7
Navy House	6
Cheril and Abbas Quays	2
Hussein Basin	17
E Berths	4
Total	59

(ii) Suez

Port Ibrahim North and South Basins	12
Petroleum Basin	8
Adabiya	4
Oil Berths	2
Total	26

II-5 Current Safety Measures (Refer to II-5)

(1) Navigation Aids

1) Aids to Navigation

(i) Lighthouses and Beacons

In the Canal and its associated waters, a total of 13 lighthouses and beacons are provided, and most of them are of steel structure.

The SCA is planning to construct four lighthouses within the Suez Bay area.

(ii) Leading Lights

Within the Canal water, six sets of leading lights are provided for southbound passage, and seven sets for northbound passage.

(iii) Buoys in the Approach and Canal

Buoys are provided as below:

439 within the Canal

65 in the approach areas

2) Maintenance of Aids to Navigation

Maintenance work for the electrical parts of the aids to navigation is undertaken directly by the SCA, while that for others is sublet to the Timsah Ship-building Company.

(i) Maintenance of Electrical Parts

Periodical checks and reconditionings are carried out at 45-day intervals with occasional service done in response to incoming calls.

(ii) Maintenance of Parts Other than Electrical

Checks are made regularly at 3-month intervals for above water and under water inspection. Those buoys provided in the Lakes and Approaches are serviced once a year and those within the Canal once every two years when they are lifted up for inspection, adjustments and repainting.

3) SCVTMS

(i) System Outline

The SCVTMS is an integrated centralized control and management system of vessels transiting the Canal, including tracking radars, Loran-C position fixing chain, computer network and communications network, and has the functions of graphical display of vessel's position, course and speed, and automatic issue of alarms for abnormal off-track, speed and ship-to-ship distance.

(ii) Present Operating Status of SCVTMS

Although operation of the SCVTMS was initiated from the middle of 1981, it is on a trial basis, and it has not been put into full-fledged operation to serve the Canal for traffic control and management of transiting vessels.

4) Pilots and Extra Pilots

(i) Compulsory Pilotage

For vessels of 300 SCGT or more, pilotage services by Harbour pilots and Canal pilots are compulsory.

(ii) Extra Pilots

For vessels of 80,000 SCGT or more and for other specified vessels, an extra pilot is arranged and pilotage services are undertaken by two pilots.

(iii) Qualification and Training of Pilots

i) Harbour Pilots

In order to become a harbour pilot, one must hold a Master license and after experiencing pilotage services 60 times in Port Said, he must pass a specified examination, and then attend a lecture on the Rules of Navigation.

ii) Canal Pilots

To be a canal pilot, one must hold a harbour pilot's license good for vessels of 25,000 SCGT, and experience pilotage services 36 times in the Canal during a 2-month period, and also must pass a specified examination.

5) Harbour Masters and Skippers of Tugs

(i) Qualification and Training of Harbour Masters

To become a harbour master, one must hold a Master license, receive training at Port Said, and attend lectures on the Canal and the Rules of Navigation.

(ii) Qualification and Training of Skippers of Tugs

To become a tug skipper, one must undergo a 2-year long education and training programme at the Suez Canal Authority Marine Institute and practice tug service for a period of one and a half years, and then pass a practical examination.

6) Signal Stations

The main duties of signal stations are to provide, transmit and to relay information on items relating to each Port Office and transit vessels and to undertake other auxiliary services for the Port Offices.

7) Tug and Escort Tug

(i) Arrangement of Escort Tug

For liquefied gas carriers of 80,000 SCGT or more, disabled vessels, and other vessels which are specifically judged necessary by the SCA, tugs must be arranged with tuggage paid for their transit through the Canal.

Vessels of less than 110,000 DWT calling specially for tug assistance, vessels with a draught of 45 ft or more, loaded vessels of 110,000 to 150,000 DWT and vessels of 200,000 DWT or more in ballast must be served by an escort tug, whereas loaded vessels of 150,000 DWT or more must be served by two escort tugs.

(ii) Attendance of Tugs at Ballah Bypass

For mooring operations of the 2nd southbound convoy at the Ballah Bypass, three tugs are employed for necessary tug assistance.

(iii) Tugs owned by the SCA

Salvage tugs	3
Escort tugs	16
Harbour tugs	15
Total	34

(2) Traffic Control

1) Outline of Traffic Control

Transit vessels are controlled by the Transit Department of the SCA in accordance with the requirements of the Rules of Navigation prescribed by the SCA.

In waters of the Canal and associated areas, transit vessels must observe the Rules of Navigation.

A booking system has been established for transit vessels, and liaisons for such purposes are obligatory.

Transit vessels proceed in a convoy, and their motions and behaviours must all meet the requirements as instructed by each Port Office.

At Ismailia Port Office, movements of all transit vessels are generally watched and controlled by preparing Transit Diagrams.

2) Traffic Control Facilities

(i) Port Said Port Office

(ii) Ismailia Port Office

(iii) Suez Port Office

(iv) Movement Office

(v) Signal Stations

(vi) SCVTMS

3) Rules and Regulations

As mentioned above, transiting of the Canal is controlled and managed in accordance with the Rules of Navigation.

(3) Disaster Treatment

To this date, SCA has not experienced a fire of dangerous cargo on transit vessels and also major oil spill from transit vessels.

SCA now possesses 35 tug boats. Details are provided in the following Table II-2.

Table II-2 List of Tugs

Disaster Treatment Capability \ Type of Tug	Sulvage Tug	Escort Tug	Harbour Tug	Total
Water Spray Dry Chemical Powder Foam Dispersant Water Curtain		2		2
Water Spray Foam Dispersant Water Curtain		4	2	6
Water Spray Dry Chemical Powder Foam		8	2	10
Water Spray Foam	2	1	8	11
Water Spray	1		3	4
———		2		2
Total	3	17	15	35

Major disaster treatment equipment and materials (including those allocated before 1983) are:
a 900-m oil boom (coastal), 4 oil skimmers and one oil skim boat; some 230-kl of dispersant, 280-kl of foam concentrate and 14-tons of dry chemicals; 37 fire pumps, 69 submersible pumps, 37 floating cranes, 11 fuel barges and 2 lightering barges.

(4) Construction and Maintenance Works

SCA owns 13 dregers (9 cutter suction dredgers, 2 hopper suction dredgers and 2 bucket dredgers) for maintenance work in the Canal, and is simultaneously carrying out maintenance dredging and a part of the Second Stage Development Project since the completion of the First Stage Development Project.

The part of the Second Stage Development Project currently under way is the deepening dredging of the Port Said approach channel and the widening dredging of the area from kilometers 1.5 ~ 61.0 and the east channel of the Kabrit Bypass.

The schedule and locations of maintenance dredging are decided according to the results of the sounding surveys.

SCA conducts surveys once every three month for the Port Said approach channel with cross-sectional leveling at 10 m intervals, once every two years for the sections north of Lake Timsah in the Canal, and once every three years fro those south of Lake Timsah with profile leveling on the center line only.

In order to avoid accidents between transit vessels and work vessel doing the dredging work in the Canal, in principle the dredgers are shifted to a position outside the navigation buoy line at least 30 minutes prior to the expected passage of transit vessels and they wait for transit vessels to pass, keeping clear of the fairway of the Canal.

II-6 Survey of Users of the Canal (Refer to II-6).

(1) Summary of Answers from Canal Pilots.

Grounding	
Causes Bank irregularities	3
Improper aids to navigation	5
Narrow area	2
Strong wind or current	2
Comments	
Buoys should be well maintained	5
More proper aids to navigation	4
Increase speed	3
Better communication with center concerned	1
Better cooperation with tug boats	1
Others	2

(2) Summary of Answers from Masters of Transiting Vessels

Table II-3 Number and Kind of Feared Danger by Causes and Positions

Kind / Cause / Position	Collision			Grounding			Total
	Improper Aids to Navigation	Narrow Area	Others	Improper Aids to Navigation	Narrow Area	Others	
Port Said Waiting Area	1	2		5		2	10
Port Said	5	2	7	36	3	7	60
In the Canal	1		2	4	2	6	15
Suez	4	2	4	13	1	4	28
Suez Inner Anchorage		1					1
Suez Waiting Area	3	2		2			7
Total	14	9	13	60	6	19	121

Table II-4 Summary of Comments by Type of Vessel

Comment \ Type of Vessel	General Cargo	Container	Tanker	Others	Total
Racon Needed	7	8	8	4	27
Lack of Information and Communications	3	8	2	2	15
Pilot must Board from Anchorage	2	0	3	2	7
Better Maintenance of Buoys	0	2	1	2	5
Others	3	3	1	2	9
Total	15	21	15	12	63

(3) Summary of Answers from Japanese Captains

Table II-5 Number and Kind of Feared Danger by Causes and Positions

Kind	Collision between Vessels								Collision with Others								Grounding								Total
Position \ Cause	Narrow Water	Small Curvature	Complexity of Meeting	Shallow Effect	Improper Aids to Navigation	Strong Current	Others	Sub Total	Narrow Water	Small Curvature	Complexity of Meeting	Shallow Effect	Improper Aids to Navigation	Strong Current	Others	Sub Total	Narrow Water	Small Curvature	Complexity of Meeting	Shallow Effect	Improper Aids to Navigation	Strong Current	Others	Sub Total	
Suez Approach and Waiting Area	4		7		2		6	19	1							1	1		1		2	1	1	6	26
Suez Inner Anchorage	10		10	1	2	2	17	42			2		1		2	5	2	1	1	2	7	1	4	18	65
Port Tewfiq									1							1	3	1		2	1	3	1	11	12
Little Bitter Lake and El Kabrit (km 116 ~ 134)						1		1				2				2	9	3	1	1	5	6		25	28
Great Bitter Lake (km 94 ~ 116)	4	1	1	1	1	1	4	13				1			1	2	1			2			3	6	21
Lake Timsah (km 73 ~ 82)																	2	1		4	1	1	2	11	11
El Ballah (km 50 ~ 62)	1				1			2									1			2			4	7	9
Port Said Bypass (km 2 ~ 20)					1			1	1			1				2	2			2	4	8	1	17	20
Port Said	15	2	12		13	13	13	68	13	2	4		10	10	8	47	14	1	3		8	20	16	62	177
Port Said Approach and Waiting Area	1		9	1	6	2	4	23			1			4	2	7							1	1	31
Total	35	3	39	3	26	19	44	169	16	2	7	4	11	14	13	67	35	7	6	15	28	40	33	164	400

Table II-6 Summary of Comments

Simplification of booking notice	41
Improvement of communications at waiting areas	61
Sure anchorage instructions	37
Widening of anchorages	54
Canal pilots should board at waiting areas	55
Increased and improved maintenance of aids to navigation	22
Widening of the Canal	19
Doubling of the Canal	35
Improvement of the Canal transit system	15
Improvement of the communication system	24
Improvement of the operation of tugs and escort tugs	18
Give information not only to pilots but also to masters	28
Others	29
Total	438

II-7 Environment (Refer to II-7)

(1) Population and Assets

The distribution of population and of major public goods along the Canal is shown in Fig. II-7-(1)-1.

In 1976, Port Said, Ismailia and Suez had populations of 78,363, 17,000 and 29,219 respectively. In total this represents 75% of the population along the Canal.

Of the public facilities, 11 signal stations, many mooring quays including jetties for ferry boats, and roads and railways are considered most important.

(2) Water Quality

The results of analysis of the samples gathered in the Canal are shown in TAble II-7-(2)-1.

The water quality of the Canal can be said to have already reached the limit of comfortable circumstances as regards contamination.

PART III ANALYSIS OF ACCIDENTS

III-1 Analysis of Accident Records (Refer to III-1)

(1) Analysis of Accident Records of SCA

A statistical table was prepared on the basis of the computer processed data of the SCA's accident record covering the period from 1976 to 1982.

The following represents part of this work.

Table III-1 Number of Accidents by Type and Year

Year	Grounding		Collision					Stuck to Bank	Touching Bank	Propeller Fouling	Total
	In Canal	In Port	Between Vessels in Canal	Between Vessels in Port	With Craft	With Buoy	With Other				
1976	89	19	2	24	38	35	23	4	12	8	254
1977	77	11	0	22	50	47	26	6	18	7	264
1978	99	6	0	27	49	56	31	2	27	3	300
1979	66	12	2	37	42	60	27	0	19	3	268
1980	85	26	1	36	50	54	19	0	13	11	295
1981	44	0	4	20	39	37	13	0	5	27	189
1982	30	26	2	22	38	33	14	1	8	0	174
Total	490	100	11	188	306	322	153	13	102	59	1,744

(2) Analysis of Accident Records in Preliminary Study Team Format

A format was prepared by the Preliminary Study Team with a request directed to the SCA to complete the form by filling in answers to the questions raised concerning the accident records for the period from February, 1983 to December, 1984. This responses were compiled in the format of statistical tables.

The following is part of this work.

Table III-2 Number of Causes by Kind of Accident

Causes \ Kind of Accident	Collision with Vessels & Crafts	Grounding	Fire	Engine Trouble	Propeller Trouble	Rudder Trouble	Damage to Buoys & Other Equipment	Others	Total
Erroneous Operation									
Negligent Look Out	5	10		1	2		10		28
Unconfirmed Position		6				1			7
Against Sailing Rules	2						2		4
Unskilled Manoeuvring	17	17		1	2		11	1	49
Unconfirmed Aid to Navigation		1							1
Unconfirmed Compass Error		1							1
No Chance to Evacuate	1								1
Negligence of Weather and Sea Conditions	2	6					1	1	10
Faulty Maintenance of Hull and Other Equipment (excluding engine)	1	7		1		9	2	3	23
Misselection of Anchoring Position		2							2
Insufficient Hydrographic Research		1					1		2
Others	3	15	1	24	3	4	4	6	60
Sub Total	31	66	1	27	7	14	31	11	188
Use of Engine									
Bad Maintenance	1	7		23	3	1			35
Mishandling	15	17		2	2	1	8		45
Others	1	7	1	1		3	7	2	22
Sub Total	17	31	1	26	5	5	15	2	102
Loading									
Misloading		1							1
Others		2					1		3
Sub Total		3					1		4
Quality of Material and Structure									
Structural Failure							1		1
Others		1		2	1		2		6
Sub Total		1		2	1		3		7
Force Majeure									
Fault of Other Vessel	4						1		5
Poor Port and Harbour Facilities	2						2		4
Abnormal Weather	1	11							12
Others	1				1		1		3
Sub Total	8	11			1		4		24
Total	56	112	2	55	14	19	54	13	325

III-2 Measures for Accident Control (Refer to III-2)

As mentioned earlier, no fire associated with the dangerous cargo of a transit vessel has ever occurred in the Canal. The following table shows, however, data regarding various oil spills which have been experienced in the past seven years. They were treated with dispersant.

Table III-3 List of Spills

Month Year	Ship's Name	Location	Cause of Accident	Kind of Spilt Oil	Amount of Spilt Oil
November 1976	Stanros Cmhaneal	Ballah Km 59	Unknown	Fuel oil	1 ~ 3 tons
February 1977	Safina Star	Bitter Lakes Km 116	Touched Bottom	Crude oil	about 600 tons
November 1977	Man Ming	Km 93.6	Mistake	Bilge oil	Very minor
January 1978	Milos Majestic	Km 32	Touched Bank	Crude oil	1 ~ 3 tons
February 1979	Skyron II	Km 155	Touched Bank	Crude oil	More than 1,000 tons

PART IV EVALUATION OF CANAL CONDITIONS

IV-1 Existing Risk Level (Refer to IV-1)

(1) Evaluation of Accident Records of the SCA

1) Annual Changes of Risk Levels

Risk levels of the Canal fell to 59% of the prior level after completion of the First Stage Development Project. The widening/deepening of the Canal is considered to be the primary cause for this sharp decrease in risk levels.

2) Monthly Change of Risk Levels

Many of the accidents are closely linked to sandstorms which occur in the spring.

Special safety measures against sandstorms are considered necessary.

3) Change of Risk Levels by Location

Distinct features are seen in that collisions are heavily concentrated in Port Said and also in El Kabrit.

When comparing risk levels before and after the First Stage Development Project, those in Port Said, Suez and Great Bitter Lake show only a moderate devrease, whereas in the Canal, levels decreased by as much as 30 to 40%.

Enhancement of the safety in ports and lakes, particularly in Port Said must be given top priority.

4) Assessment of Risk Levels by Direction of Transit and by Difference whether it is in Day-time or Nighttime

Peaks of the frequency of accidents are seen in El Ballah for southbound passage, and in El Kabrit for northbound passage.

Those accidents in El Ballah involving southbound vessels are mostly caused by grounding and contact during mooring operations, thus reinforcement in tug assisting service is considered necessary.

There is not much difference between the number of accidents in daytime and in night-time.

5) Comparison of Accidents in the Suez Canal with Those in Other Canals

Table IV-1 Comparison of Risk Levels in Various Canals

Name of Canal	Number of Transit Vessels	Number of Accidents	Length of Canal (Km)	Risk Level per Kilometer
Sueze Canal (1982)	22,545	174	162	4.76×10^{-5}
North Sea Canal (1980)	18,672	1	33	0.16×10^{-5}
Kiel Canal (1982)	64,782	265	99	4.13×10^{-5}
Panama Canal (1982)	14,009	71	82	6.18×10^{-5}
Average	30,002	128	94	4.54×10^{-5}

Note: These data were compiled under various systems.
Statistical comparison of these data on a compatible basis involves considerable difficulties.

(2) Preliminary Study Team Format

1) Causes of Accidents

The main feature is that the human-caused accidents assume the majority, as high as 82.8% of the total accidents.

For the SCA, better education and training of the Canal pilots and crewmembers of tugs may be the best possible measure.

2) Risk Level by Position within the Convoy

Collisions frequently occur in vessels within the front 40% of the convoy, whereas groundings, in many cases, take place in vessels within the rear 60%.

3) Risk Level by Number of Vessels in the Convoy

In the case of grounding, convoys consisting of 21 to 25 vessels and 6 to 10 vessels show higher risk levels than in other setups. The high risk levels seen in convoys of 6 to 10 vessels can be attributed to the high frequency of accidents in El Ballah while No.2 southbound convoy vessels are in mooring operation.

4) Risk Level by Time of Day whether it is Daytime or Nighttime

The ratio of accidents in daytime to nighttime is approximately 2 : 1 if all accidents are considered.

5) Relationship between Location of Accident and Direction of Transit

Accidents in El Ballah in southbound passage are significant.

Investigation must therefore be made on the adequacies of ship manoeuvring procedure and tug assistance.

6) Relationship between Gross Tonnage and Risk Levels

The risk levels are not related to the size of vessels.

It is generally said that larger vessels have higher risk levels, but in the case of the Suez Canal, such an even risk level distribution may perhaps be attributable to the excellent effects of considerable efforts dedicated to safety measures on large vessels.

7) Risk Levels and Ship Type

There is no appreciable difference in risk levels by ship type.

8) Risk Levels and Movement of Vessels

Collisions were frequently caused during mooring and anchoring manoeuvres, whereas groundings were often caused during passage.

9) Summary of Accident Analyses

(i) Groundings occurred in many cases in the absence of the effects of other vessels, and their trend is quite analogous to the biassed trend of frequent occurrence of human-caused accidents.

(ii) More than half the accidents took place when vessels were not using radars. Radars must be used when vessels are in waters of such a nature.

(iii) 32% of all collision and grounding accidents occurred at speeds in a range from 6 to 8 knots. Strict care must be taken because such a speed can cause major marine casualties.

(iv) 73% of groundings occurred with the Canal bank, and 27% in the shallows. The necessity of exercising more effective ship manoeuvring training within the Canal is strongly felt.

(v) Almost all collisions occurred in meeting situations thus suggesting the needs of better lookout.

Objects of collisions are mainly tugs, and better training of crewmembers serving on such tugs is much to be desired.

