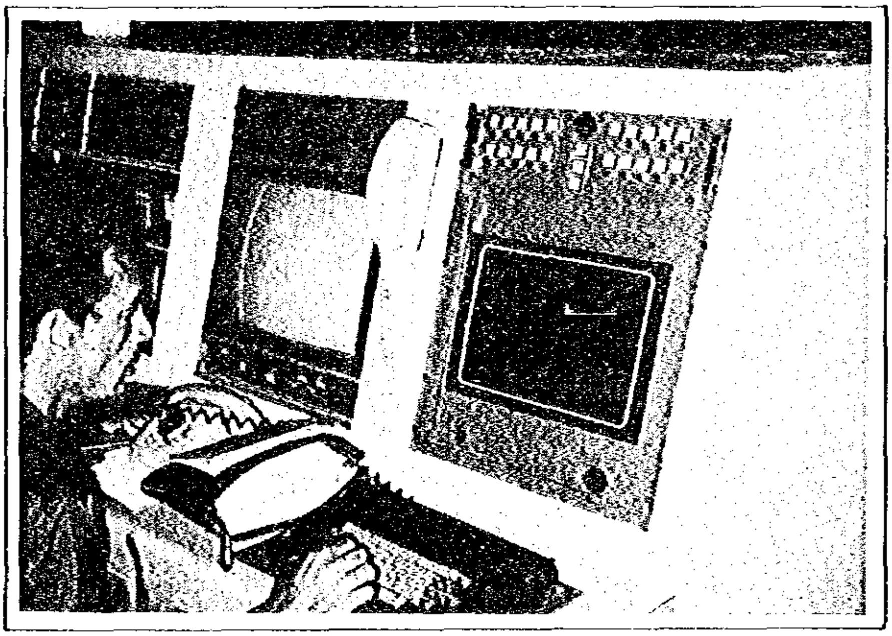
PART VI. RISK EVALUATION



SCVTMS

PART VI RISK EVALUATION

VI-1 Acceptable Risk Level

This study considers four acceptable risk levels to evaluate safety improvement. One is the level which is based on the SCA's criterion, and the others are based on the average risk levels among other canals in the world.

In this study, acceptable risk level is defined as the standard level by which actual levels are judged, whether safe or not. Those locations with risk levels over the acceptable risk level should be improved to reduce risk. In other words, the acceptable risk level is equal to the highest risk level of all locations after the improvement.

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

The risk level set here is based on the SCA's criterion, while some adjustment has been made with respect to types of accidents.

The accident types this study analyzes are groundings, collisions between vessels and collisions between vessels and dredgers during the construction of the Second Stage Development Project.

Therefore the risk levels have to be considered for each of the studied accident types.

In this study, risk level is defined as the probability that a vessel grounds, collides with another vessel, or collides with a dredger. The number of these type of accidents in '81 ~ '82 is shown in Table V-1-(1)-1.

Table VI-1-(1)-1 Number of Accidents by Location (1981 ~ 1982)*

Location	Groundings	Collisions****		Navigation Distance
		(A)**	(B)***	
Port-Said and Suez (approach channel and harbour)	20			8 Km
El-Ballah Bypass	7			9 Km
Other Parts of the Canal	66		1	162 Km
Bitter Lakes		4		—

* The total number of trasnits in '81 and '82 was 44,122

** Forward or side collision

*** Rear-end collision

**** Collisions in harbour areas are omitted.

As for the acceptable risk levels, 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-(1)-2 multiplying these reduction ratios by the present risk levels.

Table VI-1-(1)-2 Acceptable Risk Levels by SCA

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

The present and future risk levels in the Canal are also compared with the risk levels in other channels in the world. First an average risk level of selected channels is calculated. Then, based on this average and incomparison with the levels proposed by SCA, the basic 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 calculating this basic risk level are:

A: Same as in European Canals (Kiel Canal);

B: Same as in the Uraga Channel (Japan); and

C: Level decreased by the First Stage Development Project

As is shown in Table VI-1-(2)-1, the risk level in European canals is about the same as in the Canal, and the level in Uraga is much lower by 1/50. The decreasing risk ratio by the first expansion was about 40%.

Table VI-1-(2)-1 Risk Levels of Other Canals

Canals \ Risk	Number of Transits	Number of Accidents	Canal Length (Km)	Risk Level
Kiel Canal (1982)	64,782	265	99	0.41×10^{-4}
Uraga Traffic Route	269,735	4	16	0.92×10^{-6}
Suez Canal	22,545	174	162	0.47×10^{-4}

Considering the risk levels in other channels as well as the levels proposed by SCA, 40% of the present risk level is accepted as the basic criterion for this analysis. This criterion is called J-3. For comparison, alternative criteria equal to one-half J-3 and twice J-3 are also considered. These are J-2 = 20% and J-4 = 80%. By multiplying these ratios, the risk levels shown in Table VI-1-(2)-2 are obtained. Hereinafter, the acceptable risk level proposed by SCA is called J-1.

Table VI-1-(2)-2 Acceptable Risk Levels Based on Other Channels

Location \ Criterion	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

(1) Comparison with Acceptable Risk Levels

Fig. VI-2-(1)-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 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%.

J-1, J-2, J-3, and J-4 are all compared in Table VI-2-(1)-1. 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 with 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 Km 129 has to be widened according to all four criteria.

Table VI-2-(1)-1 Comparison of Accetable Risk Levels

	Locations	Risk Level at Phase II	Criterion			
			J-1	J-2	J-3	J-4
1	Km 19 ~ Km 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.