IV-2 Canal Conditions

(1) Topographical Conditions (Refer to IV-2-(1))

1) Design Depth of the Canal

Based on PIANC recommendations, the required dredged channel level is calculated as (–a–b–c) – (d+e–f) – (g+h) – (i+j+k) – ℓ = 19.6 m to 19.8 m. From the calculation, the present Suez Canal design depth of –19.5 m (under the conditions for navigation of 150,000 DWT-class tankers) seems to be reasonable when compared to the PIANC Standard and to Japanese Standards as well.

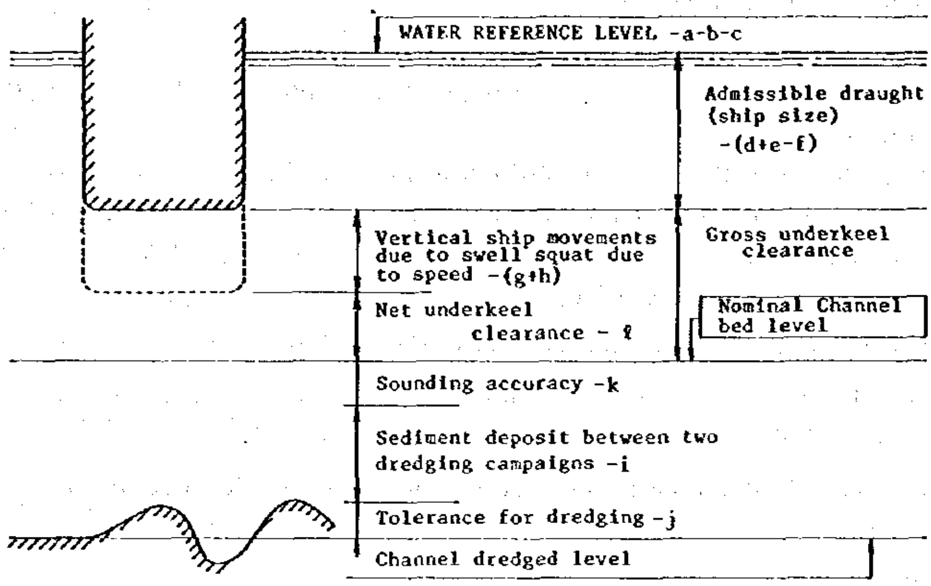


Fig. IV-1 Model of Depth Compositions

2) Width of the Canal

The results of evaluation of Canal width suggests that a width of 230 m is preferable for navigation of 150,000 DWT tankers. This width was determined considering various standards including regulations and practices in canals in other parts of the world.

Based on this suggested width, the width of the Suez Canal is insufficient in almost all areas except for the areas at the Port Said Entrance and in the Great Bitter Lake. The Canal should be widened, especially at the highest risk areas, in order to minimize damage and prevent fatal accidents.

3) Natural Conditions

(i) Comparing accident records with weather records, we see that visibility under one kilometer is closely related to the occurrence of accidents.

(ii) Comparison of records also shows that wind velocity over 22 knots is related to the occurrence of accidents.

(iii) The current runs across the channel near the junction of the Bypasses, El-Kabrit, and in the Port Said approach channel. The number of accidents at these points is high.

(iv) The area in the approach channel of the east branch is affected by high waves.

(2) Traffic and Anchorage Conditions (Refer to IV-2-(2))

1) Canal Traffic

(i) Transit System

The current transit system involving one northbound convoy and two southbound convoys per day is the best possible Canal transit system determined from years of experience well matching current needs.

(ii) Transit Speed and Ship-to-Ship Distance

The ship-to-ship distance and transit speed standards established by the SCA are considered reasonable.

Note, however, that the results of our analysis on the forementioned traffic diagrams show a range from 8.0 to 9.4 knots, indicating that the actual transit speed exceeds the speed criteria established by the SCA, and we consider that the SCA's transit speed standard should be observed more strictly.

(iii) Qualification, Education and Training of Canal Pilots

i) The present training period for Canal pilots is considered too short as the highest possible skills and experience are required in the Suez Canal.

ii) Periodical physical examinations should be carried out under an established system, and re-education and retraining for ship manoeuvring techniques should be instituted.

(iv) Arrangement of Escort Boats

For assisting emergency stopping and ship manoeuvring under the influence of strong winds, arrangement of escort boats is a prerequisite for passage of large vessels.

(v) Evaluation of Results of Survey of Users of the Canal

The results of the three types of questionnaire surveys may be summarized as below:

The major dangers feared in transiting the Suez Canal are collision and grounding, and other items are almost negligible.

The causes of collision, in many cases, are related to improper aids to navigation, narrow water and complexity of meeting.

The causes of grounding, in many cases, are related to improper aids to navigation, and strong current.

Many answers pointed out that Port Said and Suez are the places where dangers are felt most.

The improvement of aids to navigation, safety measures in Port Said and Suez, and betterment of communications in general are strongly pointed out by the respondents to the questionnaire survey.

2) Anchoring Conditions

(i) Uses of Anchorage

The anchorage of the Great Bitter Lake is used relatively evenly, but in the Port Said Wating Area, only the east half is being used. Several vessels were found anchoring within the traffic route and in other areas where anchoring is prohibited.

Anchorage must be used as evenly as possible, and the points of anchoring must be strictly controlled.

(ii) Evaluation of Track

In the Great Bitter Lake, almost all vessels were found proceeding through the anchorage to their respective points of anchorage. Guidance must be given so that vessels proceed through established traffic routes as far as possible. In the Port Said Waiting Area, almost all vessels were found proceeding through water among vessels at anchor, and even after heaving up anchor they were found heading to the traffic routes passing through those at anchors.

Guidance must be given so that vessels proceeding within the anchorage can be minimized.

(iii) Capacity of Anchorage

In both the Great Bitter Lake Anchorage and the Port Said Waiting Area, the present capacities of anchorage were found sufficient.

(3) Aids to Navigation (Refer to IV-2-(3))

1) Rate of Installation of Aids to Navigation

The rate of installation within the Canal water area is sufficient in light of comparison with other Canals.

However, aids in the approaches and waiting areas must be increased.

2) Performance of Aids to Navigation

Canal buoys were found appropriate in terms of both their functions and structures. As for buoys provided in the approaches, partial upsizing or fitting of racon is necessary.

3) Maintenance

Buoys in the approaches should be subjected to improved maintenance care.

(4) Traffic Controls and Regulations (Refer to IV-2-(4))

1) Traffic Control

(i) Transit Control System

The present transit control system relying on traffic diagrams has been developed on the basis of years of prior experience and is found to be a reasonable system.

However, for the enhancement of traffic safety in the Canal, the SCVTMS should be placed in operation as soon as possible.

(ii) Meeting of Transit Vessels in Deversoir

The traffic control in areas such as Deversoir North Junction and Kabrit South Junction where southbound vessels and northbound vessels meet should be strictly and carefully carried out with sufficient safety considerations.

(iii) Control Over Anchorage

As far as the present conditions observed by us are concerned, the control over anchorage is considered insufficient.

Guidance should be exercised for better control over anchorages.

2) SCVTMS

(i) System Evaluation

If the design performance and functions are fully utilized, the SCVTMS is an extremely effective system for efficient control and management of the Canal and for safety of traffic in the Canal.

However, the system is not in practical operation at present, because of the problems of the Loran-C vessel's position fixing system.

(ii) Comparison of SCVTMS with Tokyo Bay Vessel Traffic Advisory System

The SCVTMS closely resembles the Tokyo Bay Vessel Traffic Advisory System leaving minor differences aside. If the SCVTMS fulfills its designed performance and function, the frequency of accidents in the Canal and associated waters is expected to decrease as the post-completion accident frequency in the case of the Tokyo Bay Vessel Traffic Advisory System decreased to half that experienced before completion.

(iii) Comparison of SCVTMS with Vessel Traffic Management Systems of Other Waterways

In many VTMS, vessels' movement information is grasped through the use of radars for giving necessary items of information to vessels.

The only system relying on Loran-C is the SCVTMS.

The only vessel traffic management systems where vessels' positional information is computer processed are the Tokyo Bay Vessel Traffic Advisory System and the SCVTMS.

The SCVTMS is one of the most advanced modern VTMS.

3) Rules and Regulations

The Rules of Navigation laid down by the SCA are considered appropriate.

(5) Construction and Maintenance Works (Refer to IV-2-(5))

In the 6 years from Jan., 1977 (after the start of the First Stage Development Project) to Dec., 1982, 31 accidents occurred in the years 1977 ~ 1980 and 9 accidents in the years 1981 ~ 1982, amounting to a total of 40 accidents.

85% of the accidents involved dredgers and floating pipelines.

After the completion of the First Stage Development Project, the percentage of accidents involvings floating pipelines has decreased whereas the ratio of accidents with dredgers has increased.

The causes lie not with the dredgers, though their locations have not been clear, but rather with the human errors by transit vessel operators, especially high speed.

(6) Resources against Fire and Pollution (Refer to IV-2-(6))

Stockpile of equipment and material are being built up gradually, however, there still remain room for improvement in their quantity and quality. Also further improvement is necessary in the area of organization, manpower and facilities.

PART V RISK ANALYSIS

V-1 Setting up Conditions (Refer to V-1)

(1) Civil Engineering Factors

The current profile of the Suez Canal for risk analysis is, in accordance with the results of the review study, assumed as shown in Table II-1-(1)-1.

As for the future profile of the Canal, there are many alternatives such as the widening deepening plan scheduled by SCA, the double channel plan recommended by the former Japanese mission, and other plans including modifications of the two plans mentioned above. The future profile of the SCA plan is shown in Table V-1-(1)-1.

The Canal profile during the expansion works will change according to such factors as speed, location and shifting of working vessels. These factors are not scheduled at the present time. In this report, the premises for risk analysis on safety during the expansion works are taken as being the same as those of the current Canal.

As to the number of working vessels in the Canal to complete the Second Stage Development Project in three years, we assume, for risk analysis, that the number of dredgers during this phase is 20 x 8,000 HP class dredgers. The risk analysis estimates are based on this assumption.

(2) Natural Conditions

1) Visibility

In this section, we show the frequency of poor visibility at Port Said, Ismailia and Suez (see Table V-1-(2)-2).

2) Wind

Here, we show the most common wind conditions and the frequency of strong winds (over 22 knots) at Port Said, Ismailia and Suez (see Table V-1-(2)-3).

3) Current

In this section, we show the frequency of current direction and velocity (see Table V-1-(2)-4).

(3) Traffic Flow

On the basis of the forecast volume of world seaborne trade, we estimate the cargo volumes via the Canal in 1990 and 2000 as shown below.

(M/T)

Year	Volume
1990	349
2000	474

We estimate the number and type of vessels that will carry this cargo in 1990 and 2000 as follows:

(1,000,000 DWT)

	Tankers	Non-Tankers	Total
1990	488	488	976
2000	568	714	1,282

(4) Navigational Conditions

1) Traffic and Anchorage Conditions

(i) Traffic Conditions

For vessels transiting the Canal, a convoy transit system involving two southbound convoys and one northbound convoy per day is presently employed. This transit system will remain unchanged even after completion of the Second Stage Development Project.

(ii) Maximum Draft, etc.

The criteria of the maximum draft, transit speed and time interval between vessels are established by the SCA.

(iii) Manoeuvrability

According to the SCA's stopping trial, stopping distance in the Canal is about 1,000 m for a 71,000 DWT loaded tanker, and according to the records of the Japan Dockmaster's Association, the stopping distance in the open sea for the same initial speed and type of vessel is about 550 m.

(iv) Anchorage Conditions

The overall capacity of anchorages is sufficient to accommodate all transit vessels.

2) Current Safety Measures

(i) Aids to Navigation

The number and functions of the buoys installed in the Canal are appropriate. However, the buoys in the approaches need to be reinforced.

(ii) SCVTMS

The SCVTMS for control and management of traffic in the Canal has been installed.

However, this system is not inpractical operation at present.

(iii) Pilots

The employment of harbour pilots and Canal pilots is compulsory for vessels of 300 SCGT or more.

(iv) Escort Tug

An escort tug or tugs are arranged for specified transit vessels.

(v) Traffic Control

The traffic of the Canal is controlled by the Transit Department of the SCA in accordance with the Rules of Navigation prescribed by the SCA.

The control of transit vessels is carried out by exchanging traffic information through VHF and UHF radiotelephony among the Harbour Offices in Port Said and Suez, each signal station, each pilot and the Head Office in Ismailia with traffic diagrams prepared.

3) Survey of Canal Users

The users of the Canal strongly request improvement of the aids to navigation, improved safety measures in Port Said and Suez, and better communications.

4) Analysis of Accident Records

From the results of the analysis of accident records, it may be concluded as follows;

(i) The risk level of the Canal dropped sharply after the completion of the First Stage Development Project.

(ii) The occurrence of accidents in the Canal is closely linked with the occurrence of sandstorms.

(iii) Collision and contact accidents are heavily concentrated in Port Said, and many grounding and touching bank accidents occur at El Ballah.

(iv) The human-caused accidents assume the majority of the total accidents.

(v) The risk levels are not related to the size of vessels. This may be attributable to the effects of extra efforts dedicated to safety measures in large vessels.

(vi) Collisions are frequently caused during mooring and anchoring manoeuvres, whereas groundings are often caused during passage.

(vii) In many cases groundings occurred without the effects of other vessels, and mostly occurred at the Canal banks.

5) Study Cases

Risk Analysis was made on potential vessel accidents in the Canal. Accident types and locations considered in this report are summarized in Table V-1 and Fig. V-1. In the same table the model which is used to estimate risk levels is introduced.

Table V-1 Study Locations and Accident Types

Type	Location	
Grounding	– Throughout the Canal – Bypass – Main channel	
Collision	• Rear-end collision	
	– Throughout the Canal	
	• Between vessels	
	– Cross at Port Said Approach Channel and East Bypass	A
	– Junctions	B, C, D
	– Around South Light and North Light	F, F
	– Waiting area at Great Bitter Lake and Port Said	M, I
	• Between a vessel and a dredger	
	– Throughout the Canal	
Secondary Disasters	• Diffusion of spilled oil	
	– Port Said	A
	– Great Bitter Lake	I
	– Suez	G

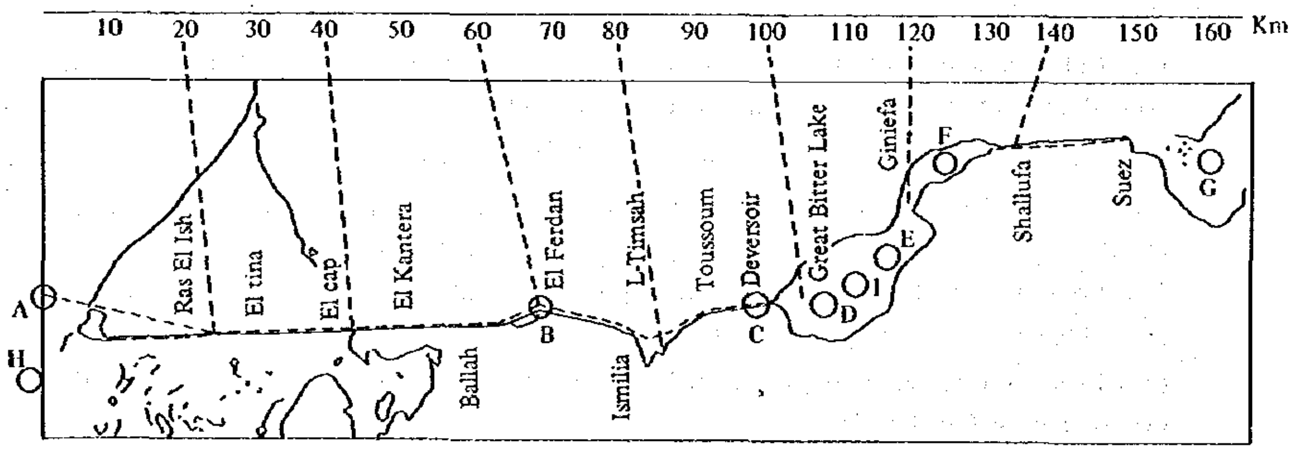


Fig. V-1 Study Locations

V-2 Results of Estimation (Refer to V-2)

(1) Estimation of Probability (Refer to V-2-(1))

Probabilities of all types of accidents studied in this report are summarized in Table V-2. These probabilities are shown by location and by phase (at present, during the execution of the Second Stage Development Project, and after the expansion).

Probabilities in the table are expressed by the estimated number of accidents per transit, which means that accidents are likely to occur 30 times a year at present and 17 times a year after the expansion for the assumed 10,000 transits per year.

Table V-2 Summary of Accident Probabilities (Number of Accidents per Transit)

Phase Location	Phase I (at Present)				During the Execution	Phase II (after the Expansion)			
	Grounding	Rear-end Collision	Collision	Total	Collision with Dredger	Grounding	Rear-end Collision	Collision	Total
Port Said and Suez	4.53×10^{-4}	–	4.65×10^{-4}	9.18×10^{-4}	9.74×10^{-4} 5.62×10^{-5}	2.10×10^{-4}	–	4.65×10^{-4}	6.75×10^{-4}
Ballah Bypass	1.59×10^{-5}	2.60×10^{-7}	–	1.62×10^{-5}	7.02×10^{-5} 5.40×10^{-5}	1.74×10^{-6}	1.39×10^{-8}	–	1.75×10^{-6}
Bitter Lakes	–	–	8.11×10^{-5}	8.11×10^{-5}	8.11×10^{-5} –	–	–	8.11×10^{-5}	8.11×10^{-5}
Other Parts of the Canal	1.49×10^{-3}	2.24×10^{-5}	4.82×10^{-4}	1.99×10^{-3}	3.09×10^{-3} 1.10×10^{-3}	4.13×10^{-4}	4.15×10^{-6}	4.82×10^{-4}	8.99×10^{-4}
Total	1.96×10^{-3}	2.27×10^{-5}	1.03×10^{-3}	3.01×10^{-3}	4.22×10^{-3} 1.21×10^{-3}	6.25×10^{-4}	4.16×10^{-6}	1.03×10^{-3}	1.65×10^{-3}

Note: Phase I : The First Stage Development Project
Phase II : The Second Stage Development Project

(2) Estimation of Cargo Hazards (Refer to V-2-(2))

Considering the general properties of crude oil, LPG and LNG, trial calculations of diffusion on the liquid and gas of 1,000 m^3 of crude oil, LPG and LNG, were performed by using the formula enunciated by Motora, Show-Briscow and Sakagami.

The results show that the spreading of the flammable range of crude oil is narrower than that of liquefied gas. They revealed also that the time of evaporation of crude oil was longer than that of liquefied gas.

Further, at the request of SCA, trial calculations of the spread of the spilled crude oil of 5,000, 10,000 and 20,000 tons, were made for Port Said, Great Bitter Lake and Suez Bay areas respectively with the Motora model, using prevailing tide and likely strong wind for a series of hypothetical accidents.

The results show that outside of Port Said, there is a general tendency of prevailing tidal current of east and west. However, spilled oil has tendency to drift to the south i.e. in the direction of the shore since northerly winds prevail in this area.

In the Bay of Suez where there is a prevailing tidal current of north and south, spilled oil drifts toward Red Sea affected by the prevailing northerly wind.

As for oil spills in the canal, spilled oil travels within the Canal along with the composit current of the wind drift and the tide.

The spilled oil exerts destructive effects upon the ecosystem of the marine fauna and flora of the area. Spills make them stink, hinder their biological functions or kill them. Spills also obstruct transition of vessels until inflammable gas dwindles away completely. After referring to the probability of fire after spills and the behaviour of such fires estimations regarding the probable maximum crude oil spill and fire were made. It was assumed, as the result of the evaluation, that the sizes would be 30,000 m^3 and 2,045 m^2 for crude oil spills and crude oil fire respectively.

It was also assumed that accidental fire of liquified gas would hardly occur and it would be minor if they were to take place.

PART VI RISK EVALUATION

VI-1 Accpetable Risk Level (Refer to VI-1)

(1) Acceptable Risk Level Based on SCA's Criteria

If we use the reduction ratios proposed by SCA, which are 23.8% at Port Said and Suez, 18.8% at El Ballah Bypass and Bitter Lakes, and 7.4% at other parts of the Canal then the risk levels are obtained as is shown in Table VI-1 multiplying these reduction ratios by the present risk levels.

Table VI-1 Acceptable Risk Levels by SCA Criteira

Location	Risk Levels at Present (1982)	Acceptable Risk Levels (SCA)
Port Said and Suez (approach channel and harbour)	4.66×10^{-4} (5.83×10^{-5})	1.11×10^{-4} (1.39×10^{-5})
El-Ballah Bypass	1.62×10^{-5} (2.02×10^{-6})	3.05×10^{-6} (3.79×10^{-7})
Other Parts of the Canal	1.55×10^{-3} (9.57×10^{-6})	1.15×10^{-4} (7.08×10^{-7})
Bitter Lakes	2.93×10^{-4} (–)	5.51×10^{-5} (–)

* Figures in parentheses are risk levels per km.

(2) Acceptable Risk Level Based on the Risk Levels in Other Channels

Other criteria are based on the risk levels in other channels in the world. First, the average risk level in selected channels is calculated. Based on this average and in comaprison with the levels proposed by SCA, the basic desirable risk level is determined. Half this level, and also twice this level, are used as alternative criteria for judging the safety level of the Canal.

Examples for acceptable risk levels other than SCA's are taken as follows:

1 Same level as European canals (Kiel canal)
2 Same level as Uraga Channel (Japan)
3 Level decreased by the First Stage Development Project

According to this study, the risk level in European canals is almost the same as in the Canal, and the risk level in the Uraga Channel is much lower by 1/50. A decreasing ratio by the First Stage Development Project in the risk level is around 40%.

Considering risk levels in other channels as well as the levels proposed by SCA, a 60% reduction from the present risk level as an average is accepted as the basic criterion for this analysis, which we call J-3. Then half this figure and twice this figure are used as alternative criteria, which we call J-2 and J-4 respectively. Hereinafter the criterion proposed by SCA is called J-1. These criteria are summarized as follow.

J-1: 13% of the present risk level -- A 87% reduction
J-2: 20% of the present risk level -- An 80% reduction
J-3: 40% of the present risk level -- A 60% reduction
J-4: 80% of the present risk level -- A 20% reduction

By multiplying these ratios by the current risk levels, the following desirable risk levels are obtained.

Table VI-2 Acceptable Risk Levels Based on Other Channels

Criterion / Location	Acceptable Risk Levels Based on Other Channels			
	(J-1)	(J-2)	(J-3)	(J-4)
Port Said and Suez (approach channel and harbour)	1.11×10^{-4} (1.39×10^{-5})	9.36×10^{-5} (1.17×10^{-5})	1.86×10^{-4} (2.34×10^{-5})	3.72×10^{-4} (4.66×10^{-5})
El-Ballah Bypass	3.05×10^{-6} (3.79×10^{-7})	3.23×10^{-6} (4.04×10^{-7})	6.46×10^{-6} (8.08×10^{-7})	1.29×10^{-5} (1.62×10^{-6})
Other Parts of the Canal	1.15×10^{-4} (7.08×10^{-7})	3.11×10^{-4} (1.92×10^{-6})	6.20×10^{-4} (3.83×10^{-6})	1.24×10^{-3} (7.66×10^{-6})
Bitter Lakes	5.51×10^{-5} (–)	5.85×10^{-5} (–)	1.17×10^{-4} (–)	2.34×10^{-4} (–)

* Figures in parentheses are risk level per km.

VI-2 Evaluation of Estimated Risk Levels (Refer to VI-2)

(1) Comparison with Acceptable Risk Levels (Refer to VI-2-(1))

Fig. VI-1 shows current risk levels by location, as well as the estimated risk levels after completion of the Second Stage Development Project. In the Figure, these risk levels are compared with the level proposed by SCA J-1 as well as with J-2, J-3, and J-4. The Figure clearly shows that none of the areas of the Canal currently meet J-1, and that none of the Canal will meet the J-1 even after the Second Stage Development Project. The proposed J-1 involves reducing the current risk levels by about 90% whereas the Second Stage Development Project will actually reduce risk by an average of 10% ~ 70%.

SCA's proposed risk level J-1, J-2, J-3 and J-4, are all compared in Table VI-3. If we apply J-1 criteria, almost none of the Canal will be suitable even after the completion of the Second Stage Development Project. If, however, we apply the other alternative criteria, the Canal will have to be widened over a length of 152 km, 67 km, 38 km, or 14 km for J-1, J-2, J-3, and J-4, respectively. These lengths are simply the total of the parts for which the risk level is above the proposed criteria. Incidentally, the section of the Canal from Km 115 to 129 has to be widened according to all four criteria.

Table VI-3 Comparison of Acceptable Risk Levels

Locations		Risk Level at Phase II	Criterion			
	Km ~ Km		J-1	J-2	J-3	J-4
1	19 ~ 34	1.36×10^{-6}	X			
2	31 ~ 34	0				
3	34 ~ 50	7.73×10^{-7}	X			
4	64 ~ 71	1.81×10^{-6}	X			
5	83 ~ 85	x 0				
6	88 ~ 93	1.09×10^{-6}	X	X	X	
7	132 ~ 134	7.27×10^{-6}	X			
8	134 ~ 145	9.97×10^{-7}	X			
9	145 ~ 147	0				
10	147 ~ 154	1.57×10^{-6}	X			
11	1E ~ 15E	1.70×10^{-6}	X			
12	15E ~ 19E	0				
13	50W ~ 52W	1.68×10^{-6}	X			
14	52W ~ 55W	0				
15	55W ~ 59W	2.71×10^{-6}	X	X		
16	59W ~ 64	3.35×10^{-6}	X	X		
17	51E ~ 60E	1.94×10^{-7}				
18	71 ~ 75	1.58×10^{-6}	X			
19	75 ~ 83	2.45×10^{-6}	X	X		
20	85 ~ 88	4.62×10^{-6}	X	X	X	
21	93 ~ 94	0				
22	94 ~ 96	0				
23	96 ~ 101	4.48×10^{-6}	X	X	X	
24	116 ~ 122	1.75×10^{-5}	X	X	X	X
25	122 ~ 126	1.17×10^{-5}	X	X	X	X
26	126 ~ 129	8.95×10^{-6}	X	X	X	X
27	129 ~ 132	2.68×10^{-6}	X	X		
28	154 ~ 162	1.05×10^{-6}	X			
29	Hm 0 ~ Hm 90	2.34×10^{-5}	X	X		

Note: 1) Phase II: The Second Stage Development Project
2) x shows that the locations that do not reach the criteria.
Acceptable risk levels: (J-1) = 87.4% down, (J-2) = 80% down, (J-3) = 60% down, (J-4) = 20% down from present levels.

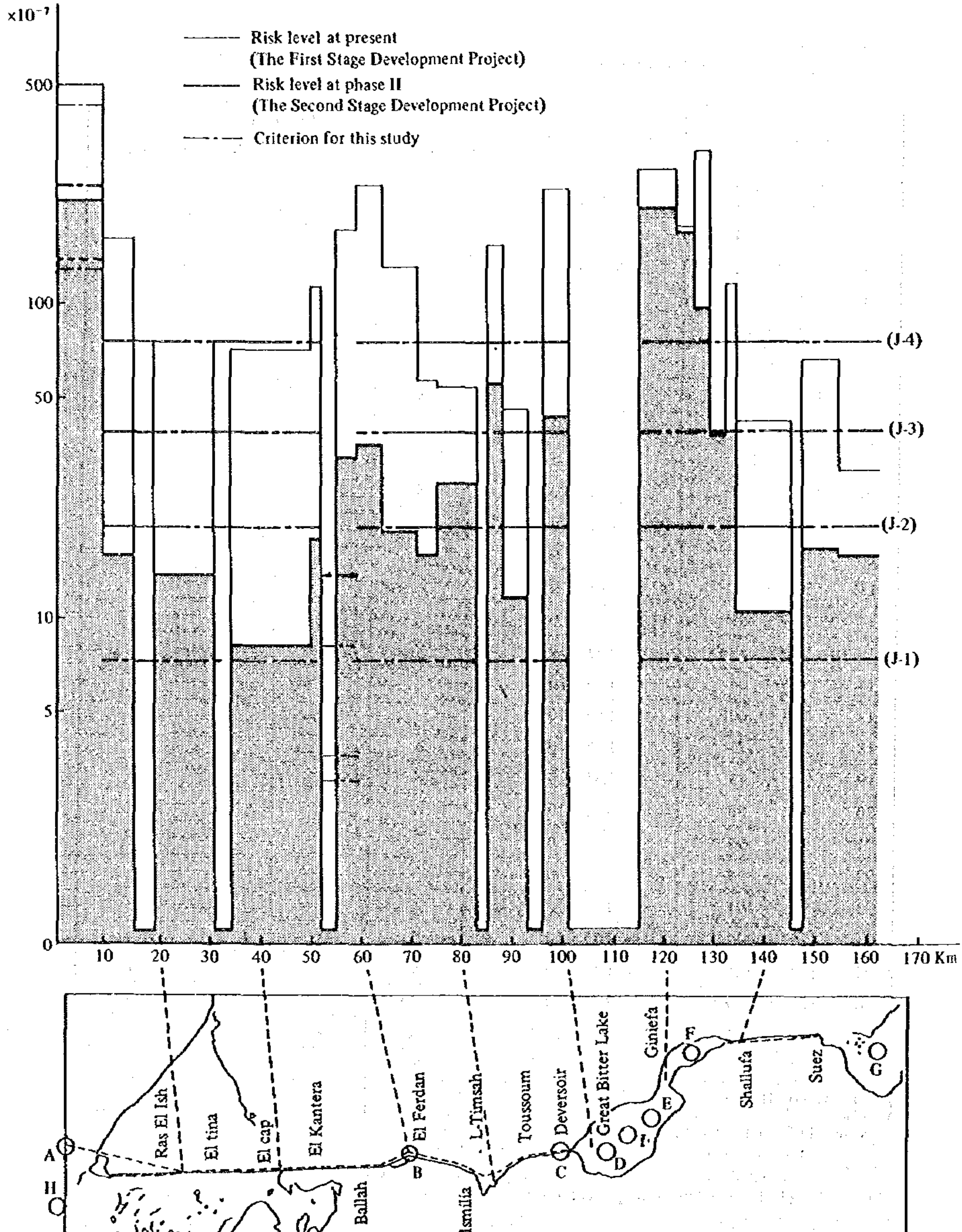


Fig. VI-1 Comparison with Acceptable Risk Levels

(2) Extraction of Critical Factors (Refer to VI-2-(2))

Risk levels change due to canal factors such as width, curvature, etc. However, as a result of sensitivity analysis, it is determined that only width has a significant affect on the risk level.

Table VI-4 shows the width (in meters) which each section of the Canal would have to be widened to meet the proposed risk levels.

The total length of widening for the proposed criteria differs somewhat from the totals presented in the previous subsection and listed in Table VI-3 because the figures in the following Table VI-4 are the actual figures necessary to widen the Canal from an engineering standpoint whereas the figures presented in Fig. VI-3 are merely the sum total of the areas which do not meet the proposed risk criteria and thus do not reflect engineering realities.

Table VI-4 Additional Widening Necessary to Meet Proposed Safety Criteria (In Addition to the Second Stage Development Project)

(Unit: meters)

Divisions \ Criterion	(J-1)	(J-2)	(J-3)	(J-4)
1 19 ~ 31	11			
2 31 ~ 34				
3 34 ~ 50	1			
4 64 ~ 71	15			
5 83 ~ 85				
6 88 ~ 93	7			
7 132 ~ 134	40	23	10	
8 134 ~ 145	6			
9 145 ~ 147				
10 147 ~ 154	13			
11 1E ~ 15E	15			
12 15E ~ 19W				
13 50W ~ 52W	15			
14 52W ~ 55W				
15 55W ~ 59W	35	12		
16 59W ~ 64	31	12		
17 51E ~ 60E				
18 71 ~ 75	14			
19 75 ~ 83	29	7		
20 85 ~ 88	53	30	9	
21 93 ~ 94				
22 94 ~ 96				
23 96 ~ 101	32	15	2	
24 115 ~ 122	130	90	66	40
25 122 ~ 126	190	130	80	35
26 126 ~ 129	54	35	20	5
27 129 ~ 132	71	33		
28 154 ~ 162	6			
29 Hm 0 ~ Hm 90	13	18		

PART VII MEASURES FOR SAFETY IMPROVEMENT

VII-1 Basic Concept (Refer to VII-1)

The Safety of the Suez Canal can be considered in terms of the functions of the Canal and the beneficiaries of safety programs.

The Canal has two main functions: to enable vessels to navigate safely within the Canal and to provide a safe space for local residents to live and work along the Canal.

The primary beneficiaries of such programs are: 1) ships and crews working in, and passing through, the Canal, and 2) the local residents.

VII-2 Canal Topography (Refer to VII-3-(1))

According to the results of risk analysis, in order to improve the safety of the Canal, additional widening, in addition to the Second Stage Development Project of SCA is required to obtain each acceptable risk level

The additional widening widths and locations are shown in Table VII-1.

Table VII-1 Additional Widening Widths (In Addition to the Second Stage Development Project Plan of SCA)

(Unit: meters)

Location	J-1		J-2		J-3		J-4	
	Results of Risk Analysis	Proposed Additional Width	Results of Risk Analysis	Proposed Additional Width	Results of Risk Analysis	Proposed Additional Width	Results of Risk Analysis	Proposed Additional Width
Hm 90^E ~ Hm 0^E	18	20	18	20				
Hm 0^E ~ Km 1^E	0	20						
Km 1^E ~ 15^E	15	15						
Km 15^E ~ 19	0	0						
Km 19 ~ 31	11	10						
Km 31 ~ 34	0	0						
Km 34 ~ 50	1	0						
Km 50 ~ 51^E	0	0						
Km 51^E ~ 60^E	0	0						
Km 50 ~ 52^W	15	15						
Km 52^W ~ 55^W	0	15						
Km 55^W ~ 59^W	35	35	12	10				
Km 59^W ~ 64^W	31	30	12	10				
Km 64 ~ 71	15	15						
Km 71 ~ 75	14	15						
Km 75 ~ 83	20	30	7	10				
Km 83 ~ 85	0	30						
Km 85 ~ 88	53	55	30	30	9	10		
Km 88 ~ 93	7	10						
Km 93 ~ 94	0	0						
Km 94 ~ 96	0	0						
Km 96 ~ 101^E	32	35	15	15	2	0		
Great Bitter Lake								
Km 115^E ~ 122^E	130	130	90	90	66	70	40	40
Km 122^E ~ 126	190	190	130	130	80	80	35	35
Km 126 ~ 129	54	55	35	35	20	20	5	5
Km 129 ~ 132	71	70	33	35	0	20		
Km 132 ~ 134	40	40	23	25	10	10		
Km 134 ~ 145	6	10						
Km 145 ~ 147	0	0						
Km 147 ~ 154	13	15						
Km 154 ~ 162	6	10						

VII-3 Construction and Maintenance Works (Refer to VII-3-(2))

(1) Outline of Work

The details of the Second Stage Development Project have not yet been decided. However, the basic plan which SCA is considering is the widening and deepening dredging of the Port Said approach channel and of the main channel, and the deepening dredging of the east anchorage area in the Great Bitter Lake (hereafter referred to as the SCA plan).

In this study, risk analysis is made based on the SCA plan. There is no basic objection to the plan, but we recommend that it be changed partially in terms of width. Table VII-2 shows the details of work necessary under the SCA plan and under four alternatively plans which would reduce the risk level to J-1, J-2, J-3, and J-4 respectively.

Under the SCA plan, the work would only involve dreging, but the alternative plans would also involve reconstruction of banks and/or mooring caissons.

Table VII-2 Work Volume of the Second Stage Development Project

km	SCA Plan	Alternative Plans									
		J-1			J-2			J-3		J-4	
	Dreding ($10^3 m^3$)	Dredging ($10^3 m^3$)	Bank Work (km)	Removal Caisson (Number)	Dredging ($10^3 m^3$)	Bank Work (km)	Removal Caisson (Number)	Dredging ($10^3 m^3$)	Removal Caisson (Number)	Dredging ($10^3 m^3$)	Removal Caisson (Number)
Port Said Approach Channel	61,400	65,300			64,800			61,400		61,400	
Km 1.5 ~ 61.0	42,700	55,300	9.5		43,900	0.2		42,700		42,700	
Km 61.0 ~ 79.0	30,200	39,200	16.9		31,900	3.5		30,200		30,200	
Km 79.0 ~ 94.5	21,300	31,300	13.7		24,300	6.2		21,900		21,300	
Km 94.5 ~ 101.0	11,700	16,000			13,300			12,300		11,700	
Km 101.0 ~ 115.0	19,000	20,400			19,600			19,400		19,200	
Km 115.0 ~ 122.0	4,300	24,300		16	18,200		16	14,900	16	10,300	
Km 122.0 ~ 145.0	36,600	67,600	10.5	36	54,900		36	47,300	36	40,200	13
Km 145.0 ~ 162.25	25,100	29,400	11.1	5	25,100			25,100		25,100	
Great Bitter Lake Anchorage	83,900	83,900			83,900			83,900		83,900	
Total	336,200	432,700	61.7	57	379,900	9.9	52	359,100	52	346,000	13

(2) Construction Schedule

The starting time of the construction has not yet been decided, so it is assumed as follows.

1) SCA decides on the full scale execution of the Second Stage Development Project by end of 1985 and starts from a LOT where there is a high probability of accidents according to the results of the Risk Analysis.

2) The dredgers owned by SCA start dredging in January, 1986, and the foreign contractors start dredging at the end of 1986. The construction schedule has been made so as to complete the Second Stage Development Project in 3 ~ 4 years after contract dredging begins.

Figs. VII-1 ~ 5 show the construction schedules for each plan. The required maximum total dredger horse power is 195,500 HP including SCA dredgers totalling 35,500 HP (in the case of altenative plan J-1, it is 225,000 HP including SCA dredgers totalling 41,000 HP).

3) The schedules are made based on the following assumptions:

(i) The monthly capacity of cutter suction dredgers is calculated based on the results of the study on each LOT of the First Stage Development Project and then adjusted due to the different conditons of the Second Stage Development Project.

(ii) As for the standard allotment of dredgers in consideration of work volume and execution conditions, the sections of the Port said approach channel, Km 1.5 ~ 61.0 and Km 115.0 ~ 122.0 except in the case of J-1 are dredged by SCA dredgers, and the other sections are dredged by contractors' dredgers.