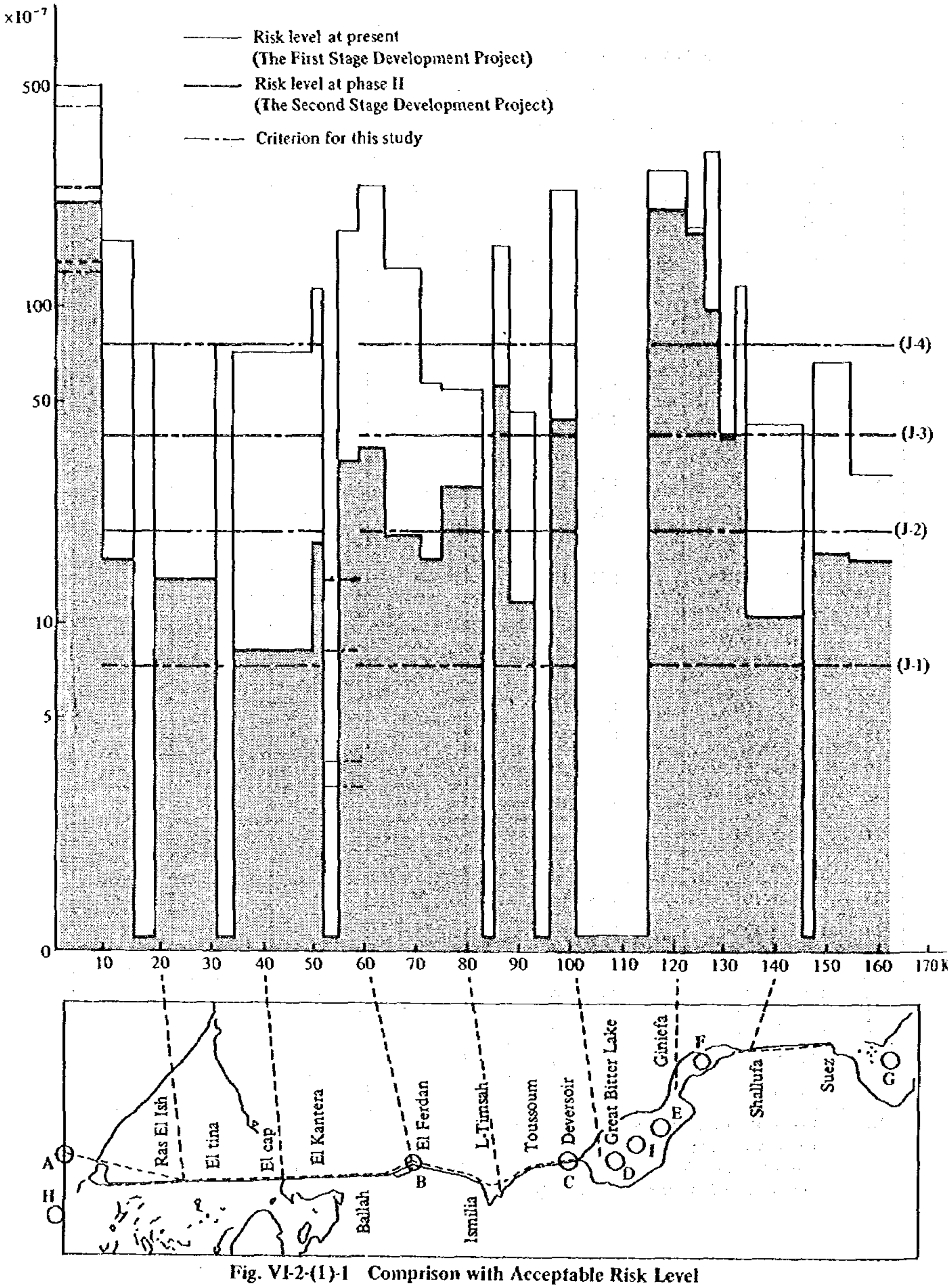


Fig. VI-2-(1)-1 Comprison with Acceptable Risk Level

(2) Extraction of Critical Factors

1) Identification of Critical Factors

By considering the different factors which relate to the occurrence of accidents, the factors which have important effects on the accident rate can be identified.

(i) Channel Width

Table VI-2-(2)-1 and Fig. VI-2-(2)-1 show grounding possibility in straight parts by width category. We see a general tendency that grounding possibility decreases by width. It is empirically noticed that no grounding accidents happened in the divisions where the width is over 190 m.

Table VI-2-(2)-1 Grounding Probability

Width Categories	Number ('81 ~ '82) / Length (Km) / Probability/Km
	Number ('81 ~ '82)
	Length (Km)
	Probability/Km
0m ~ 170 m	24
	60
	9.06×10^{-6}
170m ~ 190 m	5
	16
	7.08×10^{-6}
190m ~	0
	5
	0

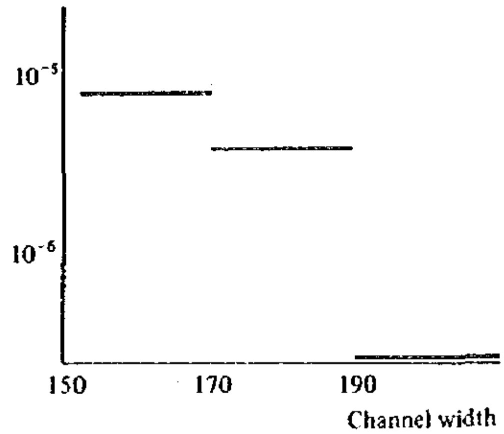


Fig. VI-2-(2)-1 Grounding Probability

(ii) Curvature

In the grounding model, curvature is introduced in the form of the curving angle. Since it is assumed that there is no unusual number of mistakes in navigating along curved areas, the risk element for the curve is only the kick amount which increases the size of the risky zone.

(iii) Winds and Currents

It is also difficult to see how winds and currents actually affect the occurrence of accidents due to the small velocities involved. This is due to monotonous natural conditions at most points.

However, in the division from Km 115 ~ 129, where the channel crosses diagonally with the winds and tidal current, grounding probabilities clearly get higher than in other divisions. Therefore, in this division, these natural conditions are critical for the occurrence of groundings.

(iv) Vessel Speed

If a ship operator increases ship speed, the time delay for starting turns decreases. Then the distance orthogonal to the center line which determines the risky zone also changes. And the grounding probability changes as the probability of necessity of give-way changes.

2) Sensitivity Analysis

Among the above factors

① Width

② Curvature, and

③ Vessel speed

can be controlled.

Fig. VI-2-(2)-2, VI-2-(2)-3, and VI-2- (2)-4 show the safety effect of improvement of the above factors.

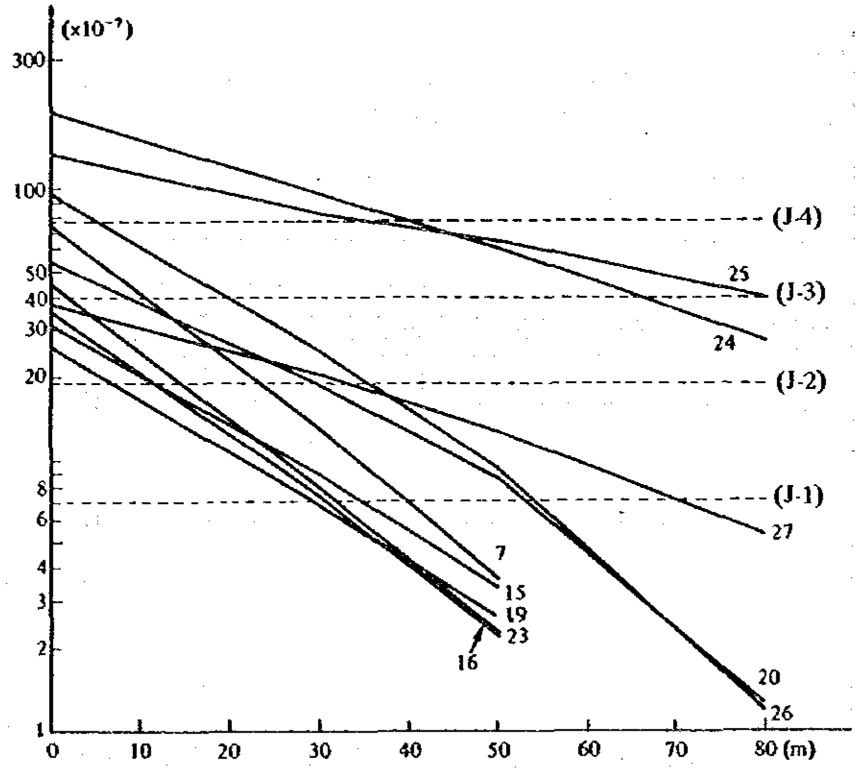


Fig. VI-2-(2)-2 Sensitivity to Width

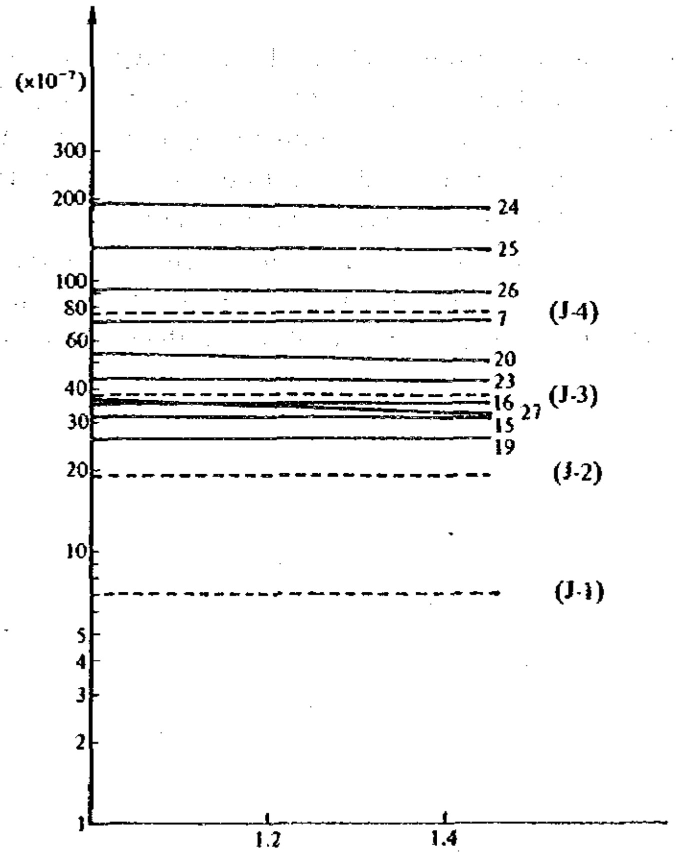


Fig. VI-2-(2)-3 Sensitivity to Vessel Speed

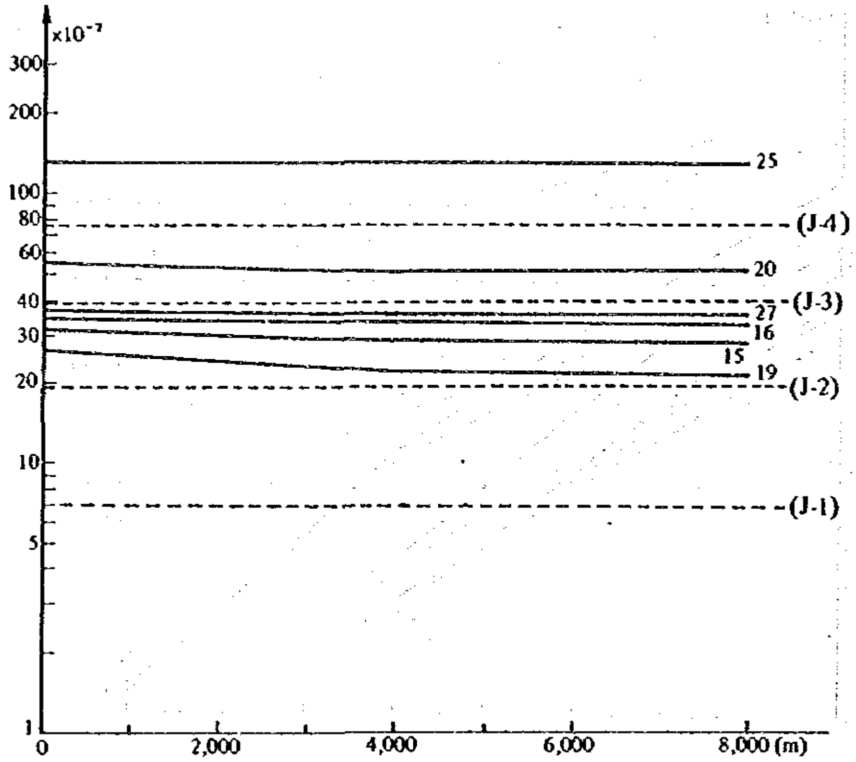


Fig. VI-2-(2)-4 Sensitivity to Curvature

As for the improvement of curvature and vessel speed, they have very slight effects, so these kinds of improvements would not be sufficient to come up with acceptable risk levels.

Therefore, widening is the most effective means to improve safety. And as the result of sensitivity analysis, the widening amounts in addition to the Second Stage Development Project necessary to obtain the acceptable risk levels are shown in Table VI-2-(2)-2.

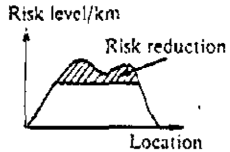
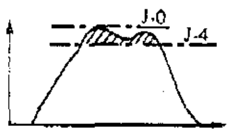
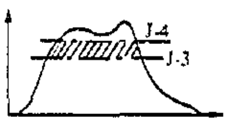
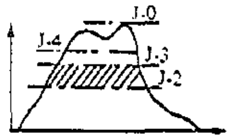
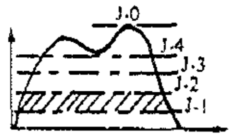
Total risk level, accident probability per transit, can be reduced as shown in Table VI-2-(2)-3. These figures are obtained by the sum of products of the lengths of improved divisions and reduced risk levels as defined per km. These figures also show the benefits obtained by increasing the acceptable risk levels from the level in present condition to J-1.