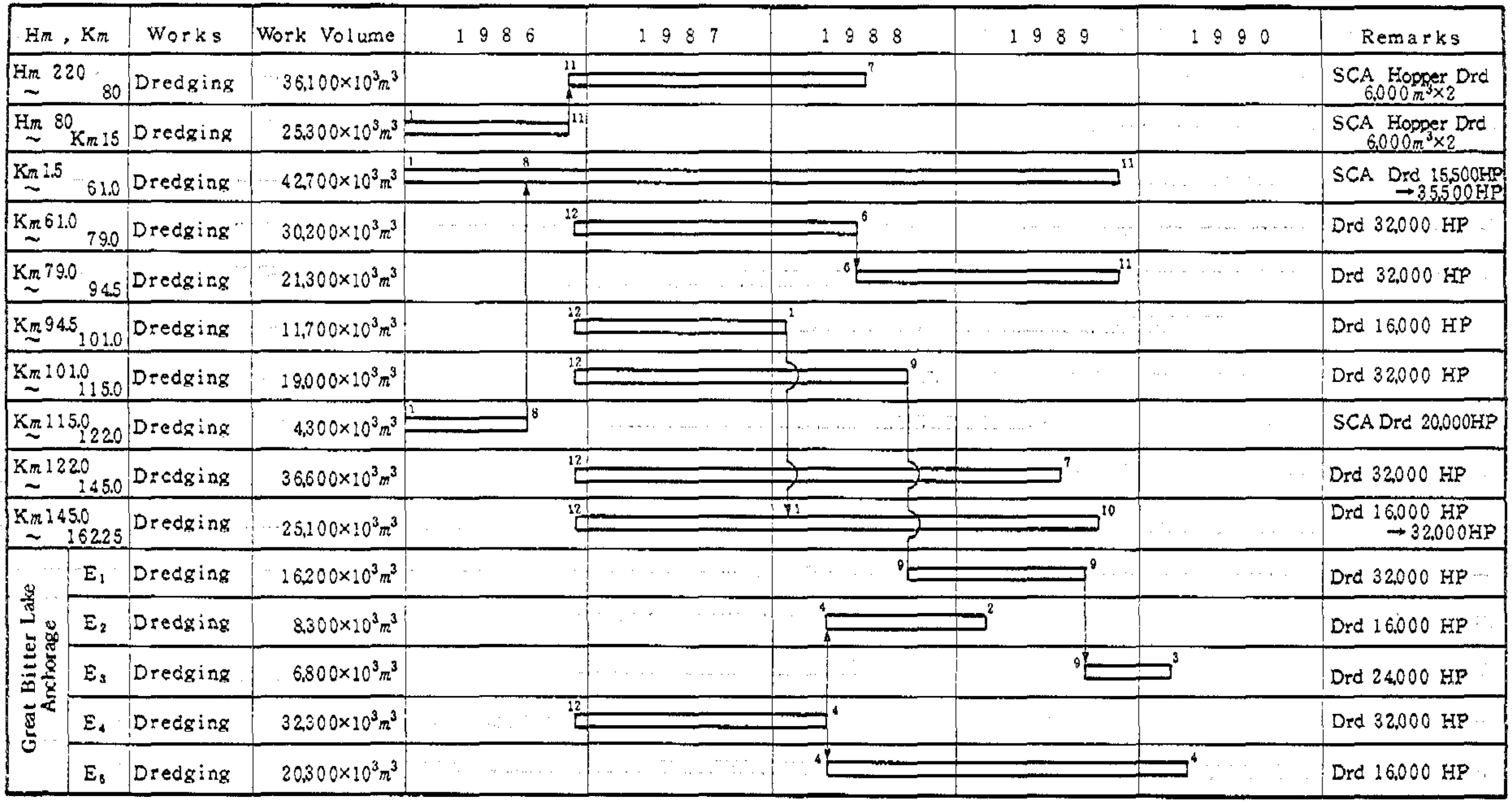


Fig. VII-1 Construction Schedule (SCA Plan)

Hm・Km		Works	Work Volume	Remarks
Hm22.0 ~ 8.0		Dredging	36,500×10³ m³	SCA Hopper Drd 6000 m³×2
Hm8.0 ~Km1.5		Dredging	28,800×10³ m³	SCA Hopper Drd 6000m³×2
Km1.5 ~61.0		Bank Works	200m	
		Dredging	51,100×10³ m³	SCA Drd 30,000HP
Km51.477w ~60.8w		Bank Works	9300m	
		Dredging	4,200×10³ m³	SCA Drd 11,000HP
Km61.0 ~79.0		Bank Works	16,900m	
		Dredging	39,200×10³ m³	Drd 32,000HP
Km79.0 ~94.5		Bank Works	13,700m	
		Dredging	31,300×10³ m³	Drd 32,000HP
Km94.5 ~101.0		Dredging	16,000×10³ m³	Drd 16,000 HP
Km101.0 ~115.0		Dredging	20,400×10³ m³	Drd 32,000 HP
Km115.0 ~122.0		Bank Works	Caisson 16 Pieces	
		Dredging	24,300×10³ m³	Drd 16,000HP
Km122.0 ~145.0		Bank Works	Bank 10,500 m Caisson 36 pieces	
		Dredging	67,600×10³ m³	Drd 40,000HP
Km145.0 ~162.25		Bank Works	Bank 11,100m Caisson 5 Pieces	
		Dredging	29,400×10³ m³	Drd 16,000HP → 32,000HP
Great Bitter Lake Anchorage	E1	Dredging	16,200×10³ m³	32,000HP
	E2	Dredging	8,300×10³ m³	Drd 16,000HP
	E3	Dredging	6,800×10³ m³	24,000HP
	E4	Dredging	32,300×10³ m³	Drd 32,000HP
	E5	Dredging	20,300×10³ m³	Drd 16,000HP

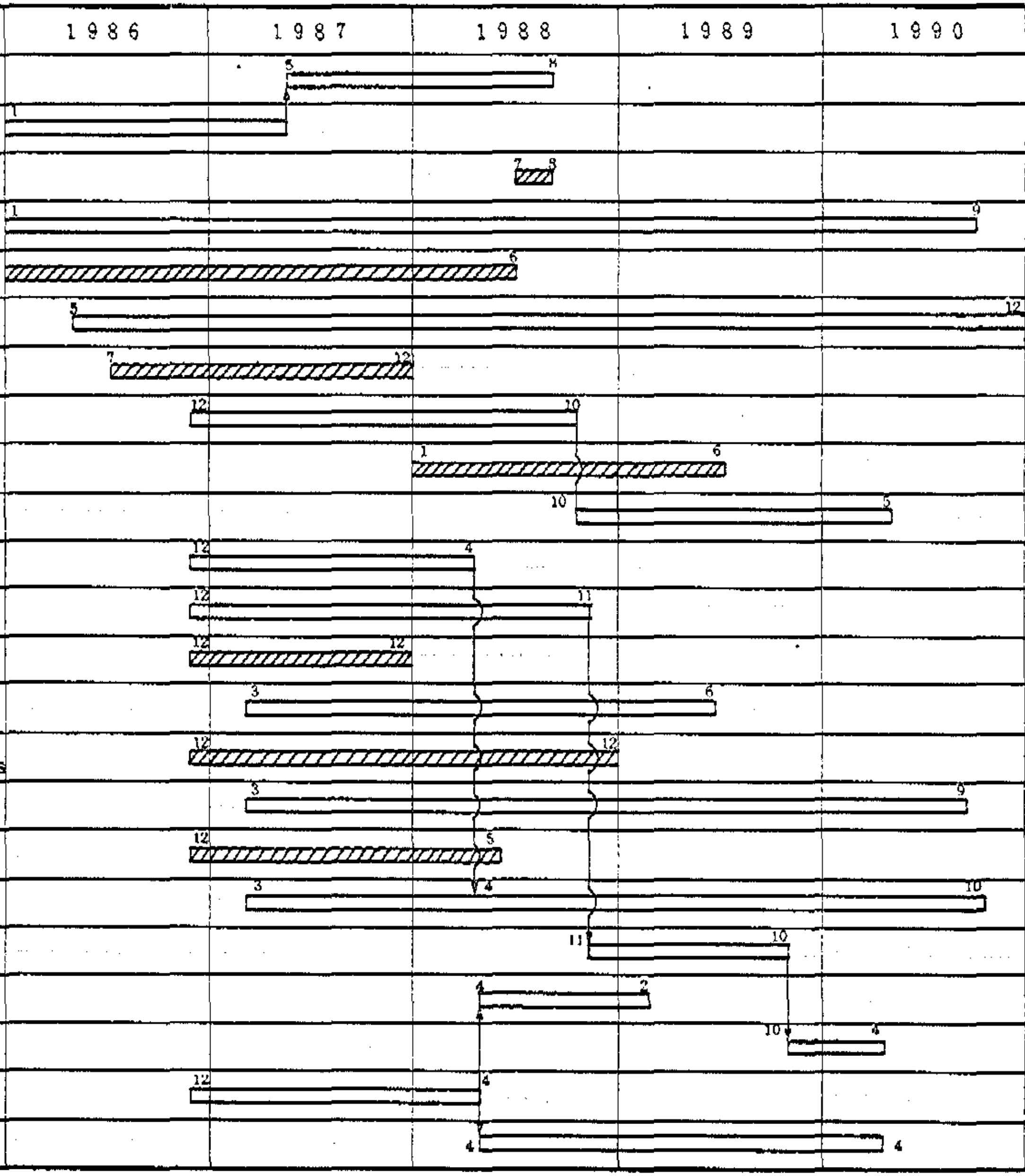


Fig. VII-2 Construction Schedule (Alternative Plan J-1)

Hm, Km		Works	Work Volume	1986	1987	1988	1989	1990	Remarks
Hm 220 ~ 80		Dredging	36,500×10³m³		3	8			SCA Hopper Drd 6,000 m³×2
Hm 80 ~ Km 1.5		Dredging	28,300×10³m³	1	3				SCA Hopper Drd 6,000 m³×2
Km 1.5 ~ 61.0		Bank Works	200m	10 11					
		Dredging	42,900×10³m³	1 3		1		7	SCA Drd 35,500 HP →15,500 HP→35,500 HP
Km 50.5 w ~ 60.8 w		Dredging	1,000×10³m³		1		9		Drd 5,500 HP
Km 61.0 ~ 79.0		Bank Works	3,500m	12	12				
		Dredging	31,900×10³m³		3	9			Drd 32,000 HP
Km 79.0 ~ 94.5		Bank Works	6,200m			1	6		
		Dredging	24,300×10³m³			9		1	Drd 32,000 HP
Km 94.5 ~ 101.0		Dredging	13,300×10³m³	12		2			Drd 16,000 HP
Km 101.0 ~ 115.0		Dredging	19,600×10³m³	12		10			Drd 32,000 HP
Km 115.0 ~ 122.0		Bank Works	Caisson 16 Pieces	1 12					
		Dredging	18,200×10³m³	4		1			SCA Drd 20,000 HP
Km 122.0 ~ 145.0		Bank Works	Caisson 35 Pieces	12	12				
		Dredging	54,900×10³m³		3			7	Drd 32,000 HP
Km 145.0 ~ 162.25		Dredging	25,100×10³m³	12		2	10		Drd 16,000 HP → 32,000 HP
Great Bitter Lake Anchorage	E₁	Dredging	16,200×10³m³			10	10		Drd 32,000 HP
	E₂	Dredging	8,300×10³m³			4	2		Drd 16,000 HP
	E₃	Dredging	6,800×10³m³				10	3	Drd 24,000 HP
	E₄	Dredging	32,300×10³m³	12		4			Drd 32,000 HP
	E₅	Dredging	20,300×10³m³			4		4	Drd 16,000 HP

Fig. VII-3 Construction Schedule (Alternative Plan J-2)

Hm, Km	Works	Work Volume	1986	1987	1988	1989	1990	Remarks
Hm 220 ~ 80	Dredging	36,100×10³m³	11		7			SCA Hopper Drd 6,000m³×2
Hm 80 ~ Km 15	Dredging	25,300×10³m³	1, 11					SCA Hopper Drd 6,000m³×2
Km 1.5 ~ 61.0	Dredging	42,700×10³m³	1, 3	11			5	SCA Drd 35,500HP
Km 61.0 ~ 79.0	Dredging	30,200×10³m³	12		6			Drd 32,000 HP
Km 79.0 ~ 94.5	Dredging	21,900×10³m³			6	11		Drd 32,000 HP
Km 94.5 ~ 101.0	Dredging	12,300×10³m³	12		2			Drd 6,000 HP
Km 101.0 ~ 115.0	Dredging	19,400×10³m³	12		10			Drd 32,000 HP
Km 115.0 ~ 122.0	Bank Works	Caisson 16 Pieces	12					
	Dredging	14,900×10³m³	4	10				SCA Drd 20,000HP
Km 122.0 ~ 145.0	Dredging	Caisson 36 Pieces	12	12				
	Dredging	47,300×10³m³		3			4	Drd 32,000 HP
Km 145.0 ~ 162.25	Dredging	25,100×10³m³	12		2	10		Drd 16,000 HP → 32,000HP
Great Bitter Lake Anchorage E₁	Dredging	16,200×10³m³			10	9		Drd 32,000 HP
E₂	Dredging	8,300×10³m³			4	2		Drd 16,000 HP
E₃	Dredging	6,800×10³m³				10	3	Drd 24,000 HP
E₄	Dredging	32,300×10³m³	12		4			Drd 32,000 HP
E₅	Dredging	20,300×10³m³			4		4	Drd 16,000 HP

Fig. VII-4 Construction Schedule (Alternative Plan J-3)

Hm, Km	Works	Work Volume	Remarks
Hm 220 ~ 80	Dredging	36,100×$10^3 m^3$	SCA Hopper Drd 6,000m^3×2
Hm 80 ~ Km 15	Dredging	25,300×$10^3 m^3$	SCA Hopper Drd 6,000m^3×2
Km 1.5 ~ 61.0	Dredging	42,700×$10^3 m^3$	SCA Drd 15,500HP → 35,500HP
Km 61.0 ~ 79.0	Dredging	30,200×$10^3 m^3$	Drd 32,000 HP
Km 79.0 ~ 94.5	Dredging	21,300×$10^3 m^3$	Drd 32,000 HP
Km 94.5 ~ 101.0	Dredging	11,700×$10^3 m^3$	Drd 16,000 HP
Km 101.0 ~ 115.0	Dredging	19,200×$10^3 m^3$	Drd 32,000 HP
Km 115.0 ~ 122.0	Dredging	10,300×$10^3 m^3$	SCA Drd 20,000HP
Km 122.0 ~ 145.0	Bank Works	Caisson 13 Pieces	
	Dredging	40,200×$10^3 m^3$	Drd 32,000 HP
Km 145.0 ~ 162.25	Dredging	25,100×$10^3 m^3$	Drd 16,000 HP → 32,000 HP
Great Bitter Lake Anchorage E1	Dredging	16,200×$10^3 m^3$	Drd 32,000 HP
Great Bitter Lake Anchorage E2	Dredging	8,300×$10^3 m^3$	Drd 16,000 HP
Great Bitter Lake Anchorage E3	Dredging	6,800×$10^3 m^3$	Drd 24,000 HP
Great Bitter Lake Anchorage E4	Dredging	32,300×$10^3 m^3$	Drd 32,000 HP
Great Bitter Lake Anchorage E5	Dredging	20,300×$10^3 m^3$	Drd 16,000 HP

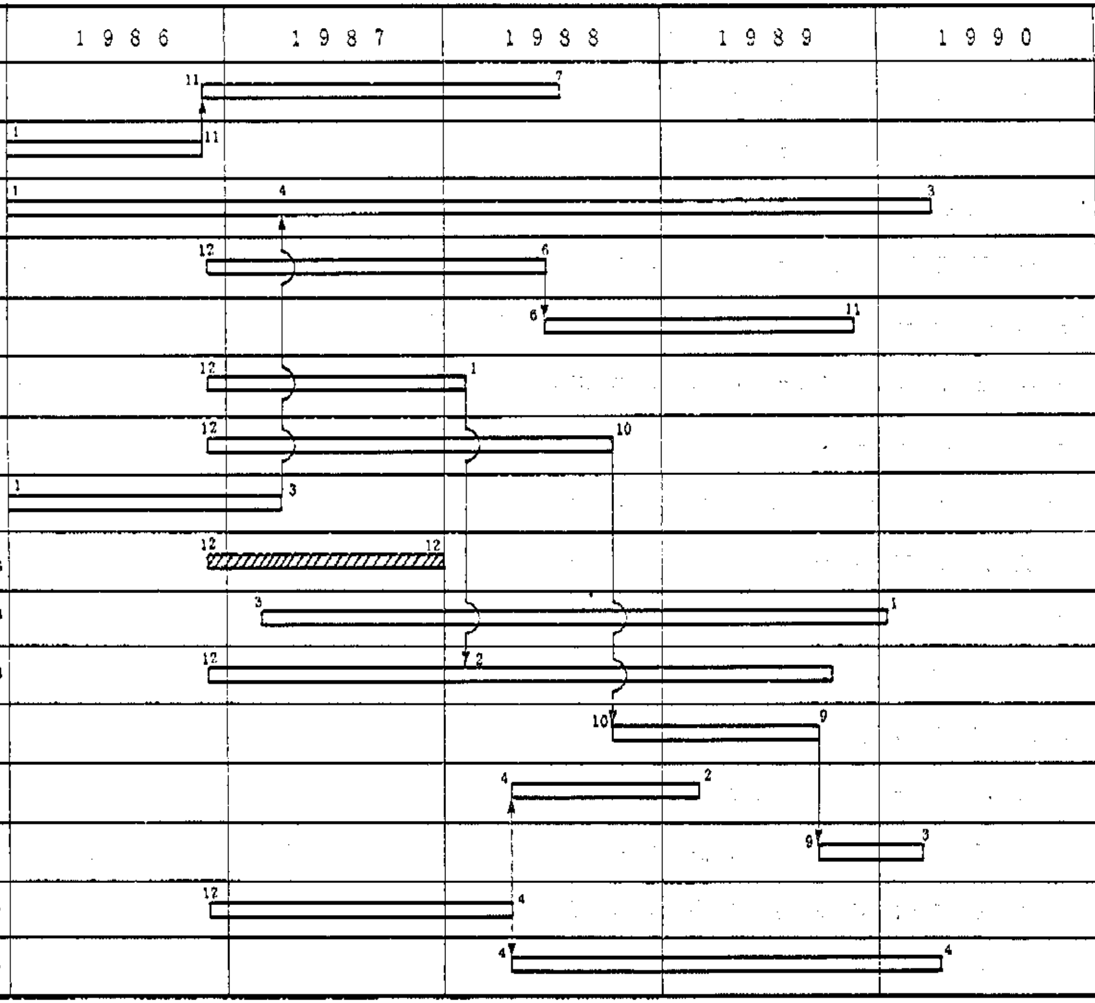


Fig. VII-5 Construction Schedule (Alternative Plan J-4)

3) Construction Cost

Construction costs of the Second Stage Development Project are estimated as follows, based on 1983 prices.

The unit cost of contract dredgers for the Second Stage Development Project is calculated from the estimated monthly dredging volume of each LOT based on the actual results of the First Stage Development Project, and from the dredging expenses for one month.

The estimation method of the unit cost of SCA's dredger is assumed the same as for contract dredging, because the dredging expenses of SCA are not known.

The cost for removal caissons is calculated based on the actual costs of the First Stage Development Project taking price hikes into account. Estimated costs include a contingency of 10%, but do not include further price increases due to future inflation.

The costs are divided into local currency (LC) and foreign currency (FC). For contract dredging, the ratio of local and foreign currencies is estimated based on the actual work to be done. For other work, the ratio of local and foreign currencies is based on the ratio from the First Stage Development Project.

The construction costs for each of the proposed plans are shown in Table VII-3. Foreign currencies are shown in U.S. Dollars. However, the foreign currency payments were actually calculated in Yen and then converted to dollars at the rate of ¥250=US$1.

Table VII-3 Cost of the Second Stage Development Project

1.40 LE = 1 US$ = 250 ¥

	SCA Plan		Alternative Plan															
			J-1				J-2				J-3				J-4			
	Dredging		Dredging		Bank Works		Dredging		Bank Works		Dredging		Bank Works		Dredging		Bank Works	
	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC
	10^3 LE	10^3 $	10^3 LE	10^3 $	10^3 LE	10^3 $	10^3 LE	10^3 $	10^3 LE	10^3 $	10^3 LE	10^3 $	10^3 LE	10^3 $	10^3 LE	10^3 $	10^3 LE	10^3 $
Port Said Approach Channel	38,928	10,806	41,400	11,493			41,083	11,405			38,927	10,806			38,928	10 806		
Km 1.5 ~ 61.0	70,882	14,048	108,984	21,608	4,950	1,020	78,387	15,538	104	21	70,882	14,048			70,882	14,048		
Km 61.0 ~ 79.0	11,869	57,501	14,073	68,051	8,805	1,815	11,548	56,016	1,824	376	11,869	57,501			11,869	57,501		
Km 79.0 ~ 94.5	10,011	48,479	11,456	55,589	7,138	1,471	9,744	47,239	3,230	666	10,162	49,144			10,011	48,479		
Km 94.5 ~ 101.0	4,411	21,388	5,296	25,664			4,668	22,610			4,637	22,484			4,411	21,388		
Km 101.0 ~ 115.0	14,136	68,476	14,994	72,542			14,582	70,638			14,434	69,918			14,285	69,197		
Km 115.0 ~ 122.0	9,322	1,849	8,505	41,213	126	362	22,786	4,532	126	362	18,863	3,740	126	362	15,069	2,987		
Km 122.0 ~ 145.0	19,325	94,574	32,042	156,832	5,754	1,943	25,144	122,756	283	815	23,224	113,520	283	815	20,984	102,590	102	294
Km 145.0 ~ 162.25	16,792	86,846	17,464	90,199	5,822	1,305	16,792	86,846			16,792	86,846			16,792	86 846		
Great Bitter Lake Anchorage	29,508	142,905	29,508	142,905			29,508	142,905			29,508	142,905			29,508	142,905		
Mobilization & Demobilization	–	65,440	–	75,256			–	65,440			–	65,440			–	65,440		
Total	225,184	612,312	283,722	761,352	32,595	7,916	254,242	645,925	5,567	2,240	239,298	636,352	409	1,177	232,739	622,187	102	294
Grand Total	773,158 × 10^3 US$		995,209 × 10^3 US$				833,743 × 10^3 US$				808,748 × 10^3 US$				788,796 × 10^3 US$			

4) Measures for Prevention of Accidents

Preservation works to keep the Canal functioning, such as widening and deepening dredging and maintenance dredging of the Canal, are indispensable to safe navigation of transit vessels.