Table VI-2-(2)-2 Additional Widening Necessary to Meet Proposed Safety Criteria
(In Addition to the Second Stage Development Project)

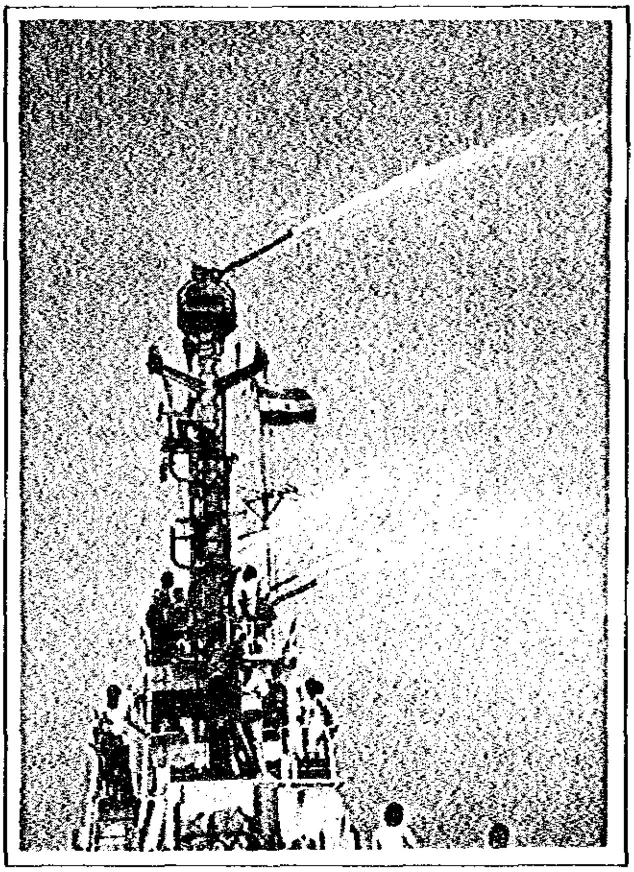
(Unit: meters)

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		

Table VI-2-(2)-3 Risk Reduction by Canal Improvement
(Total accident probability reduction by projects)

Accidents \ Projects	J-0 → J-4	J-4 → J-3	J-3 → J-2	J-2 → J-1
Grounding (× 10^{-5})	8.89	6.61	17.14	10.46
Rear-end Collision (× 10^{-7})	11.52	6.88	4.39	8.84
				

PART VII. MEASURES FOR SAFETY IMPROVEMENT



Training of Fire-fighting Vessel

PART VII. MEASURES FOR SAFETY IMPROVEMENT

VII-1. Basic Concept

(1) Safety in Terms of Canal Functions

The safety of the Suez Canal can be considered in terms of the functions of the Canal. 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.

There are three requirements to ensure safe passage of vessels through the canal:

1) The shape of the Canal must be suitable;
2) Proper support facilities such as navigational aids and mooring facilities must be provided; and
3) Proper support systems such as communications system must be provided.

Provisions for local residents include:

1) Residential areas;
2) Industrial or commercial areas; and
3) Facilities to cross the Canal

(2) Safety in Terms of Beneficiaries

Another way to consider Canal safety is in terms of the beneficiaries of safety programs. The primary beneficiaries of such programs are: 1) ships and crews working in, and passing through, the Canal, and 2) the local residents. Both crews and local residents may be affected by various types of accidents. Potential accidents include those which necessitate the closure of the Canal and those which do not.

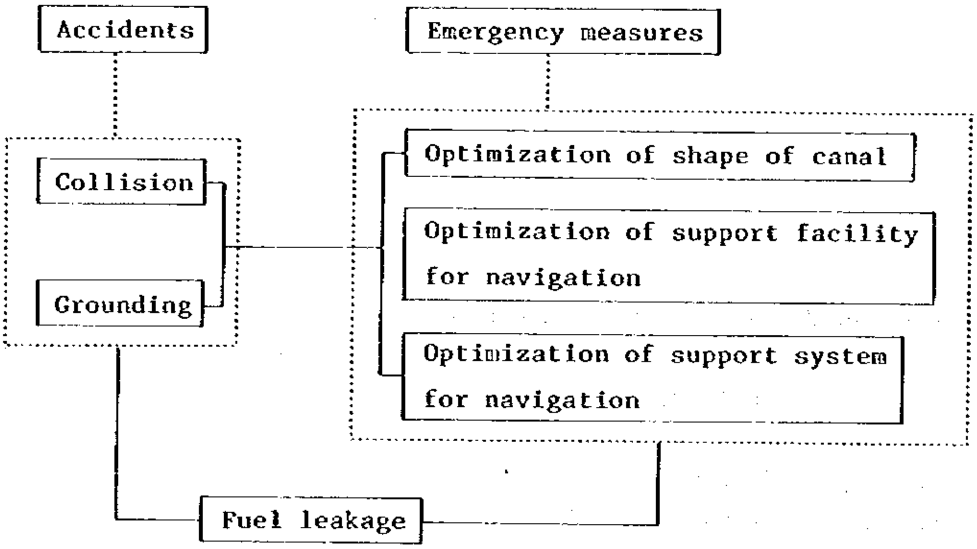
(3) Urgently-needed Countermeasures

The basic concept for urgently-needed countermeasures is similar to the overall basic concept for safety improvement. The idea is to consider the types of accidents that may occur and measures which may prevent such accidents. Here again, the most important measures are:

1) Optimizing the shape of the Canal;
2) Optimizing support facilities for navigation; and
3) Optimizing the support systems for navigation.

In accordance with this study, we analyze urgent measures considering the points in the Canal where collisions and groundings are most likely to occur, and accidents involving fuel leakage leading to fire. We have limited our study of urgent measures to those which can be implemented within one to two years. The urgent measures are directed towards the main body of the Canal, that is between Km 0.00 and 162.25.

The basic concept for urgently-needed countermeasures is illustrated as follows:



The recommendations described below concerning Navigational Aids & Disaster Treatment are not the result of full risk analysis. They are based on the original evaluation of current conditions in the Canal.

Considering the urgency of these measures, we feel that our recommendations are justified. Fortunately the proposed urgently-needed countermeasures are, for the most part, coordinated with the permanent safety measures.

VII-2 Urgently-needed Countermeasures

(1) Navigation

1) Reorganization and Reinforcement of Aids to Navigation

(i) Proposals

i) Lighthouse is to be constructed at the breakwater end of Port Said, and ramark beacon is to be fitted.

ii) The Port Said approach buoy and Suez separation zone No.1 buoy are to be upsized and racons are to be fitted.

iii) The four lighthouses which are reportedly under construction in outer harbour of Suez are to be completed as soon as possible.

iv) A total of 4 lighthouses, 2 each on the east side and west side of the Great Bitter Lake are to be constructed and racons are to be fitted to each of them.

v) Maintenance system is to be improved on each buoy provided in the approaches, waiting areas and fairways of Port Said and Suez with due observance of routine checks on the lighting condition, and when irregularities are discovered, immediate repairs are to be arranged. Such practice is to be made obligatory.

vi) On the buoys within the Canal, not only checks on lighting condition but also positional checks are to take place without fail.

vii) Authorized charts incorporating the latest information of water depth and aids to navigation etc. are to be offered to users of the Canal.

(ii) Reasons for the Proposals

For vessels approaching the waiting areas of Port Said and Suez, very few reference objects for fixing ship's position are available at present.

It goes without saying the correct position-fixing of a vessel is extremely important for ensuring the vessel's operational safety.

The proposed construction of lighthouses in Port Said and Suez would ameliorate this problem.

The installation of Ramarks can be justified in consideration of the installed position of the lighthouses. The installation of racons for the buoys in the approach and other water areas is necessary for safeguarding transiting vessels at times of restricted visibility. As mentioned above, misinterpretation of a buoy can often cause serious accidents.

The Great Bitter Lake is not provided with adequate reference objects for fixing the anchor positions, and thus provision of lighthouses is necessary not only for verifying the anchor positions of vessels but also for the controlling the anchoring of vessels.

Those buoys provided in the approaches, waiting areas and in waters in the vicinity of the fairway tend to be poorly maintained due to multiple reasons such as greater difficulties involved in the carrying out of maintenance work than in the case of those within the Canal water, little attention is directly called by the pilots and others. Appropriate maintenance is to be arranged in recognition of the actual needs of approaching vessels.

As mentioned earlier, strong requests have been made by the respondents to our questionnaire survey for the strict maintenance of those buoys provided outside the ports.

As for the buoys within the Canal, they must always be positioned at the right places as ship manoeuvres within the Canal require extremely accurate ship handling.

(iii) Effects

For vessels approaching the waiting areas or those bound for the fairways, the availability of easy and correct position-fixing not only helps reduce the dangers of running aground but also contributes to a great extent to the prevention of collisions with eventual enhancement of the safety in ship operation with ample allowance provided.

In addition, the verification of correct anchor position can help detect dragging anchors earlier.

When the positions of Canal buoys are incorrect, such can give undue fear to the pilot with resultant inflexibility in ship manoeuvres and higher vulnerability to accidents as in the case shown above.

(iv) Brief Descriptions of Lighthouses, and Estimated Work Period

Port Said breakwater lighthouse:

Reinforced concrete construction with a height of 25 m provided with its own power generating plant

Lighting range: 25 miles

Ramark beacon and radar reflector are to be provided

Work period: 28 months

Port Said approach buoy and Suez separation zone No.1 buoy:

LAN buoy 8 m dia. with racon

Work period: 15 months

Great Bitter Lake lighthouse:

Steel framed rig with a height of 10 m powered by solar batteries

Lighting range 15 miles fitted with racon

Work period 18 months

2) Establishment of Canal Traffic Communications System

(i) Proposals

A Canal Traffic Communications System of the following particulars should be established.

i) Periodic broadcasts and emergency braodcasts of the following contents using VHF radiotelephony or SSB (or middle wave transmission) should be implemented:

(a) Organization of convoys and other operational information such as the time of commencement of transit

(b) Estimated times of passage of very large vessels and carriers of dangerous goods and other special cargoes

(c) On-going work in the waterways

(d) Accidents

(e) Sea and weather conditions

(f) Malfunctioning of aids to navigation

(g) Other items of information considered necessary for the transit of vessels

ii) The following items of information should be provided for each vessel individually on the basis of the results of radar observation.

(a) Information on the position and movement of the vessel itself and other nearby vessels

(b) Warnings when collisions, groundings or dragging anchors are anticipated

(c) Other items of information necessary for the safe operation of the vessel

iii) Control Services

(a) Booking for transit

(b) Communications in approach operation

(c) Giving instructions for anchor positions

(d) Verification of anchor position and anchoring time

(e) Liaisons of information related to transit such as organization of the convoy, estimated time of commencement of transit, etc.

(f) Giving instructions for the time and position of the boarding of pilots and heaving in anchors

(g) Controls during the passage through the Canal

(h) Emergency procedures when accidents occur

(i) Other items of information as necessary

iv) Sufficient consideration should be given to the following items in establishing the proposed system:

(a) Personnel in charge of the communication and control services are to be educated and trained on subjects such as the waterways, the Rules of Navigation, and sea and weather conditions.

When appropriate, training by means of a simulator may be considered in addition to on-site training.

(b) Proper training should be given to all of those who are engaged in communication and control including pilots, the significance of communication, importance of giving account on the standing of vessels and avoidance of abuse in the use of VHF should be instructed.

(c) Information collecting systems should be established.

(ii) Reasons Behind the Proposals

As was mentioned in the summary of the questionnaire survey on users of the Canal, as many as 129 out of a total of 517 comments received mentioned the need to improve communications while transiting the Canal, as follows:

Masters of transiting vessels:	15 out of 63
Japanese Captains:	113 out of 438
Canal pilots:	1 out of 16

For transiting vessels, the lack of information and unsmooth communication at time of transit not only cause difficulties in the preparation of transit operation but also bring about undue fear and irritation with resultant deterioration of the safety in transit of the Canal.

Hence, instructions should be given to those engaged in communications services to make them fully conversant with the importance attached thereto, and the organization of the services should be reinforced.

3) Establishment of an Emergency Transit Control System

(i) Proposals

The following emergency transit control system to be used in case a serious accident occurs within the waters of the Canal should be established.

i) Occurrence of Accident

The descriptions given below represent an outline of a transit control system to respond to a major accident, for example if a very large loaded crude carrier collided with a large general cargo vessel at the northern junction of Deversoir with consequential massive oil spillage causing temporary suspension of transit of vessels through the Canal.

ii) Correct Understanding of Accidents

Efforts should be made to obtain as much correct information as possible by exchanging and monitoring messages with the pilot and master of the vessel involved in the accident, skippers of escort boats, and the pilots and masters on board those vessels operating in waters in the vicinity of the vessel(s) in trouble.

iii) Establishing a Headquarters for Accident Controls

In accordance with the organization chart, the headquarters should be organized in Ismailia whereby all the men necessary to form a three-shift system for around-the-clock service and communication equipment should be located.

In the organization chart shown below, details are omitted from the transit control section downwards.

- Chief of the Headquarters for accident control
  - Acting Chief of the Headquarters
  - Commanding transit control
    - Control team
    - Transit control team
    - Navigational Safety team
    - Liaison/communications team
  - - - - Commanding disaster treatment
  - - - - Commanding rescue and medical services
  - - - - Commanding communications services
  - - - - Commanding recording services
  - - - - Commanding assisting work

Each team assumes the following duties:

The control team assumes the duties of integrating all the transit control teams.

The transit control team assumes the duties of grasping the movements of all vessels within the Canal and controls all the vessels' movements.

The navigational safety team assumes the duties of giving necessary instructions to those vessels in the vicinity of the accident site and all transiting vessels by boarding tugs, pilot boats and others to prevent secondary accidents.