To avoid accidents between transit vessels and work vessels doing dredging work in the Canal, in principle the dredgers are shifted to a position outside the navigation buoy line at least 30 minutes prior to the expected passage of transit vessels. Work vessels then wait until transit vessels have passed, keeping clear of the fairway of the Canal. A meeting of the persons concerned, i.e. pilots, captains of dredgers and members of the transit department, should be held to formalize SCA's safety countermeasures into written documents.

Furthermore, it is necessary to make these guidelines understood by all the staff members concerned.

VII-4 Navigational Measures (Refer to VII-2-(1), VII-3-(3), (4))

1) Improvement of Aids to Navigation

For the enhancement of navigational safety and for traffic control in the areas of the approaches and in Great Bitter Lake, aids to navigation in those areas should be reinforced.

Followings are the proposals for the improvement of aids to navigation and others;

(i) A lighthouse should be constructed at the end of Port Said breakwater.

(ii) The Port Said Approach Buoy and Suez Separation Zone No.1 Buoy be upsized.

(iii) The construction of lighthouses in the Suez Bay should be realized at the earliest possible opportunity.

(iv) Four lighthouses should be constructed on the East and West banks of Great Bitter Lake.

(v) The maintenance organization and system of buoys provided in the approaches should be reinforced.

(vi) The installed positions of Canal buoys should be maintained correctly.

(vii) The latest authorized charts should be distributed to those concerned.

2) Establishment of Canal Traffic Communications System

As for transit vessels, insufficient information and unsmooth communications reduces safety of navigational operations. Therefore, instructions should be given to those engaged in the communication services to recognize the importance of communications, and the particular communication systems such as periodical and emergency broadcasting, individual information service and control service should be established.

3) Establishment of Transit Control System in an Emergency

For preventing undue disorders and disturbances at the time of the occurrence of accidents and for dealing with such emergency situations in a most organized and systematic manner, it is necessary to establish in advance an organization and system taking into consideration the following items, with proper drill and training postulating possible casualties.

(i) Correct grasp of accidents

(ii) Organizing ad-hoc accident control headquarters

(iii) Evaluation of countermeasures

(iv) Traffic controls

i) Emergency broadcasting service

ii) Judgement on danger area

iii) Giving instructions for required moves to each transit vessel

iv) Dispatching tugs and others

v) Assessment of disposition of the vessel involved in the accident

vi) Resumption of transiting

4) Utilization of Port Said Bypass

The frequency of accidents in Port Said is much higher than those in other areas and Suez, and thus this is the area where establishment of effective safety measures is most strongly desired.

Utilizing the non-service time belt of Port Said Bypass, those vessels presently channelled through the West Branch should be brought via the Bypass to the extent possible for mooring at the Buoy Berths which are now under construction on the South Part of the West Branch for necessary preparation for transit; then let them head towards the Canal.

If the number of vessels transiting across the harbour of Port Said is reduced by the forementioned method, the risk levels would surely come down.

5) Countermeasures against Sandstorms

Sandstorms have been the major factor for a variety of accidents. Further investigations on the critical wind velocity and visibility as the criteria to prohibit transiting is considered necessary.

The wind velocity criterion to prohibit transiting established by the SCA, i.e., 50 km/hr (13.9 m/sec) is generally appropriate for tankers, but for container vessels and PCC, about 12 m/sec and 10 m/sec should be applied, respectively.

The visibility criterion to prohibit transiting established by the SCA, i.e., 300 m seems a bit too small considering stopping within visibility and criteria in other waterways.

6) Safety Measures for Berthing Operations in Ballah West Channel

A high frequency of grounding and contacting accidents to the Canal banks occurred in Ballah West Branch by second southbound convoy vessels. Proper guidance should be given to the pilots so that they pay better attention to the effects that bank suction and the inclined bottom of the Canal exert on manoeuvring there.

7) Qualifications, Fitness, Education and Training of Pilots

The majority of the total accidents were caused by human errors.

In recognition of the importance of the Suez Canal as an international waterway, it is the responsibility of the SCA to maintain the knowledge and skills of the pilots piloting such an important waterway of the world at reasonably high levels. In this context, the SCA should make its efforts as follows:

(i) Qualifications

An upper age limit for becoming a pilot should be prescribed.

The qualifications for pilots should be at least a Chief Mate license for ocean-going service, and those young and capable candidates should undergo effective education and training for a reasonable period of time.

(ii) Fitness Examination

For pilots, periodical physical fitness examinations and examinations for proving intellectual fitness for pilotage duties should be carried out for the proper maintenance of reliable pilotage.

(iii) Education and Training

For the proper maintenance and improvement of pilots' professional knowledge and skills, they should be given opportunities for taking re-education and retraining at regular intervals.

The curricula should not only include technological innovations, but also be closely connected to specific procedures necessary for communications, liaisons and traffic controls including cooperative activities for emergency procedures in the Canal and associated waters. For ship manoeuvring training, ship manoeuvring simulators should be introduced.

8) Controls over Anchorage

The controls over each anchorage are presently insufficient.

It is necessary to realize closely attended control practices in times of anchoring and heaving up anchor, on the use of the anchorages and on the tracks in the anchorages.

9) SCVTMS

The SCVTMS is not in practical operation at present, because the system has the problems of the Loran-C vessel's position fixing system. However, it is evident that the SCVTMS is an extremely effective system for the enhancement of safety of the Canal, and hence a positive effort should be made for the early commencement of the practical operation taking into consideration of the following hints:

(i) Using the systems other than the Loran-C System, i.e., the Tracking Radar System, the Computer Network System and the Communication System, a periodical and emergency broadcasting, an individual information providing and a control services should be started.

(ii) To operate the SCVTMS, the mutual understanding and cooperation between SCVTMS engineering staffs and transit operation staffs are extremely important and indispensable.

(iii) Reviews should be made to reassess the number and positional relationships between the master, slave and monitor stations of the Loran-C system, and the correlation with relevant maps, and service radio waves, etc., whatever is related to the fundamental design of the system.

(iv) A feasibility study should be made on any other alternative position fixing system other than the Loran-C system, such as the radar chain system.

The required level of position fixing accuracy by the radar chain system can be obtained without much difficulty. However, a considerable number of radars is required for such a radar network system, and thus operation, maintenance and management may be problematic.

10) Countermeasures for Preventing Collisions within the Harbour of Port Said

The most significant feature of the accident statistics is the very high frequency of collisions and contacts in Port Said and associated waters. Effective safety measures must be established in this area.

Shown below are several possible countermeasures:

(i) Commencement of use of the new waiting buoy berth of Port Said West Branch

(ii) Move towards dual track feature of the Port Said Bypass

(iii) Modify the goods circulation system, divert vessels calling at Port Said to other ports and reduce the frequency of calls at Port Said; thus the number of vessels and craft within the harbour area would be reduced to a reasonable level.

For realizing such proposals, positive efforts should be made by organizing committees and other concerned parties.

11) Arrangement of Escort Tugs

Based on the results of assessments on vessels' towing resistance, wind pressure, and the stopping distance of vessels when they are subjected to braking operation by tugs within the Canal water, the change in the criterion for the arrangement of escort boats effected by the SCA from 100,000 DWT to 110,000 DWT is considered to be inappropriate, and rather it should be lowered, in our opinion, to 100,000 DWT or even lower.

12) Cost of Navigational Measures

The costs of the major navigational measures are presented in the following table.

Table VII-4 Cost of Navigational Measures

	Great Bitter Lake Light Houses		Port Said Approach LAN Buoy		Suez Separation Zone LAN Buoy		Port Said Breakwater Light House		Manoeuvring Simulator		Total	
	LC $\times 10^3$ LE	FC $\times 10^3$ US$	LC $\times 10^3$ LE	FC $\times 10^3$ US$	LC $\times 10^3$ LE	FC $\times 10^3$ US$	LC $\times 10^3$ LE	FC $\times 10^3$ US$	LC $\times 10^3$ LE	FC $\times 10^3$ US$	LC $\times 10^3$ LE	FC $\times 10^3$ US$
1986	767	456	0	320	0	320	599	412	0	999	1,366	2,507
1987	577	344	0	80	0	80	599	412	0	999	1,176	1,915
1988							201	136			201	136
Total	1,344	800	0	400	0	400	1,399	960	0	1,998	2,743	4,558
Maintenance Cost per Year	$\times 10^3$ US$ 36		$\times 10^3$ US$ 11		$\times 10^3$ US$ 11		$\times 10^3$ US$ 20		$\times 10^3$ US$ 60		$\times 10^3$ US$ 138	
Durable Years	15		15		15		15		15			

VII-5 Measures for Dealing with Accidents (Refer to VII-2-(2), VII-4)

Port Said, Ismailia and Suez will remain as the disaster treatment bases. After a uniform and effective re-allocation of the equipment and materials on hand to each base, the following equipment and materials on hand to each base, the following equipment, materials, facilities and structures are to be provided to the bases.

Inflammable-gas detectors	Low toxic dispersant	Recovered-oil disposal basins
Explosion-proof VHF	Oil-boom tender boats	Oil-recovery ponds
Protective apparatus	Oil-spill control boats	Inlet or mooring buoy for the disposal of damaged tanker
Training school	Fire-fighting vessels	

After developing specialists, the following steps should be taken

- Organize Execution Team
- Prepare disaster treatment manual
- Develop environment for the positive control of accident
- Provide necessary training and education to related personnel so that effective control operation can be undertaken.

After the following should be mandatory for dangerous cargo vessels in transit:

- To hang fire wire rope to facilitate towing in case of trouble
- To provide escorting tug boat(s) with fire fighting capability

Costs for measures for dealing with accidents are indicated as follow.

Table VII-5 List of Costs

Equipment, Materials and Facilities Upper Row: Foreign Currencies Lower Row: Domestic Currencies	Total Costs	The Year 1986	1987	1988	1989	1990	Maintenance Cost per Year	Durable Years
A. Urgently-needed Counter-measures								
① Oil Booms	186	186					10	10
② Skimming Equipment	1,166	1,166					56	25
③ Oil Boom Tender Boats	420	420					20	25
④ Detector-VHF	240	240					12	15
⑤ Protective Apparatuses	204	204					12	15
⑥ Air Refilling Sets	43	43						25
⑦ Basins	2	2						Long time
	19	19						
⑧ Fire-fighting Vessels	18,000	18,000					866	25
B. Measures for Dealing with Accidents								
① Oil-spill Control Boats	6,000			2,000	2,000	2,000	289	25
② Dispersant	2,508			836	836	836	24	5
③ Protective Apparatuses	46			46			2	15
④ Training School								
	3,918			1,371	1,371	1,176	151	Long time
⑤ Stockpile at Base (Transfer Pump Systems)	1,128			376	376	376	33	25
(Buckets Scoops Ladles)								
	9			3	3	3		25
⑥ Stockpiles at Pond (Skimmer)	494			247	247		14	25
(House, Bollard)								
	46			23	23		1	50
C. Preliminary Contingency Plan								
① Inlet x 2	30,253	17,173	13,080					Long time
	42,068	4,615	37,453					
② Buoy x 1	5,200	2,600	2,600				250	50
Total × 10^3 US$	65,890	40,034	15,680	3,505	3,459	3,212	1,586	
Total × 10^3 LE	46,060	4,634	37,453	1,397	1,397	1,179	152	

VII-6 Evaluation of Measures (Refer to VII-5)

(1) Project Evaluation

The various alternative plans are evaluated based on the IRR (Internal Rate of Return). Cost/benefit analysis is conducted for all the alternatives. The estimated risk levels at present and for each of the alternative plans are shown in Table VII-6.

Table VII-6 Estimated Risk Levels

Area	Accident (Case / Risk Level)	SCA Plan	Alternatives			
		After Completion of the Second Stage Development Project 0.62×10^{-3}	J-1 Current Risk Level $\times 0.126$ $= 0.25 \times 10^{-3}$	J-2 Current Risk Level $\times 0.2$ $= 0.40 \times 10^{-3}$	J-3 Current Risk Level $\times 0.4$ $= 0.79 \times 10^{-3}$	J-4 Current Risk Level $\times 0.8$ $= 1.58 \times 10^{-3}$
Port Said & Suez	G	1.36×10^{-6}	1.39×10^{-5}	1.17×10^{-5}	2.34×10^{-5}	4.66×10^{-5}
	C	*1.84×10^{-4}	*0.43×10^{-4}	*0.37×10^{-4}	*0.74×10^{-4}	*1.48×10^{-4}
Ballah Bypass	G	1.94×10^{-7}	3.79×10^{-7}	4.04×10^{-7}	8.08×10^{-7}	1.62×10^{-6}
	C	0.15×10^{-8}	0.24×10^{-7}	0.26×10^{-7}	0.51×10^{-7}	1.02×10^{-7}
Great Bitter Lake	G	–	–	–	–	–
	C	*2.93×10^{-4}	*5.51×10^{-5}	*5.85×10^{-5}	*1.17×10^{-4}	*2.34×10^{-4}
Other Ports	G	1.75×10^{-5}	7.08×10^{-7}	1.92×10^{-6}	3.83×10^{-6}	7.66×10^{-6}
	C	2.3×10^{-7}	0.95×10^{-8}	0.26×10^{-7}	0.51×10^{-7}	1.02×10^{-7}

Note: 1. G stands for grounding accidents and C for collisions.
2. * Numerals are levels per total area (not per Km figures).
3. The risk level of each alternative is not equal to the total of the numerals in each column.

1) Cost Calculation

The total cost for each plan includes canal dredging, improvement of the navigation system, and improvement of the system to respond to disasters, and this is the additional cost necessary for achievement of each acceptable risk level to the cost of the Second Stage Development Project which will be carried out by SCA.

The costs for dredging are different for each alternative plan. However, the costs to improve the navigation system and the system to respond to disasters are the same for all four alternative plans. These improvements are considered essential for the safety of the Canal.

The costs include items which will be paid in local (Egyptian Pound: LE) and foreign ($US) currencies. When it is necessary to exchange local to foreign currency, an exchange rate of 1.40 is applied for the shadow price. This takes into account the average exchange rate on the black market. The official exchange rate for the people of Egypt is 1US$ = 0.82LE. The period for implementing the project is assumed to be 5 full years, from 1986 to 1990. This estimate takes into account the dredging work that is currently being carried out by SCA.

Table VII-7 shows the estimated costs for each plan.

Table VII-7 Project Cost

(Unit: LC in Million LE, FC and total in Million US$)

Item / Currency / Study Case	Canal Widening			Improvement of Aids to Navigation			Preparation for Disaster Response			Total		
	LC	FC	Total	LC	FC	Total	LC	FC	Total	LC	FC	Total
J-1	91.1	157.0	222.1	2.7	4.6	6.5	46.1	65.9	98.8	139.9	227.5	327.4
J-2	34.6	35.9	60.6	2.7	4.6	6.5	46.1	65.9	98.8	83.4	106.4	165.9
J-3	14.5	25.2	35.6	2.7	4.6	6.5	46.1	65.9	98.8	63.3	95.7	140.9
J-4	7.6	10.2	15.6	2.7	4.6	6.5	46.1	65.9	98.8	56.4	80.7	120.9

Note: An exchange rate of 1.40 LE per US$ is used in consideration of the shadow price.

2) Benefit Calculation

Benefits for each alternative plan are considered as the amount of reduced expenditure due to reduced losses from reduced risk.

Table VII-8 shows the items which are considered when calculating benefit for all the alternative plans. Benefits are considered from the time the project is completed until the end of the project life. Benefits are summarized as shown in Table VII-9.

Table VII-8 Classification of Losses

<table>
<tr><th rowspan="2"></th><th colspan="2">Dangerous Cargo Carriers</th><th rowspan="2">General Cargo Carriers (Incl. Working Vessels)</th></tr>
<tr><th>With Cargo Spill</th><th>Without Cargo spill</th></tr>
<tr><td>Item 1</td><td colspan="3">Damage to the Accident Vessel(s)
Damage to the Canal
*Personal Damage
Watchmen, Vessels, and/or Helicopters</td></tr>
<tr><td>Item 2</td><td colspan="2">Tanker Hiring and Cargo Transferring
Tanker Cleaning and Gas Discharging</td><td></td></tr>
<tr><td>Item 3</td><td>Treatment of Spilled Cargo
Manpower
Equipment
Disposal of Spilled Cargo
Fire Fighting
Manpower
Equipment
Losses due to Oil Pollution
Fishery
Marine Sports
Water Supply
*Environmental Impacts
Losses due to Fire
*Inhabitants
Houses and Goods
Facilities
Losses by Regulations
Detour by Road
Ferry Closing and/or Railway Closing</td><td></td><td></td></tr>
<tr><td>Item 4</td><td colspan="3">Refloating Work
Manpower
Equipment
Salvage Work
Hiring Working Vessels
Manpower
Equipment
Loss due to Waiting
At Port Said
At Suez
In the Canal
*Insurance Premiums</td></tr>
</table>

* : Items difficult to calculate in monetary terms.

Table VII-9 Benefits of the Alternatives

(Unit: Million US$)

Study Case / Item \ Period	J-1		J-2		J-3		J-4	
	~1999	2000~	~1999	2000~	~1999	2000~	~1999	2000~
1	3.9	4.0	2.9	3.1	1.4	1.5	0.8	0.8
2	0.5	0.6	0.4	0.4	0.2	0.2	0.1	0.1
3	0.8	0.9	0.6	0.7	0.3	0.3	0.2	0.2
4	35.0	37.5	26.5	28.4	12.7	13.6	7.3	7.8
Total	40.2	43.0	30.4	32.6	14.6	15.6	8.4	8.9

Note: Item numbers refer to Table VII-8

3) Evaluation of Plans

Based upon the results of estimated costs and benefits, each plan, J-1, J-2, J-3, and J-4 is evaluated and they are comapred with each another. Project value is determined using the concept of Net Present Value (NPV). This is calculated using discount ratios. The concept is easy to understand if we consider that the money which will be invested in the Second Stage Development Project could, alternatively, be invested elsewhere at various rates of return. Three alternative rates, 5%, 10%, and 15% are applied for the current analysis.

It is also important to determine the project life. Strictly speaking, the project life is the period of time that the improvements will remain in effect. For the current evaluation of plans, fifteen years after the completion of the work is assumed to be the project life. However, some of the benefits of this Safety Improvement Proejct will actually last more than fifteen years.

The results of the Cost/Benefit Analysis are shown in Table VII-10 for each alternative plan and discount ratio.

Table VII-10 Cost-Benefit Ratio (B/C)

(Unit: Million US$)

Study Case / Item \ Discount Ratio	J-1			J-2			J-3			J-4		
	5%	10%	15%	5%	10%	15%	5%	10%	15%	5%	10%	15%
Cost	308.2	273.4	246.3	165.8	146.6	132.4	145.6	130.2	119.1	128.8	115.8	106.7
Benefit	350.8	212.4	131.1	265.5	160.7	103.0	127.4	77.1	49.4	73.1	44.3	28.4
B/C Ratio	1.138	0.777	0.532	1.601	1.096	0.778	0.875	0.592	0.415	0.568	0.382	0.266

By these B/C ratios, it can be judged that plan J-2 has the highest benefit ratio. The IRR can also be calculated based upon NPV, and the result is shown in Table VII-11. It is very clear that the IRR of plan J-2 is the highest of the four alternatives and the value of 11.4% can be considered high enough to justify the implementation of this plan.