The liaison/communications team assumes the duty of the overall liaisons and communications of the transit control section.

iv) Investigation of Countermeasures

In collaboration with other section of disaster treatment, rescue and others, effective countermeasures to be taken by the control team against the entire accident should be discussed.

v) Transit Controls

(a) Emergency Broadcasting

Information on the occurrence of accident in a vessel transiting the Canal, outline of the accident, the suspension of transit through the Canal and the execution of special emergency controls must be directed to all the vessels within the Canal water for calling their attention to assume stand-by until further notice is given. These messages should be broadcast by VHF radiotelephony and radiotelegraphy to ensure full awareness of the accident.

When necessary , communications should also be subjected to control.

On the other hand, liaisons must also be made by the agents to the vessels approaching Port Said or Suez.

An ample number of men and equipment should be allotted for such liaisons and communications.

(b) Judgement of Dangerous Areas

The scope of dangerous areas should be judged on the basis of inspection of the spilled oils and the dispersion of petroleum gases as indicated by gas detector, and the established prohibition of access to the dangerous area by vessels should be brought to the attention of them, and controlled use of bare fire and smoking should also be notified.

Notice should also be given to land facilities to control admission and to instruct evacuation when necessary.

(c) Instructions Given to Each Vessel for Actions to be Taken

For those vessels of the northbound convoy located north of the site which can continue their passage and those vessels of the southbound convoy located south of the site, their continued passage should be instructed. For vessels other than the above, tying up at designated bank positions of the Canal should be instructed, and depending on the situation, designation of anchorages in the Great Bitter Lake and Lake Timsah should be made for their anchoring. Vessels should be requested to report the completion of tying up or anchoring for due recording. Instructions may be given to assume standby for shifting vessels to the Great Bitter Lake.

Thoughtful controls of the waiting areas are to be effected because as the period of closure of the Canal is extended, the number of vessels in the waiting areas also increases.

Consideration should be given to securing additional anchorages outside the waiting areas.

(d) Mobilization of Tugs, etc.

Tugs, pilot boats and helicopters are to be urgently despatched for advising, controlling and assisting vessels' movement, including actual assistance in tying up operations to prevent undue disturbance in the transit of vessels. Advisory services from automobiles running along the Canal Road may be arranged.

(e) Study on Preferred Disposition of the Vessel in Trouble

The disposition of the vessel in trouble should be studied.

Even when disaster response is taking place, the latest situation should be broadcasted to each vessel either regularly or occasionally.

(f) Resumption of Transit

While the disaster treatment is in progress, the transit control team must draw up a plan for the resumption of passage of vessels through the Canal on the basis of the records of tying up and anchor positions. Once it is verified that the disaster treatment is completed, and trouble-free transit of vessels becomes possible, transiting of vessels through the Canal will resume in accordance with the predetermined plan. Such reopening of the Canal is to be broadcast to all the vessels concerned, and specific instructions are to be given to individual vessels.

In reopening the Canal, advisory services and actual assistance by tugs, pilot boats and others may be necessary.

(ii) Reasons Behind the Proposals

To prevent undue disorder and disturbances at the time of occurrence of accidents, and for dealing with such emergency situations in a most organized and systematic manner, it is necessary to establish an organization and system in advance, with proper drill and training, followed by postulating possible aspects of casualties.

For reference, the risk levels of massive oil spillages or fire after collision and grounding in the peripheral waters of Japan for the 10-year period from 1973 to 1982 are as follows:

Collisions which developed into fires	2.25%
Collisions associated with massive oil spillages	7.91%
Groundings which developed into fires	0.00%
Grounding associated with massive oil spillages	2.34%

4) Utilization of the Port Said Bypass

(i) Proposals

At present, vessels with drafts not exceeding 38 ft in the No.1 and No.2 southbound convoys are once moored at the waiting buoy berth in Port Said harbour, and enabling them to complete preparation for transit, then proceed to Suez via the West Branch, but we suggest that this transit system be amended as below:

Utilizing the time belt during which the Port Said bypass is not being used, vessels with drafts not exceeding 38 ft should be channelled through the east branch as much as possible, thence moored at the buoy berth now under construction at the south part of the west branch where preparation for transit is made, thence they are induced to Suez there from.

For realizing such a transit system, it is necessary to newly dig a short-cut canal from the east branch to the new buoy berth of the west branch.

(ii) Reasons

As mentioned above, Port Said is characterized by its significant risk levels which are higher than in any other part of the Canal. In this area, the risk levels involving collisions are particularly high, and thus early establishment of effective safety measures is most strongly requested.

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

(iii) Effects

Fig. VII-2-(1)-1 shows the traffic diagram model representing a case where 6 vessels with drafts exceeding 38 ft and 40 vessels with drafts not exceeding 38 ft of the Southbound convoy, and 6 vessels with drafts exceeding 38 ft and 41 vessels with drafts not exceeding 38 ft of the northbound convoy transit. According to this diagram, the Port Said bypass is not used for a total of approximately 11 hours, from about 0520 hours to 1630 hours. If it is made an operational principle not to let any vessel wait for a full day, then vessels moored at the new buoy berth of the west branch after passing through the east branch would be forced to be closed for registration at about 1400 hours, and thus other vessels that arrive from 1400 hours to 2330 hours when the No.1 southbound convoy starts would be moored at the waiting buoy berth within the conventional harbour and pass through the west branch.

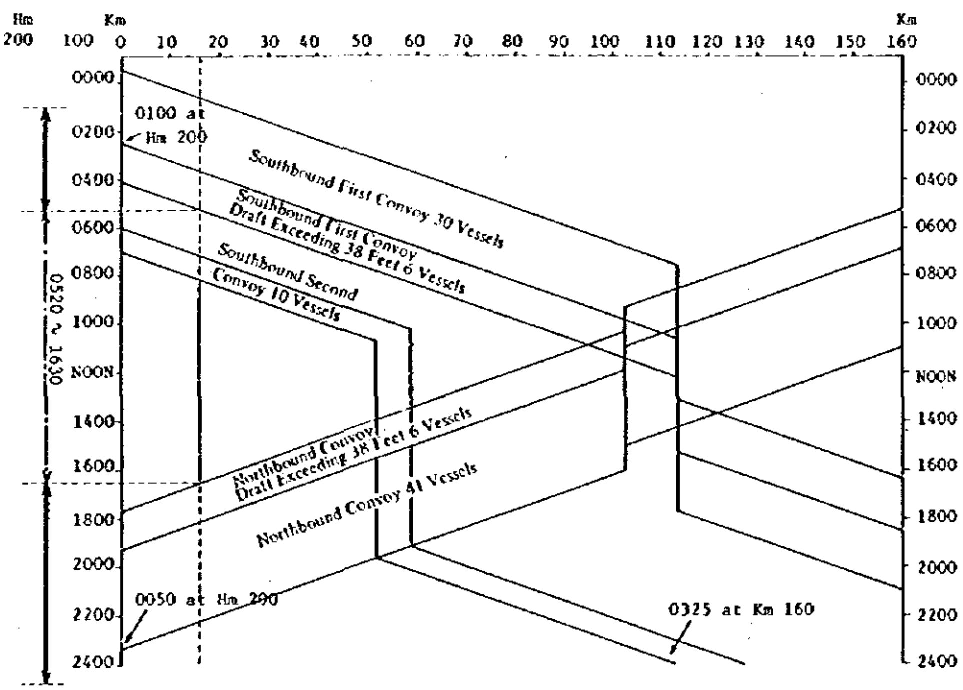


Fig. VII-2-(1)-1 A Model Traffic Diagram

In Table II-4-(1)-7, it is shown that the arrival times of transiting vessels are distributed over the full span of 24 hours with few exceptional small peaks, and if we assume that two transiting vessels come in every hour, then a total of 29 vessels proceed through the East branch, whereas the remaining 19 vessels would proceed across the water of the port. Accordingly, the risk level of transiting vessels within the water of Port Said can be reduced theoretically to 19/48 = 40%.