Table VII-11 Result of IRR Calculation

J-1	J-2	J-3	J-4
6.6%	11.4%	3.5%	–

The acceptable risk levels are calculated for the three discount ratios as shown in Table VII-12.

The relation between the loss sum and the risk level is drawn in Fig. VII-5 at a discount ratio of 10%. This shows that the minimum value of the cost plus loss can be obtained at the point of the risk level, 0.38×10^{-3}, and it is nearly equal to the one of J-2 plan.

It can be concluded that the acceptable risk level is about 0.40×10^{-3} and that J-2 plan is the most feasible one among the four alternatives.

Table VII-12 Acceptable Risk Level

Discount Ratio	5%	10%	15%
Acceptable Risk Level	0.34×10^{-3}	0.38×10^{-3}	0.40×10^{-3}

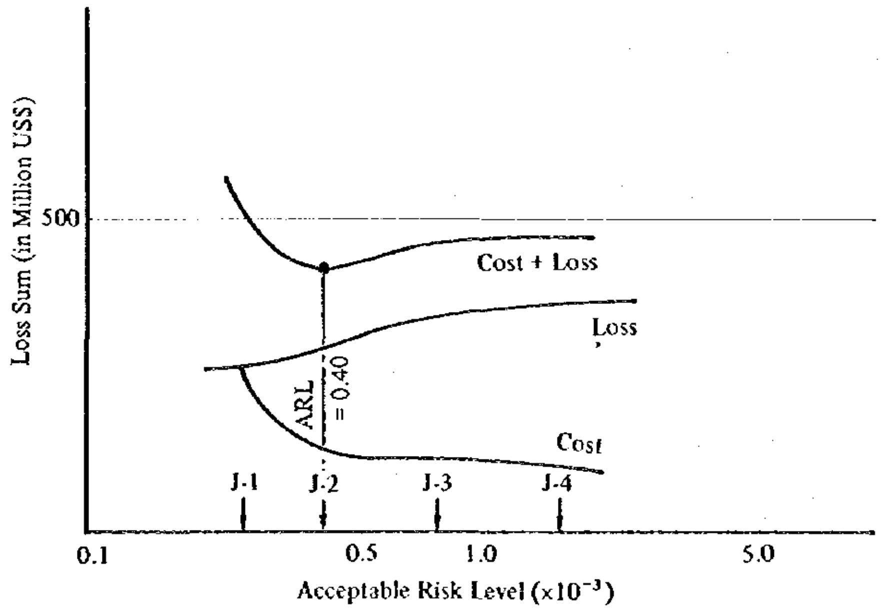


Fig. VII-5 Relation between Loss Sum and Acceptable Risk Level

(2) Financial State

It is essential to understand that the capacity of the Canal is enough to accommodate the traffic volume in 1990 and even in 2000 without any difficulties. It seems that the 50 day closure assumed in economic evaluation will force an average of about 3,000 vessels not to transit as usual, and in the study, we assume that all the waiting vessels, which arrive at both entrances from the beginning of the closure to 5 days before the reopening of the Canal, would abandon their planned passage of the Suez Canal.

The toll rate for a ship of average size in a convoy mixture is currently about 50 thousand US$. The total volume of transit vessel is estimated as 27,262 in 1990 and 28,273 in 2000 as described before, and consequently the number of transit vessels per day is 74.7 and 77.5 respectively. Table VII-13 shows the results of the calculation of income reduction.

Table VII-13 Estimated Reduction of Losses Per Year

(Unit: Million US$)

Year	Study Case			
	J-1	J-2	J-3	J-4
1990	34.1	25.8	12.4	7.1
2000	36.7	27.8	13.3	7.6

Using the same method as IRR calculation, FRR can be obtained for each alternative and the values are 4.6% of the plan J-1, 9.0% of the plan J-2, and 1.4% of J-3. The FRR of the plan J-4 is negative. These results are shown in Table VII-14 and Fig. VII-6.

From this FRR we conclude that J-2 plan is the most profitable among the four alternatives from a financial viewpoint, and that SCA will lose income from the increased likelihood of Canal closure if none of the alternatives are implemented and the project is not realized.

Table VII-14 Results of FRR Calculation

J-1	J-2	J-3	J-4
4.6%	9.0%	1.4%	–

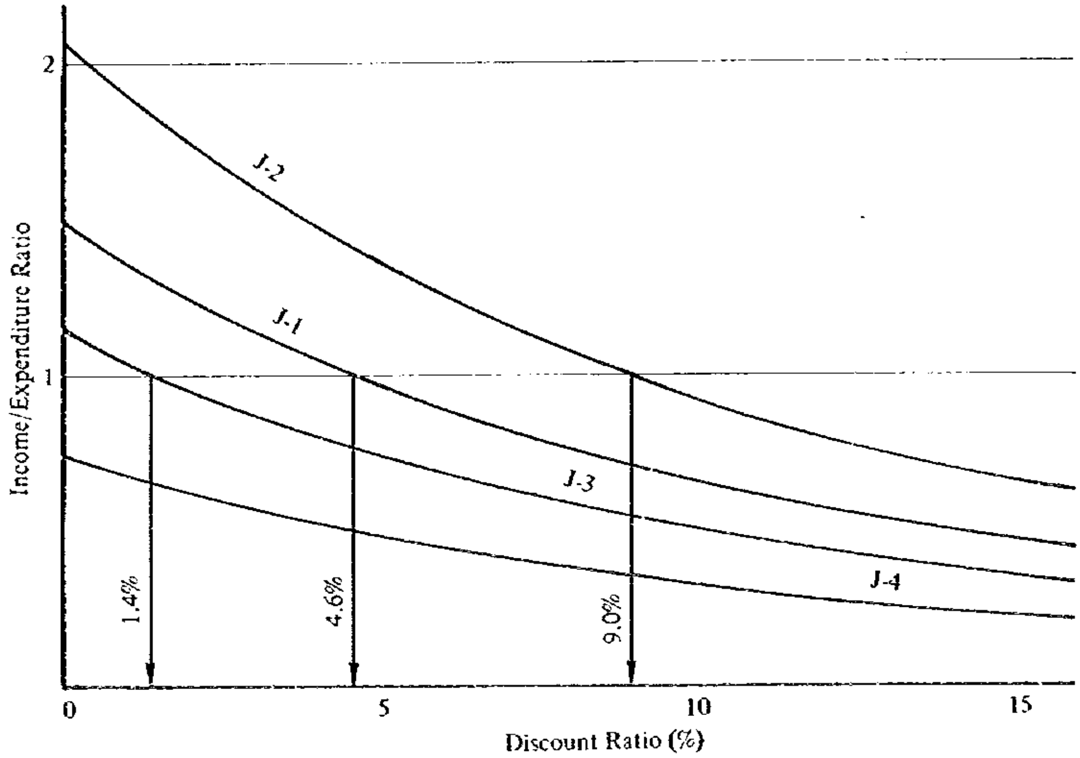
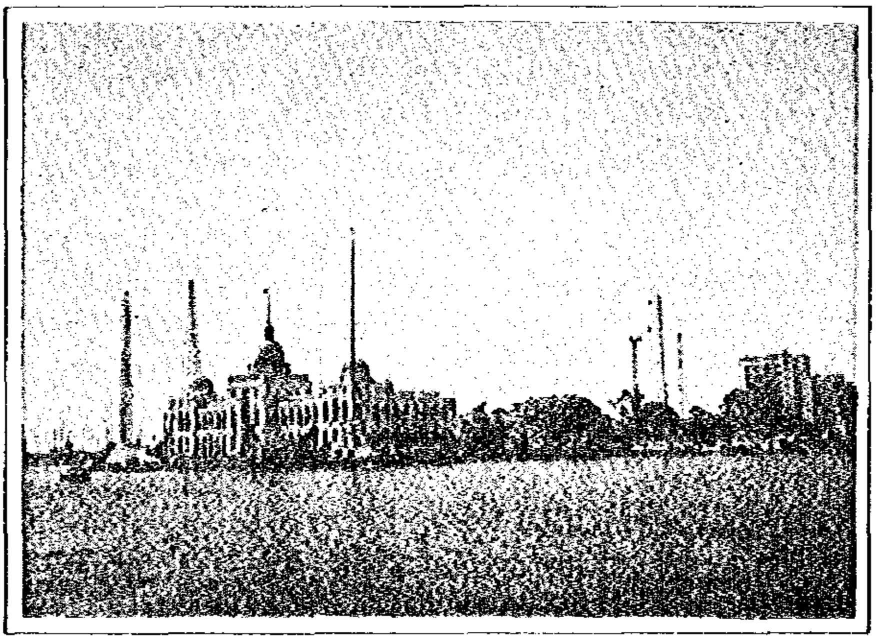


Fig. VII-6 FRR of Alternatives

PART I. INTRODUCTION



Port Said Office of SCA

PART I INTRODUCTION

In response to a request made by the Government of the Arab Republic of Egypt, the Government of Japan conducted a Study on the Safety Improvement of the Suez Canal in the Arab Republic of Egypt (hereinafter referred to as "the Study") in accordance with laws and regulations in force in Japan. The Japan International Cooperation Agency (hereinafter referred to as "JICA"), an official agency responsible for the implementation of the technical cooperation programmes of the Government of Japan, carried out the Study in close cooperation with the authorities concerned of the Government of the Arab Republic of Egypt.

I-1 Background

The Suez Canal located along the Northwestern edge of the Sinai Peninsula is a shortcut route about 160 km long connecting the Mediterranean Sea with the Red Sea.

It plays a vital role as a main international shipping route and also as the backbone of the Egyptian economy.

The sailing of fully loaded 150,000 DWT class ships and 350,000 DWT class ships in ballast has become possible in this Canal by the completion of the First Stage Development Project in December, 1980. Further, the widening and deepening of the Canal have been planned as the Second Stage Development Project.

The Suez Canal employs a convoy system of about 20 ships and the navigation through the Canal is controlled by the Suez Canal Vessel Traffic Management System (SCVTMS).

Due to the increasing rate of transportation through the Suez Canal, especially of large size tankers and gas carriers, a large number of safety and environmental decisions are being, and will continue to be made especially during the second stage construction period when these large tankers will interact with the construction work. The magnitude and severity of the incremental risks are related to the environmental and geographical characteristics of the Canal and its entrances, as well as to the base line description of risks associated with the current operations.

In order to establish countermeasures to accidents, it is first necessary to identify the type, magnitude, and location of possible accidents and hazards, and the potential damage and influence on Canal traffic and on the Canal itself taking into consideration such factors as topography, construction work, navigation aids, navigation control systems, handling operations and management of ships which may cause accidents.

Safety criteria are established by analyzing the interrelations among these factors.

Of course, it is necessary to determine proper techniques to minimize risks and avoid accidents.

Such considerations are required to assure safe world marine transportation, especially within the Suez Canal. This project to establish proper safety measures and reduce the risk of accidents must be initiated promptly.

I-2 Objective of the Study

The objective of this study is to make some suggestions on measures to prevent accidents which are likely to occur at present, during and after the completion of the Second Stage Development Project of the Canal. This study also considers countermeasures to deal with such accidents considering the present situation of the Canal including traffic and environmental conditions, and also taking into account the expected increase in the number of transit vessels, particularly dangerous cargo vessels, and the increased size of such vessels.

The necessary measures could be considered in two stages:

Stage (1):

Short term study including:

- Hazard identification
- Evaluation of the present canal situation, especially fire fighting and anti-pollution measures

Stage (2):

Long term study including:

- Detailed risk analysis
- Risk evaluation and control

I-3 Outline of the Study

In order to achieve the objectives mentioned above, the Study covers the following:

(1) Review of Current Canal Conditions

Existing data and the results of the field surveys conducted by the Study Team are used to review and analyze current Canal conditions in terms of safety. The review covers the following points:

1) Canal topography (width, length, depth and curvature)

2) Natural conditions
   - (i) Meteorological conditions (weather, visibility, wind)
   - (ii) Oceanographical conditions (waves, currents, littoral drift, siltation)

3) Traffic flow
   - (i) Ships (number of ships by type, size, and direction)
   - (ii) Cargo (tonnage by commodity and direction)

4) Traffic and anchorage conditions

(i) Traffic conditions (convoy transit system, distribution of sailing speed, and course position)

(ii) Anchorage conditions at ports and lakes

(iii) Maneuverability of ships in the Canal (speed performance, steering performance, stopping distance, etc.)

5) Current safety measures

(i) Navigation aids

(ii) Canal traffic control and regulations

(iii) Canal maintenance

(iv) Construction work

(v) Resources for responding to emergencies

6) Survey of Canal users

Opinions of captains and pilots regarding safety and ship maneuverability through various points of the Canal.

7) Environment in and around the Canal

(i) Distribution of population and property

(ii) Environment to be protected

(2) Analysis of Accidents which have occurred in the Canal

Records of Canal accidents are analyzed. The nature of the accidents as well as the cause, degree of suffering, measures taken, etc. are studied.

(3) Evaluation of Canal Conditions in Terms of Safety Factors

1) Existing risk levels are identified based on the results of 1 and 2.

2) Canal conditions are evaluated in terms of safety factors, as follows:

(i) Topographical conditions such as width, length, depth and curvature

(ii) Traffic and anchorage conditions

(iii) Navigation aids

(iv) Canal traffic control and regulations

(v) Canal maintenance

(vi) Construction work

(vii) Resources for responding to emergencies especially regarding fire fighting and pollution

(4) Examination of Urgently-needed Countermeasures

1) The basic concept for improving the safety of the Canal is examined.

2) Urgently-needed countermeasures are considered including:

(i) Equipment and an execution team to respond to emergencies

(ii) A preliminary contingency plan

(5) Risk Analysis

First the cases to be studied are decided. Then, through a process of detailed risk analysis, risk levels are estimated for the present time as well as for the periods of time during and after the Second Stage Development Project.

This estimation process includes:

(i) Setting up conditions: future topography of the Canal, traffic flow, Canal traffic control;

(ii) Estimation of the probability of such things as traffic hazards, blockages of the Canal and cargo spillings with attendant hazardous effects;

(iii) Estimation of the rate and amount of cargo spill;

(iv) Estimation of the consequences of cargo spills
(i.e. the spreading of hazardous gases and/or liquids and their influence on the safety of convoys and navigation, human life and the environment); and

(v) Final collation of all estimates to determine future risk levels.

(6) Risk Evaluation

1) The risk acceptance criteria is established based upon comparisons with risk levels for other systems (and their countermeasures), as well as criteria given by the Suez Canal Authority (SCA).

2) The acceptability of the estimated risk levels are evaluated by means of comparisons with the risk acceptance criteria.

3) Events to be controlled are outlined.

(7) Countermeasures for Improving Safety of the Canal

Countermeasures for preventing and dealing with accidents are studied, based on the above study results, for the periods of time at present, during, and after the Second Stage Development Project. Then the evaluation of the countermeasures is carried out.

1) Countermeasures for preventing accidents

(i) Detailed topography study (such things as width, length, depth and curvature) for the Second Stage Development Project

(ii) Work method for the Second Stage Development Project

(iii) Maintenance plan and operation plan for the Canal

(iv) Navigation aids

(v) Traffic control plan

2) Countermeasures for dealing with accidents

(i) Allocation of counter-accident equipment

(ii) A team for responding to accidents

(iii) Contingency plans for combating oil-spills and leaks of hazardous gases

3) Evaluation of countermeasures

I-4 Study Method

(1) Basic Plan of the Study

1) Conceptual flow

The overall flow of this Study is as shown in Fig. I-4-(1)-1.

Study methods for the main items described in Fig. I-4-(1)-1 are dealt with in the next section of this Chapter.

2) Study in Egypt (1983, 1984 and 1985)

Upon arrival in Ismailia, the Inception Report was submitted to the SCA, and discussions were held between the Study Team and the SCA to coordinate the study plan the study schedule.

After this, together with visiting related government offices, etc. for performing interviews and collecting data necessary for this study, a field survey was performed along the entire Suez Canal.

Some members of the Study Team were boarded on vessels transiting the Suez Canal in order to obtain information through the questionnaire for pilots and captains of vessels, and to grasp the actual conditions on the safety of canal transit. Further, observations of tidal current were conducted.

Such field surveys were conducted upon consultation with the government agencies of Egypt and related organs.

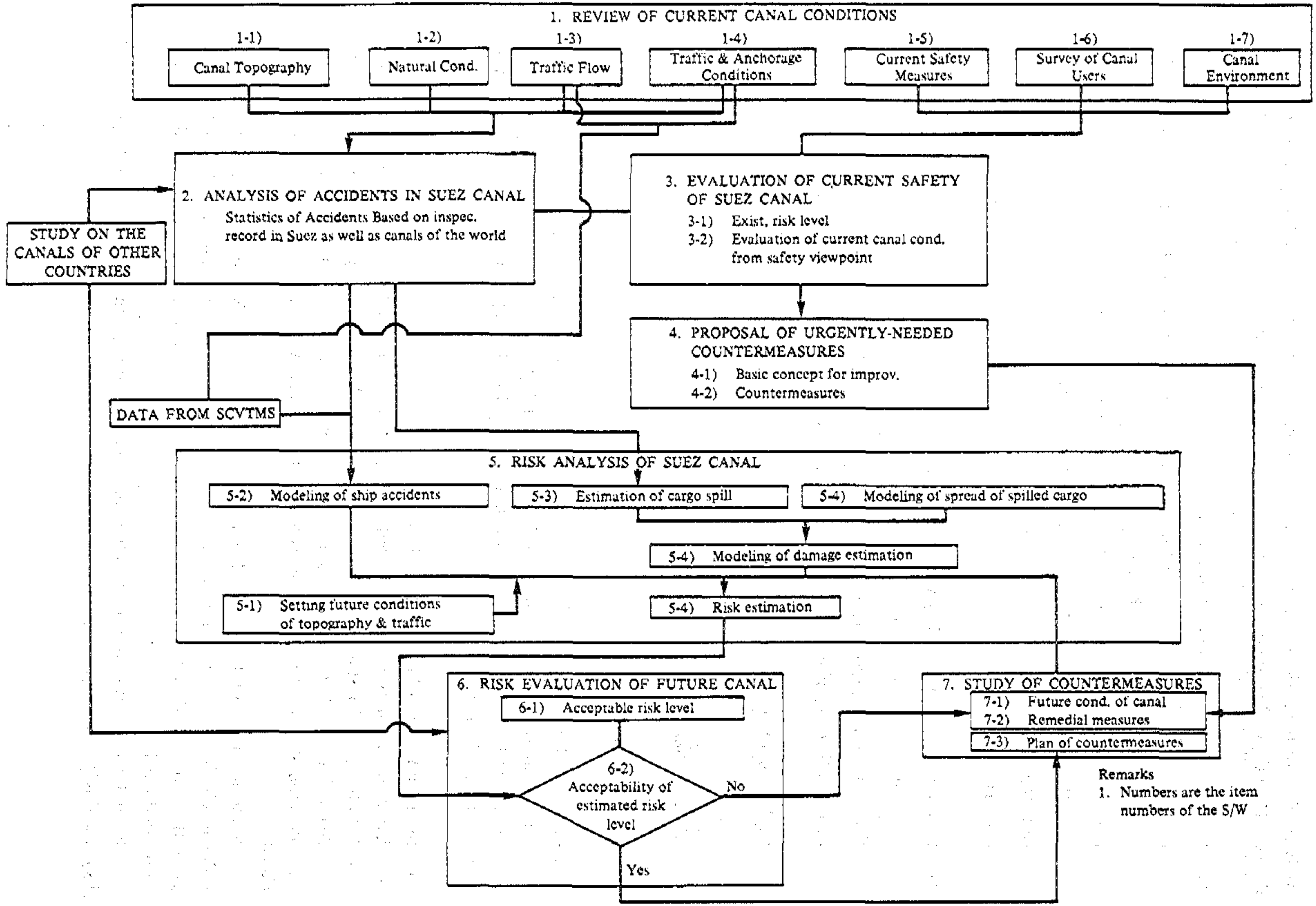


Fig. I-4-(1)-1 The Study Flow for The Safety Improvement of The Suez Canal

3) Analysis conducted in Japan and in Egypt (1983, 1984 and 1985)

The data and information obtained through the field surveys were sorted out and analysed for the purpose of preparing various reports.