For the desirable location and shape of the short-cut canal, in-depth studies using a simulator may be required.

(2) Disaster Treatment

1) Operational Bases

As to the location of operational bases to deal with marine disasters, it is recommended that the bases be located in the center of each of the existing 3 jurisdictional areas, namely Port Said, Ismailia and Suez, considering that the Canal stretches in a north-south direction for a distance of 160 kilometers, and that the potential of marine incidents is higher in areas where vessels are entering and leaving the Canal.

2) Equipment and Material

(i) Equipment and Material on hand

i) Allocation

Tug boats and other equipments that are considered adequate will be maintained on "as-is" basis under the current allocation program. Regarding oil booms, skimming equipments, dispersant, foam concentrate, dry chemical powder and those schedule for addition to 1984 their allocation should be taken into consideration.

(a) Oil Booms

Assuming that oil booms are allocated equally to 3 bases, the Bridgestone type oil booms currently assigned to Port Said should remain there to eliminate uneconomical transfer. Hyle marine coastal booms assumed to be allocated to Ismailia, and Hoyle marine permanent type booms to Suez.

(b) Skimming Equipment

The self-propellered weir type skim boat is recommended to be assigned to Ismailia located in between Port Said and Suez so that the skim boat can be dispatched to either area if assistance is needed. The two Cyclonets are to be assigned to Port Said where number of accidents have been reported so far, and the remaining weir type skimmer and a weir type skimmer for training purposes are to be assigned to Suez.

(c) Dispersant

There is sufficient volume of dispersant stockpiled in respective places which will be left as it is.

(d) Foam Concentrate

There is sufficient volume of foams stockpiled in respective places, which will be left as it is.

(e) Dry Chemical Powder

2-tons of dry chemical powder at Port Said, 9 tons at Ismailia and 3 tons at Suez are stockpiled.

An inventory of 4 ~ 5 tons at each location is recommended to averaged by changing assignment of the boats or by providing dry chemical powder units on the tug boats in Port Said and Suez.

ii) Quantity

(a) Oil Spill Control

a) Oil Boom

Depending upon the behavior of oil spills and the method of boom use, the required length of booms will vary. When the most basic method of booms use, i.e. "containment", is employed to herd 1,000 m^3 of crude oil in case of an instantaneous spill under calm conditions, the radius of spilled oil in 2 hours will be 182 meters, according to the calculation using Motora model on spread. The required length of the booms for the containment of the oil by single deployment is 1,143 meters.

Then, each base requires 1,143 meters long or longer oil booms which can be used in same condition as a minimum requirement.

Therefore,

i Port Said needs 1,143 m − 600 m = 543 meters or more additional Bridgestone type boom as addition.

ii If Hoyle marine coastal booms are to be used at Ismailia, 1,143 m − 150 m = 993 meters or more additional booms of the same type are required at Ismailia.

iii If Suez used Hoyle marine permanent type booms, 1,143 m − 150 m = 993 meters or more additional boom of this type are required.

b) Skimming Equipment

If 1,000 m^3 of crude oil is spilled, it is impossible to recover all of the 1,000 m^3 of oil using skimming equipment. Even if skimming equipment is used under ideal conditions, still more than 20% of the spill will disperse in the least estimate. Also, what appear in catalogues as the skimming capacity usually represents the maximum figures that are attainable if all conditions are met. However, actual skimming efficiency may decrease to 1/2 or less of the stated efficiency.

Also if skimming work must be conducted before emulsification takes place, it means that the work must be completed within 2 days.

Assuming that the net working hours during the period is 24 hours, skimming equipment with the rated recovery capacity of approx. 70 m^3 per hour is needed.

i Port Said

Cyclonet (30 m^3/h) x 2 = 60 m^3/h

Approx. 10 m^3/h in shortage. This will be supplemented by the effective use of submersible pumps

ii Ismailia

Assuming that the skimming capability of the self-propelled weir type skim boat is 30 m^3/h, the skim boat is far insufficient to meet the criteria.

It will become necessary to assign 1 or more skim boat of identical type, or to dispatch assistance from Port Said.

iii Suez

Assuming that the skimming capacity of the weir type skimmer at Port Said is 20 m^3/h.

(20 m^3/h x 2 = 40 m^3/h)

It will become necessary to assign more than one skimmer of the same type, or dispatch assistance from Ismailia or use submersible pumps.

c) Dispersant

It is not recommendable to use dispersant in large quantities, because it harms the natural environment. Supposing that the 20% of the oil spill that could not be recovered by the skimming equipment will be treated with dispersant, 1,000 tons x 0.2 x 0.25 = 50 tons of dispersant is required on the assumption of the application rate of 4 : 1 (oil: dispersant).

There is sufficient dispersant in each of the 3 areas.

(b) Firefighting

While spraying of foam on the liquified gas fire results increase of fire through promoting gasfication due to rise of liquid temperature, foam works effectively in fighting crude oil fire. Therefore, foam will be handled as crude oil fire extinguishing material, and dry chemical powder as anti-liquified gas fire material. Minimum requirements of foam concentrate and dry chemical powder as urgently-needed countermeasures are as follows:

a) Foam Concentrate

Assuming that a 130,000 DWT crude oil tanker caught fire when oil spilled out from one tank, the area requiring firefighting would be approx. 1,000 m^2.

The equation of foam concentrate and the area where fire is extinguishable is as follows:

Area where fire is extinguishable =

$$\frac{\text{Foam concentrate x Form expansion rate x Effective ratio}}{\text{Mixing ratio x Thickness of foam x 10}}$$

(Foam generation qty. = foam concentrate x foam expansion rate)

Qty. of foam concentrate	unit in litre.
Mixing ratio	mixing ratio of foam concentrate and water is either 0.03 or 0.06.
Foam expansion rate	multiples at which mixed liquid generates foam.
Effective ratio	ratio of effectiveness on the actual usage. Depending on the mode of burning and spraying technique and others, the ratio changes substantially. Generally, the ratio is 1/2 to 1/3.
Thickness of foam	normally a thickness of over 15 cm is necessary. unit in centimeter.
Area where fire is extinguishable	unit in m^2 (sq. meter).