(2) Study Method for Main Items

1) Study of current Canal conditions

(i) Canal topography

A survey was conducted on the curvature of the center line of the channel as well as on the cross sections (width and depth) of the Canal at points selected at appropriate intervals along the entire route of the Canal.

Marine charts and up-to-date sounding survey maps (maps upon completion of the First Stage Development Project and upon completion of maintenance dredging) were utilized for the survey.

(ii) Natural conditions

Meteorological conditions:

A survey was conducted on the weather, visibility, and frequency of wind (wind direction and wind speed) which is used as data related to vessel navigation. The findings are illustrated by histograms. In cases where sandstorms affected navigation, their locations, duration, atmospheric pressure, etc. were recorded for each case. For obtaining such data, the observation records of nearby meteorological stations and those at Port Said and Port Suez were utilized.

Oceanographical conditions:

As for tidal current, a study was made to examine the direction and speed of the current in the Canal including the harbours of Port Said and Port Suez based on the analysis of collected data and the findings of the survey which was conducted using a tidal current meter furnished by JICA.

An analysis is also made of the relationship between the tide and tidal current.

As for waves, an analysis is made of the collected data, the results of which are arranged, in terms of the frequency of wave direction and wave height. If there are cases of anomalous waves, the conditions of each case are analyzed. As for littoral drift, annual sounding survey maps are compared to determine the amount of shoaling on the spots where the navigation of vessels is apparently affected by such shoaling. Wind-blown sand and sand moved by ship waves are also investigated.

(iii) Environmental conditions:

A survey was conducted on the population, houses, cultivated fields, factories, and other assets existing along the Canal. The findings of the survey are diagrammed. The data available on the water quality of the Canal are analyzed to find out the degree of pollution.

(iv) Traffic flow

Ships:

Based on an analysis of the SCA's statistical data for the last five years, the number of transit ships are classified by type, size and sailing direction. Dangerous cargo ships such as tankers and LNG carriers are considered separately. A daily record of canal transit is tabulated for the month in which the largest number of transit vessels was recorded over the last five years. The number of convoys on the day when the largest number of transit vessels was recorded, and the type, size and number of ships in the convoy are also considered.

Cargoes:

Based on an analysis of SCA's statistical data for the last five years, the amount of cargoes are classified by item and direction. Dangerous cargoes such as crude oil, oil products and LNG are considered separately.

(v) Traffic and anchorage conditions

Traffic conditions:

A survey was conducted on the actual conditions of Canal transit, i.e. the particulars of vessels (kind and type), distribution of course position in the Canal and ports, deviation from the center line of the channel, and convoy speed, by analysing the data which were recorded by SCVTMS and copies onto magnetic tapes. A study was also made on the time and position of selected vessels.

Some members of the Study Team boarded transiting vessels, both northbound and southbound, to grasp the actual conditions of Canal transit.

Anchorage conditions:

A survey was conducted on the actual conditions (capacity, soil condition, etc.) of anchoring in the harbours of Port Said and Port Suez, and in Lake Timsah and the Bitter Lakes, by analysing radar records, soil data, etc. The findings of the survey are illustrated with figures. The illustrations for dangeous cargo vessels are made separately.

As for vessels mooring at wharves or buoys, their illustrations are made showing the specifications of the mooring facilities (length, water depth, number of berths, etc.) as well.

Waiting conditions:

A survey was conducted on the waiting conditions in the harbours and lakes (at the times of forming convoys and of convoys passing each other) to grasp the most seriously congested situations.

A study was also made on the time interval of vessels' arrival and the temporal distribution of waiting vessels.

Manoeuverability of vessels:

Based on the analyses mentioned above, a study was made on the behaviour of specific vessels (dangerous cargo vessels, VLCC, etc.) when navigating in the Canal.

(vi) Safety measures

Navigation aids:

A survey was conducted on the location and performance (quality and color of light, frequency, etc.) of navigation aids, such as buoys, light buoys, radar reflectors, and Loran and Decca systems, which are installed for assisting transit vessels. Interviews were also conducted with persons concerned with maintenance methods and the number of persons and expenses required for maintenance.

Traffic control:

A survey was conducted on traffic control equipment to collect information on the names, locations, service areas, and other particulars about the control and interconnection of traffic control equipment. The rules, regulations and organizational charts relating to traffic control were also collected.

Counter-accident equipment:

A survey was conducted on fire-fighting ships, oil fences and other materials and equipment for combating accidents to collect information about the nubmer, amount of stock, capacity and range of this type of equipment. Interviews were conducted with the persons concerned about the method of maintenance, number of persons, and expenses required for maintaining this equipment.

Structure for dealing with accidents:

A survey was conducted on the structure for dealing with accidents such as the emergency communication system, system of command, and manning.

(vii) Survey of Canal users

A survey was conducted by means of a questionnaire to pilots and captains of vessels transiting the Canal to gain information as to where they felt danger, what were the types and causes of such danger, and what actions they take in the face of such danger, and also to know about their general precautions for Canal transit (steering, dangerous spots, etc.) and their requests for the maintenance of the Canal. Similar surveys were also conducted in Japan on the captains of Japanese vessels to supplement the above survey.

(vii) Maintenance works

A survey was conducted on maintenance dredging and other maintenance works. The items surveyed were:

i) frequency and place of maintenance, soil volume, work method, cost, method of soil disposal and other specifications of works,

ii) type and number of work vessels, their anchorages, working hours and precautions for the transit vessels. The results of the survey are analysed by comparing them with the requests of Canal users.

2) Analysis of accidents

(i) Analysis of accidents in the Canal

The records of accidents which have taken place in the canal were examined and analyzed. Accidents were evaluated according to the following criteria:

Particulars of the vessel(s):

Type of vessel, kind of cargo, speed of the convoy at the time of the accidents, positions of preceeding and following vessels, and position in the channel.

Type of accident:

Collision, grounding, fire, etc.

Accident location:

Distribution of locations and distribution by type of accident in each section of the canal.

Conditions at the time of the accident:

Condition of equipment, actions taken, combustibles, engine trouble, etc. For collision accidents, the conditions of the object collided with (other vessels, revetments, etc.) are also considered.

Causes of accidents:

The causes are arranged hierarchically (tree diagram) to facilitate conducting risk analysis.

Damage:

Degree of damage to vessels and other facilities.

Spill of dangerous cargo:

Type and amount of spilled cargo and area affected by the spill.

Navigation aids:

Operation condition of navigation aids related to the accident.

Response to accidents:

From the beginning of the accident to the end of the response operation, including the method(s) by which the information about the outbreak of the accident is transmitted and details of the response.

Fire:

Operation and location of fire-fighting vessels and effectiveness of fire-fighting operation.

(ii) Examples of accidents in the Canals of other countries

Field surveys were conducted on accidents in the Kiel Canal and the Essen Canal (West Germany) and in the Eems Canal and Amsterdam Canal (Netherlands).

The results of these surveys are compared and analysed. Analysis is also made of accidents in the Panama Canal based on data available in Japan.

3) Evaluation of the current safety conditions of the Canal

(i) Risk level of the Canal

The acceptability of the risk level in the Canal is determined based on criteria given by SCA and by comparison with the level of risk in similar canals in other countries.

The actual risk level in the Canal is also determined for each type of accident based on the record of Canal accidents.

(ii) Evaluation of current Canal conditions

Canal topography:

Analysis is made of the relationship between the location of accidents and the Canal topography (width, depth and curvature) to clarify the areas which have high probability of accident occurrence.

Natural conditions:

Analysis is made of the relation between the locations of accidents and the natural conditions at the time when the accidents occurred ((1) meteorological conditions – wind, visibility, weather, etc. (2) oceanographical conditions – current, waves, etc.), to determine the degree of influence which natural conditions have on the occurrence of accidents.

Traffic and anchorage conditions:

Synthetic analysis is made of the results of the surveys on traffic and anchorage conditions and the results of the analysis of accidents, to estimate the degree to which the current transit scheme and anchorage conditions influence the occurrence or accidents.

Navigational aids:

Accident records are examined to determine the relation between navigational aids and accident occurrence. The requests of Canal users (obtained through the questionnaire) are also considered in deciding whether or not present navigational aids are sufficient.

Traffic control:

The conditions of traffic control at the times when accidents occur and the results of the questionnaire made to the Canal users are analyzed to determine the effectiveness of the current traffic control system and to list necessary improvement measures.

Accident response:

The records of the measures taken after accidents occurred are analyzed to determine the effectiveness of procedures and equipment (including fire-fighting vessels), and to determine if current equipment is sufficient.

Maintenance works:

Accidents which happened during dredging and other maintenance operations are examined to calculate the relation between maintenance operations and accidents of transiting vessels. If there are cases where work vessels have a direct bearing on accidents, the movement of such vessels are examined individually. Further, the overall safety conditions of maintenance operations are studied.

4) Risk analysis of the Canal

(i) Setting up of premises

The following conditions are all utilized as premises when analyzing risk:

Canal Topography including the present depth and width of the Canal and the projected depth and width during the after the Second Stage Development Project;

Natural Conditions including all major phenomena (tidal currents, etc.) which are estimated to occur most frequently for each section of the Canal;

Environmental Conditions at present and as estimated for the target years 1990 and 2000;

Traffic Flow – the current flow of vessels and cargoes and the estimated traffic flow for the target years; and

Traffic and Anchorage Conditions – those conditions which are assumed to occur most frequently based on the current traffic and anchorage situation and the results of the questionnaire made to Canal users are used for risk analysis.

(ii) Accidents to be considered

All accidents which might reflect or influence present or future safety measures are included in the analysis.

(iii) Probabilistic accident models

Various models are used to predict the probability of Canal accidents considering the various phenomena which may cause accidents. Models include:

ETA Model – a model which calculates accident probability using Fault Tree Analysis;

Track Model – a model which calculates accident probability using track data and Canal topography;

Blocking Model – a model used to calculate the probability of Canal closure due to various types of accidents;

Cargo Spill Model – a model for calculating the probability of cargo spill due to various types of accidents; and

Spilled Cargo Spreading Model – a model to estimate the spread of spilled cargo over time.

(iv) Damage estimation model

A model for calculating various damages due to the Canal accidents and secondary disasters and for measuring the estimated damage in monetary terms.

(v) The accident occurrence probability and extent of damages are calculated by inputing the aforementioned premises into the accident probability and damage estimation models.

(vi) Estimation of risk level

The total risk level is calculated under current conditions, and during and after the Second Stage Development Project.

(vii) Estimation of expected damage value

The expected damage is calculated corresponding to the estimated risk level.

5) Risk evaluation (1984)

(i) Establishment of acceptable risk levels (safety standards)

With reference to the survey results of similar canals in other countries and the intentions of SCA, 4 proposed acceptable risk levels (safety standards) are established. The following evaluations are made based on these 4 proposed risk levels, and the acceptable risk level (safety standard) of the Suez Canal will be finally established based on the analysis results.

(ii) Evaluation of the Canal improvement alternatives

The current risk level, the risk level during the Second Stage Development Project, and the risk level after the completion of the Second Stage Development Project which are obtained by risk analysis are compared with established acceptable risk levels (safety standards), and the type, content and scale of accidents which can be expected to occur for each proposed risk level are estimated.

(iii) Extraction of control factors (critical factors)

For each proposed risk level, the factors which contribute to the risk are extracted and arranged in order, starting with the greatest contributing factors. Contributing causes are separated into those factors which are due to natural conditions and those factors which are man-made, that is those factors which can be controlled artificially.

(iv) Cost estimate for each proposed risk level

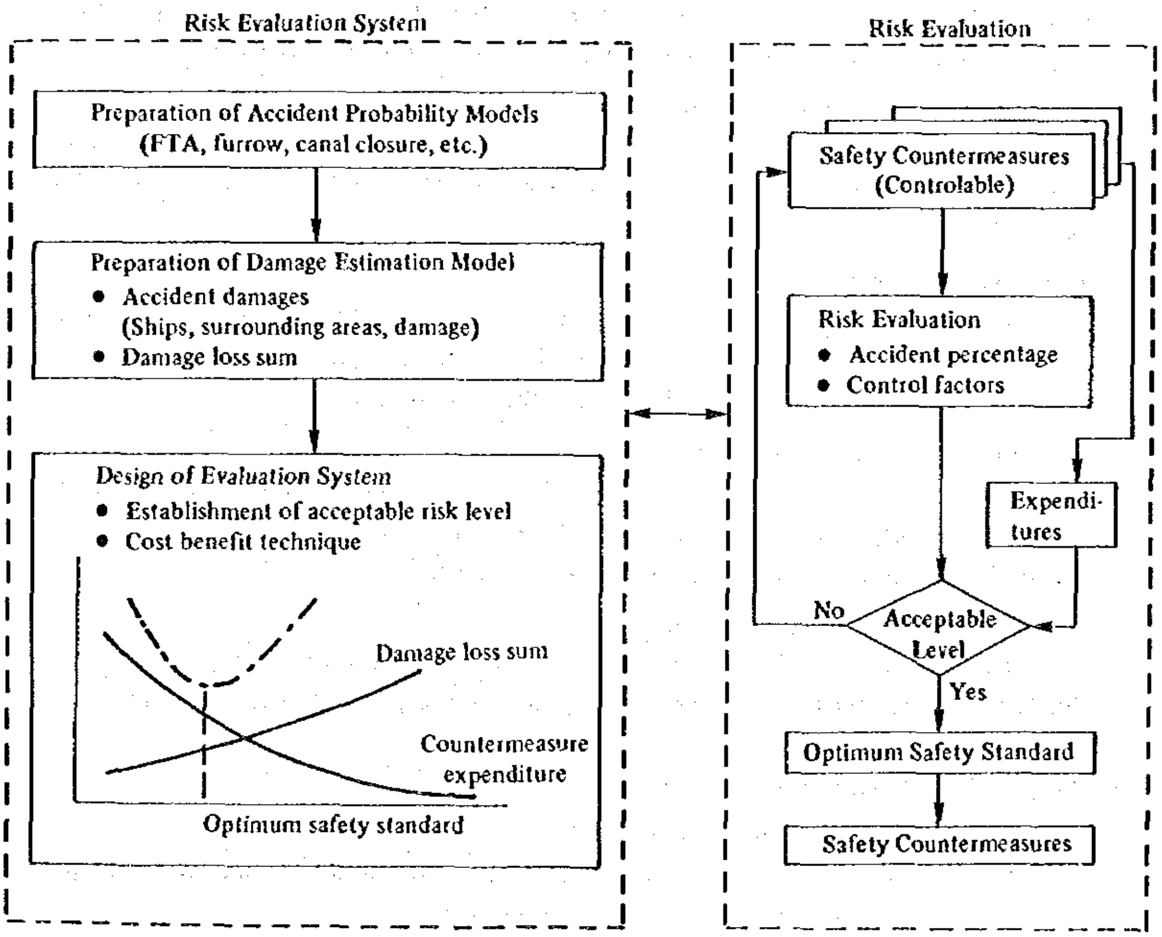
Considering the man-made factors which contribute to accident risk level, the expenditure necessary to reduce accident risk to each of the proposed risk levels is calculated. A risk level/expenditure curve is presented.

(v) *Estimate of damage for each proposed risk level*

After reducing risk to any of the proposed risk levels, there will still be a certain number of accidents. The estimated damage for each of the proposed levels is calculated in monetary terms.

A risk level/estimated damage curve is also presented.

(Reference) Conception Diagram of Risk Analysis and Risk Evaluation



6) Basic concepts for safety improvement

The basic concepts for improving the safety of the Canal are determined taking into account the characteristics of the Suez Canal as well as the safety measures taken at similar canals in other countries. Basic concepts are established for both categories of safety measures, i.e. urgently-needed measures and permanent measures.

7) Urgently-needed countermeasures

(i) Present measures

The present safety measures of the Canal are examined based on the evaluation of Canal safety to specify the points which need improvement. These points are classified considering the type of accidents to be eliminated, universality of the measures, amount of necessary expenses, and effectiveness.

(ii) Risk analysis

Scenarios are written to determine the effectiveness of each of the safety measures which is considered to be urgently-needed. Each scenario consists of considering the conditions and causes of hypothetical accidents and the effectiveness of the proposed measures in preventing such accidents. Risk analysis is conducted for each scenario.

(iii) Selection of urgently-needed countermeasures

Based on the risk analysis, urgently-needed countermeasures which are in line with the basic concept and are considered necessary for attaining the acceptable risk level are selected.

(iv) Execution plan

A plan is proposed listing the urgent measures including improvement of the Canal, navigation aids, a team to respond to hazards, traffic control, and accident response equipment including a proposed time schedule for these improvements.

(v) Rough economic evaluation

The cost-benefit ratio of the proposed measures is made considering the price of implementing safety measures as the cost, and the decrease of loss which will be brought about by implementing the proposed measures as the benefit.

(vi) Preliminary contingency plan

This contingency plan considers the most typical and most serious accidents which are likely to occur in the Canal and proposes appropriate responses to such accidents.

8) Proposed permanent navigation safety measures

(i) Preparation of accident prevention plan

On the basis of the results of risk evaluation, the following improvement plans are proposed to help prevent accidents in the Suez Canal.

Canal plan:

As for the shape of the Canal (width, depth, curvature, slope of revetments, etc.), improvements are proposed considering the proposals put forward in the Second Stage Development Project.

Construction plan:

As for the method of executing maintenance works and improving and expanding the Canal, concrete execution plans are prepared considering the proposed specifications of the Second Stage Development Project.

Navigation aids plan:

The number, type and location of the navigation aids (including vessels) which should be newly installed or improved are proposed.

Traffic control plan:

The plan includes comments on the existing traffic control system and proposals on the new system and relevant regulations.

Maintenance plan:

The plan proposes methods for maintaining the Canal, navigation aids, a traffic control system and other facilities.

(ii) Plans for dealing with accidents

On the basis of the results of risk evaluation, (range of impact, degree of impact, etc. as estimated by the impact estimation model), the following improvement plans are proposed as measures for quickly dealing with accidents which occur in the Canal.

Plan for allocation of counter-accident equipment:

The allocation plan is prepared with respect to the equipment needed for combating accidents. It will provide for the kind and amount (or number) of necessary equipment (including vessels), their deployment and movement.

Plan for the teams for dealing with accidents:

This plan provide for the number of team members, communication systems, training, education, and stationing of the teams.

Plans for combating the release of dangerous cargo:

Simulations are conducted for each of the proposed plans for combating the spill of oil or release of other dangerous cargoes.

(iii) Economic evaluation of safety improvement measures

Economic evaluation is made on each the proposed plans for preventing accidents and of the plans for dealing with accidents to analyse their cost (cost needed for the implementation of the plan) and bendfit (lowering of risk level and decrease in the anticipated damages).

(iv) Proposed safety improvement measures

On the basis of the results of the above-mentioned studies, various measures are proposed to improve the safety of the Suez Canal.

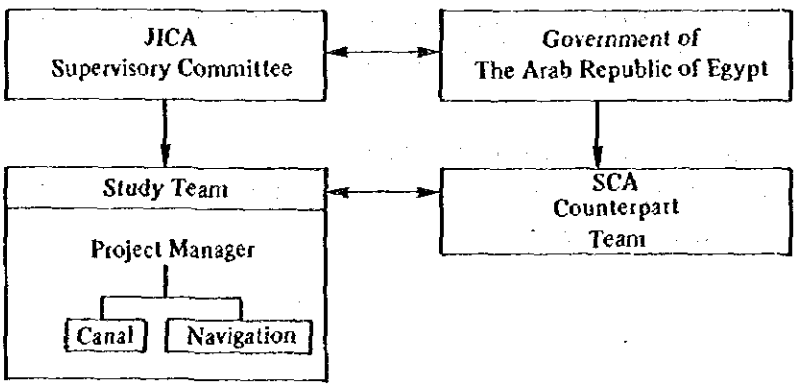
I-5 Organization

(1) Advisory Committee

For the successful implementation of the Study, a advisory committee has been set up by JICA as an advisory body to the Study Team. The committee provides the Study Team with advice, suggestions, and assistance by examining and guiding the plans prepared by the Study Team.

The members and organization of the Advisory Committee are as follows:

Name	Assignment	Present Post
Prof. Dr. Yoshimi Nagao	Chairman	Kyoto University
Assist. Prof. Dr. Katsuhiko Kuroda	Risk Analysis	Kyoto University
Assist. Prof. Dr. Kinzo Inoue	Navigation	Kobe Merchant Marine University
Mr. Hisao Ouchi	Canal Planning	Deputy Director of Construction Division, Ports and Harbours Bureau, MOT
Mr. Ryuichi Takei (Mr. Kunio Tashima)	Disaster Prevention	Deputy Director of Navigation Safety Division, Guard and Rescue Department, Maritime Safety Agency, MOT
Mr. Masao Wada	Ship Safety Planning	Chief of International Cooperation Division, Bureau of International Transport and Tourism, MOT
Mr. Tokuji Ohara	Marine Economy	Chief of Overseas Division, Bureau of International Transport and Tourism, MOT



(2) Japanese Study Team

The Japan International Cooperation Agency (JICA) consigned the Study to the Joint Venture, which consists of the Overseas Coastal Area Devlelopment Institute of Japan (OCDI) and the Japan Association for Preventing Marine Accidents (JAPMA), for the Study on the Safety Improvement of the Suez Canal.

This study is made jointly by the two parties and the study team is made up of 13 professionals.

Their names, titles, and responsibilities are listed here.

Title	Name	Responsibility
Project Manager	Mr. Takashi Hazama	Overall Management
Deputy Manager	Capt. Koichi Kuwazaki	Canal Planning (I)
Expert	Mr. Yasuyuki Nakayama	Canal Planning (II) and Economic Evaluation
Expert	Capt. Masaaki Saito	Navigation Safety Plan (I)
Expert	Mr. Masaharu Sugawara	Navigation Safety Plan (II)
Expert	Mr. Akira Takahashi	Marine Economy
Expert	Mr. Kimito Suzuki	Disaster Prevention (I)
Expert	Mr. Kanji Fujioka (Mr. Yoshiro Kanetomo)	Disaster Prevention(II)
Expert	Mr. Tetsuo Yoshida	Risk Analysis (I)
Expert	Mr. Yasunori Shibahara	Risk Analysis (II)
Expert	Mr. Taro Ochiai	Risk Analysis (III)
Expert	Mr. Tadayuki Yokoyama	Execution Conditions
Expert	Mr. Yukio Koga	Natural Conditions

(3) Counterparts

SCA provides the Study Team with counterparts for the entire duration of work in Egypt. They consist of officers in charge of the following fields:

Canal Planning
Safe Navigation
Maneuverability
Marine Economy
Disaster Treatment
Risk Analysis
Environment
Economic Evaluation

SCA Team

Capt. Aman Allah Mohy Eldin,
Chief Pilot,
Transit Dept.
"Maneuverability -- Disaster treatment"

Dr. Eng. Mohamed S/El Ghamry,
Deputy Head Research Section,
Planning, Research and Project Dept.
"Environment – Canal Planning"

Dr. Eng. Mahmoud E. Shukry,
Deputy Head Research Section,
Planning, Research and Project Dept.
"Navigation Modeling"

Mr. Reda Negm,
Economic Unit,
Planning, Research and Project Dept.
"Economic Evaluation"

Eng. Medhat El Magrabi,
Economic Unit,
Planning, Research and Project Dept.
"Marine Economy"

Eng. Maged Abou Zead,
Salvage Section,
Shipyard Dept.
"Disaster Treatment"

Eng. Mostafa
Marine Engineer,
Transit Dept.
"Safe Navigation"

Eng. Hussein Kamel,
Research Section,
Planning, Research and Project Dept.
"Environmental Modeling"

Mr. Rizk
Economic Unit,
Planning, Research and Project Dept.
"Risk Analysis"

Eng. Yaser,
Research Section,
Planning, Research and Project Dept.
"Navigation Modeling"

The SCA team is headed by Capt. Aman Allah and the Vice coordinator is Dr. Eng Mohamed S/El Ghamry

I-6 Survey Schedules

(1)	First Survey	August ~ October, 1983
(2)	Second Survey	December, 1983
(3)	Third Survey	March, 1984
(4)	Fourth Survey	October ~ November, 1984
(5)	Draft Final Report	May, 1985

(1) First Survey (August ~ October, 1983)

Members:	Dr. K. Kuroda	(Vice Chairman of the Advisory Committee)
	T. Ohara	(Member of the Advisory Committee)
	S. Naruse	(JICA)
	T. Hazama	(Leader of the Study Team, OCDI)
	K. Kuwasaki	(Co-Leader of the Study Team, OCDI)
	Y. Nakayama	(Member of the Study Team, OCDI)
	M. Saito	(Member of the Study Team, JAPMA)
	M. Sugawara	(Member of the Study Team, JAPMA)
	A. Takahashi	(Member of the Study Team, OCDI)
	K. Suzuki	(Member of the Study Team, JAPMA)
	T. Yoshida	(Member of the Study Team, JAPMA)
	Y. Shibahara	(Member of the Study Team, JAPMA)
	T. Yokoyama	(Member of the Study Team, OCDI)
	Y. Koga	(Member of the Study Team, OCDI)

Date	Itinerary	Activities
Aug. 15 Mon.	Tokyo	
16 Tue.	→ Athens → Cairo	
17 Wed.	Cairo	Courtesy call and explanation of the outline of the study to the Japanese Embassy and JICA
18 Thu.	Cairo → Ismailia	Call at the SCA Research Center
19 Fri.	Ismailia	Team meeting
20 Sat.		Courtesy call to SCA and explanation of the Inception Report
21 Sun.		Discussion of the schedule with the SCA counterparts
22 Mon.		Data collection in SCA
23 Tue.		Discussion on the sphere of the study with the SCA counterparts, observation of SCVTMS and exchange of signatures on R/D
24 Wed.		Data collection
25 Thu.		Data collection
26 Fri.		Team meeting
27 Sat.	Ismailia → Port Said	Observation of the Canal and Port Said Harbour (by car and boat)
28 Sun.	(Group 1) Port Said → Ismailia	Observation of Ballah signal station on the way to Ismailia
	(Group 2) Port Said → Suez	Experimental navigation by a container ship (SCANDUTCH CORONA)

Date	Itinerary	Activities
Aug. 29 Mon.	(Group 1) Ismailia → Suez	Observation of Suez Harbour by boat
30 Tue.	Suez → Ismailia	Observation of Kabrit signal station on the way to Ismailia
31 Wed.	Ismailia	Data collection and analysis
Sep. 1 Thu.	Ismailia	Data collection and analysis
2 Fri.		Holiday
3 Sat.		Data collection and analysis
4 Sun.		Data collection and analysis
5 Mon.	(Group 1) Ismailia	Data collection and analysis
	(Group 2) Ismailia → Suez → Ismailia	Move to Suez for experimental navigation in the Canal, but return to Ismailia as there was no appropriate vessel
6 Tue.	(Group 1) Ismailia	Data collection and analysis
	(Group 2) Ismailia → Suez	Move to Suez for experimental navigation
7 Wed. 7 Wed.	(Group 1) Ismailia	Data collection and analysis
	(Group 2) Suez → Port Said → Ismailia	Experimental navigation by a container ship (KAMAKURA MARU) and return to Ismailia (by car)
8 Thu.	Ismailia	Data collection and analysis
9 Fri.		Observation of Lake Timsah by boat and team meeting
10 Sat.		Data collection and analysis, and lecture on Risk Analysis
11 Sun.		Data collection and analysis, and lecture on Risk Analysis
12 Mon.		Data collection and analysis
13 Tue.		Data collection and analysis
14 Wed.		Data collection and analysis 4 members: Cairo →
15 Thu.		→ Tokyo
16 Fri.		Holiday
17 Sat.		Data collection and analysis
18 Sun.		Data collection and analysis
19 Mon.		Data collection and analysis
20 Tue.		Data collection and analysis
21 Wed.		Data collection and analysis
22 Thu.		Data collection and analysis
23 Fri.		Team meeting
24 Sat.		Data collection and preparation of the Progress Report

Date	Itinerary	Activities
Sep. 25 Sun.		Preparation of the Progress Report, and lecture on Disaster Prevention
26 Mon.		Preparation of the Progress Report, and data collection and analysis
27 Tue.		Preparation of the Progress Report, and data collection and analysis
28 Wed.		Preparation of the Progress Report, and data collection and analysis
29 Thu.		Preparation of the Progress Report, and data collection and analysis
30 Fri.		Preparation of the Progress Report
Oct. 1 Sat.	Ismailia	Preparation of the Progress Report, and data collection and analysis
2 Sun.		Preparation of the Progress Report, and data collection and analysis
3 Mon.		Preparation of the Progress Report, and data collection and analysis
4 Tue.		Preparation of the Progress Report, and data collection and analysis
5 Wed.		Preparation of the Progress Report, and data collection and analysis
6 Thu.	Ismailia → Damietta → Ismailia	Observation of Damietta Port construction site
7 Fri.	Ismailia	Preparation of the Progress Report, and data collection and analysis
8 Sat.		Preparation of the Progress Report, and data collection and analysis
9 Sun.		Preparation of the Progress Report, and data collection and analysis
10 Mon.		Preparation of the Progress Report and lecture on the contents of this study
11 Tue.		Submission and explanation of the Progress Report and exchange of signatures on R/D
12 Wed.	Ismailia → Cairo	Courtesy call and report to the Japanese Embassy and JICA
13 Thu.	Cairo → Athens	
14 Fri.	→ Tokyo	

(2) Second Survey (December, 1983)

Members:	Dr. K. Inoue	(Member of the Advisory Committee)
	H. Ouchi	(Member of the Advisory Committee)
	R. Takei	(Member of the Advisory Committee)
	S. Naruse	(JICA)
	K. Kuwasaki	(Co-Leader of the Study Team, OCDI)
	Y. Nakayama	(Member of the Study Team, OCDI)
	M. Saito	(Member of the Study Team, JAPMA)
	K. Suzuki	(Member of the Study Team, JAPMA)
	T. Yoshida	(Member of the Study Team, JAPMA)
	Y. Koga	(Member of the Study Team, OCDI)

Date	Itinerary	Activities
Dec. 6 Tue.	Tokyo →	
7 Wed.	→ Cairo	
8 Thu.	Cairo → Ismailia	Courtesy call and explanation on the Interim Repor [I] to the Japanese Embassy and JICA
9 Fri.	Ismailia	Team meeting
10 Sat.	Ismailia	Submission and explanation of the Interim Report [I] to SCA
11 Sun.		Explanation of the Interim Report [I] and discussion with the SCA counterparts
12 Mon.		Explanation of the Interim Report [I] and discussion with the SCA counterparts
13 Tue.		Discussion with the SCA counterparts on the Interim Report [I]
14 Wed.		Discussion with the SCA counterparts and preparation of R/D
15 Thu.		General discussion on the Interim Report [I] and exchange of signatures on R/D
16 Fri.	Ismailia → Cairo	Move to Cairo
17 Sat.	Cairo	Courtesy call and report to the Japanese Embassy and JICA
	(Group 1)	
18 Sun.	Cairo → Hamburg	Discussion on the schedule with the consul of the Japanese Consulate and data collection
	(Group 2) Cairo → Amsterdam	Discussion on the schedule with the secretary of the Japanese Embassy
	(Group 3) Cairo →	
19 Mon.	→ Tokyo	

Date	Itinerary	Activities
Dec. 19 Mon.	(Group 1) Hamburg	Call at Traffic Control Office of Kiel Canal, data collec collection and observation of the Canal
	(Group 2) Amsterdam	Call at Rotterdam Port Authority and observation of Rotterdam Port and Maas River
20 Tue.	(Group 1) Hamburg	Observation of Kiel Canal by boat and discussion
	(Group 2) Amsterdam	Observation of Amsterdam Port and Noordzee Canal
21 Wed.	(Group 1) Hamburg	Call at Hamburg Port Authority, data collection and observation of radar station
	(Group 2) Amsterdam → Groningen	Investigation of Amsterdam Port and Noordzee Canal, and move to Groningen
22 Thu.	(Group 1) Hamburg → Dusseldorf	Observation of traffic vessels in the Rhine River
	(Group 2) Groningen	Investigation and observation of Delfzijl Port, Eems Port and Eems Canal
23 Fri.	(Group 1) Dusseldorf	Call at Essen Canal Authority, data collection and of the Canal by boat, and discussion
	(Group 2) Groningen → Amsterdam	Data analysis and move to Amsterdam
24 Sat.	Dusseldorf → (Group 2) Amsterdam →	
25 Sun.	→ Tokyo	

(3) Third Survey (March, 1984)

Members:	Dr. Y. Nagao	(Chairman of the Advisory Committee)
	M. Wada	(Member of the Advisory Committee)
	S. Kohiyama	(JICA)
	T. Hazama	(Leader of the Study Team, OCDI)
	Y. Nakayama	(Member of the Study Team, OCDI)
	M. Saito	(Member of the Study Team, JAPMA)
	K. Suzuki	(Member of the Study Team, JAPMA)
	T. Yoshida	(Member of the Study Team, JAPMA)

Date	Itinerary	Activities
Mar. 9 Fri.	Tokyo →	
10 Sat.	→ Cairo	Courtesy call and explanation on the Interim Report [II] to the Japanese Embassy and JICA
11 Sun.	Cairo → Ismailia	Discussion on the schedule with the SCA counterparts
12 Mon.	Ismailia	Explanation of the Interim Report [II] (plenary session) and data collection
13 Tue.		Explanation of the Interim Report [II] (plenary session) and data collection
14 Wed.		Discussion with the SCA counterparts by field on the Interim Report [II], and data collection
15 Thu.		Discussion with the SCA counterparts by field on the Interim Report [II], and data collection
16 Fri.		Team meeting
17 Sat.		Discussion with the SCA counterparts by field
18 Sun.		Discussion with the SCA counterparts by field
19 Mon.		Preparation of R/D and data collection, and general discussion on the Interim Report [II] including the chairman and Director of SCA
20 Tue.	Ismailia → Cairo	Exchange of signatures on R/D
21 Wed.	Cairo	Courtesy call and report to the Japanese Embassy and JICA
22 Thu.	Cairo → Athens →	
23 Fri.	→ Tokyo	

(4) Fourth Survey (October ~ November, 1984)

Members:	Dr. K. Inoue	(Member of the Advisory Committee)
	H. Ouchi	(Member of the Advisory Committee)
	K. Tashima	(Member of the Advisory Committee)
	T. Hazama	(Leader of the Study Team, OCDI)
	Y. Nakayama	(Member of the Study Team, OCDI)
	M. Saito	(Member of the Study Team, JAPMA)
	K. Suzuki	(Member of the Study Team, JAPMA)
	T. Yoshida	(Member of the Study Team, JAPMA)
	T. Yokoyama	(Member of the Study Team, OCDI)
	Y. Koga	(Member of the Study Team, OCDI)

Date	Itinerary	Activities
Oct. 2 Tue.	Tokyo →	
3 Wed.	→ Cairo	Courtesy call and explanation on the Interim Report [III] to the Japanese Embassy and JICA
4 Thu.	Cairo → Ishmailia	Submission of the Interim Report [III] to SCA
5 Fri.	Ismailia	Team meeting
6 Sat.		Team meeting
7 Sun.		Explanation on the Interim Report [III] to the Director and the counterparts of SCA (plenary session)
8 Mon.		Discussion on the Interim Report [III] by field, and arrangement of the schedule of the field survey of the Canal
9 Tue.		Discussion on the Interim Report [III] by field, and field survey of the Canal (Km 50 ~ 53)
10 Wed.		Discussion on the Interim Report [III], and field survey of the Canal (Km 50 ~ 53) and lecture on the survey method of this project to SCA counterparts
11 Thu.		Preparation of draft of R/D with the SCA counterparts and field survey of the Canal (Km 145 ~ 148)
12 Fri.		Team meeting
13 Sat.		Arrangement of draft of R/D, exchange of signatures on R/D, and field survey of the Canal (Km 16 ~ 19)
14 Sun.		Field survey of the Canal (Km 16 ~ 19) and video photographing of Great Bitter Lake anchorage
15 Mon.		Field survey of the Canal (Km 145 ~ 148) and video photographing of Great Bitter Lake anchorage
16 Tue.		Field survey of the Canal (Km 93 ~ 96) and video photographing of Great Bitter Lake anchorage
17 Wed.		Field survey of the Canal (Km 118 ~ 121) and video photographing of Port Said anchorage

Date	Itinerary	Activities
Oct. 18 Thu.		Report to the Japanese Embassy and JICA, field survey of the Canal (Km 93 ~ 96), and video photographing of Port Said anchorage
19 Fri.		Video photographing of Port Said anchorage
20 Sat.		Discussion with a counterpart in charge of SCVTMS, fie field survey of the Canal (Km 59 ~ 62), and video photographing of Port Said anchorage
21 Sun.		Discussion with members of the Economic Unit, field survey of the Canal (Km 59 ~ 62), and video photographing of Port Said anchorage
22 Mon.		Field survey of the Canal by CORTs (Km 59 ~ 62) and video photographing of Port Said anchorage
23 Tue.		Discussion with a counterpart in charge of SCVTMS
24 Wed.		Field survey of the Canal by CORTs (Km 145 ~ 148) and video photographing of Great Bitter Lake anchorage
25 Thu.		Field survey of the Canal by CORTs (Km 118 ~ 121) and video photographing of Great Bitter Laka anchorage
26 Fri.		Field survey of the Canal by CORTs (Km 16 ~ 19) and video photographing of Great Bitter Lake anchorage
27 Sat.		Field survey of the Canal by CORTs (Km 93 ~ 96) and video photographing of Great Bitter Lake anchorage
28 Sun.		Experimental navigation by a container ship (Ismailia → Port Said) and video photographing of Great Bitter Lake anchorage
29 Mon.	Ismailia → Cairo	Video photographing of Great Bitter Lake anchorage, arrangement of SCA's comments, and exchange of signatures
30 Tue.	Cairo	Courtesy call and report to the Japanese Embassy and JI JICA
31 Wed.	Cairo	
Nov. 1 Thu.	→ Tokyo	

(5) Draft Final Report (May, 1985)

Members:	Dr. K. Kuroda	(Vice Chairman of the Advisory Committee)
	K. Suzuki	(Japanese Government)
	J. Kugimiya	(JICA)
	T. Hazama	(Leader of the Study Team, OCDI)
	Y. Nakayama	(Member of the Study Team, OCDI)
	M. Saito	(Member of the Study Team, JAPMA)
	T. Yoshida	(Member of the Study Team, JAPMA)
	T. Yokoyama	(Member of the Study Team, OCDI)

Date	Itinerary	Activities
May 12 Sun.	Tokyo →	
13 Mon.	→ Athens → Cairo	
14 Tue.	Cairo → Ismailia	Courtesy call and explanation on the Draft Final Report to the Japanese Embassy and JICA
15 Wed.	Ismailia	Courtesy call to SCA and explanation on the Draft Final Report (plenary session)
16 Thu.		Discussion on the Draft Final Report by field
17 Fri.		Team meeting
18 Sat.		Discussion on the Draft Final Report by field
19 Sun.		Discussion on the Draft Final Report by field
20 Mon.		General discussion and preparation of R/D
21 Tue.	Ismailia → Cairo	Exchange of signatures on R/D
22 Wed.	Cairo	Courtesy call and report to the Japanese Embassy and JICA
23 Thu.	Cairo → Athens →	
24	→ Tokyo	