Consequently, the volume of neat concentrate required for extinguishing fire of 1,000 m^2 under the assumption of mixture ratio 0.03, expansion rate 420%, effective ratio 1/3, and thickness of foam 15 cm, will be 3,214 litres. Therefore, there is sufficient foam concentrate.

b) Dry Chemical Powder

The molecular weight of propane, the principal component of LPG, is 44, which is heavier than the specific gravity of the ambient air and the vapor remains on the surface of the sea.

It is said that if the burning vapor is extinguished, the vapor will be released on the sea and continuous release of the vapor would make a big vapor mass and cover the surface of the sea. If that big vapor mass is reignited, the gas will burst into flame all at once. It will create a tremendous combustion shock and fire will spread over a wide area.

Therefore, there are cases where it is considered better to leave LPG burning and to consume the vapor as long as it is stable fire.

Whether LPG fire should be extinguished or not is a serious question to be determined on the scene of the accident.

On the other hand molecular weight of LNG vapor is 16. So, it is lighter than air.

It is said that LNG vapor goes upward and dissipates in the atmosphere when it come up to the normal temperature and is safer than LPG vapor.

For this reason, we chose the LNG as the subject of study, but large quantity of spill of LNG will not let the vapor's temperature rise rapidly.

LNG vapor will stay on the surface of the sea when it is less than −120°C.

The legal requirement of dry chemical powder to be equipped on LPG/LNG tankers in Japan is 2 tons. It is intended only for the initial fire-fighting. The larger the amount of fire extinguishing material, the larger and wider the firefighting area will be.

However, as the complexity of the relationship between the size of accident and costs required, quantitative criteria for stockpiles on board is hard to be derived. If an initial firefighting is our immediate goal the amount of approx. 2 tons will be appropriate as practiced in Japan by taking into consideration the load capacity on escort boats.

Therefore, an arrangement should be made to assign a tug boat loaded with over 2 tons of dry chemical powder to every LNG-loaded vessel.

The capability of available tug boats are as follows:

Base of tug	Dry chemical (ton)	Extinguishable burning gas area (m^2)
Port Said	4	400
Ismailia	5	500
Suez	5	500

(ii) Firefighting Vessel

The probability of spill of LPG or LNG is very rare because of IMO's severe ship construction rules, low speed and one way convoy system in the Canal.

If there is a big fire by other any reason, there is no solution in the world to stop such a disaster. But at least, we can say, more equipments, materials and training make the effect of fire decrease and there is no limitation for it.

From the point of view of above mentioned reason we recommend to possess 3 fire-fighting vessels which have more capability than available tug boat and can be always available in 3 areas as cores of the firefighting operation and also can be one of symbol of safety improvement of the Suez Canal.

(iii) Oil Boom Tender Boat

When oil is spilled, the first step to be taken is to prevent oil spread and make it easier to recover spilled oil. For this reasons, measures have to be taken to have boats carrying booms arrive at the scene of oil spill as soon as possible. Under the circumstances, there will be no time for taking booms out of a warehouse, loading them aboard boats, connecting them together and making necessary adjustment of accessories. Use of "Oil Boom Tender Boat" will be the answer.

The boat is coffer barge loaded with pre-connected booms. The boat can be easily towed by a tug boat to the scene of accident, and is recommended to be allocated in each 3 area.

Example of oil boom tender boat is as follows:

Boat is made of steel

Gross tonnage: 130 tons

Major dimensions: L x B x D

25 m x 7.5 m x 2.5 m

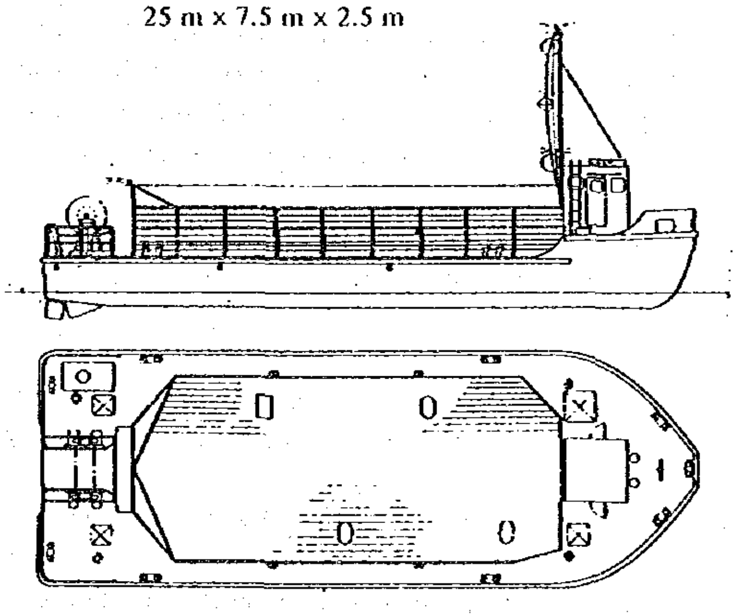


Fig. VII-2-(2)-1 Non-self-propelled Oil Boom-Tender Boat

Carrying oil booms, the boat proceeds to the scene of an oil spill accident, deploy the the booms around the oil spill and take them back. It is loaded with 1,160 meters long oil booms and is equipped with a boom retrieving apparatus. Additionally, the boat is so devised as to keep recovered oil in void space in the boat.

(iv) Inflammable Gas Detector and Explosion-proof VHF

As already mentioned in describing the natures of crude oil, LPG and LNG, generated vapor will cause disasters of various types. Therefore, it is indispensable to know the state of vapor and to communicate safely with each other in order to execute effective anti-disaster measures.

Total 194 sets of them are necessary to be distributed to all of Transit Team members, signal stations, skim boats, oil boom tender boats, 100 pilots and tug boats. 4 sets to each salvage and each firefighting vessel.

Additional distribution should be made when necessary.

(v) Protective Apparatus

In order to conduct disaster control work safely and to make effective use of gas detectors, it is necessary to have self-contained breathing apparatus, non flammable heat resistant garments, anti-electrostatic coats, anti-electrostatic shoes, and explosion-proof portable lamps.

In addition air refilling set must be supplied to the 3 bases.

Additional distribution should be necessary as occasion demands.

(vi) Dispersant

Use of dispersant should be avoided as much as possible from the viewpoint of the protection of marine environment. Dispersant causes oil to disperse when applied, and assists and expedites natural degradation of oil, and yet use of dispersant adds strange substances in natural environment. In particular, the type of dispersant currently supplied has stronger toxicity elements when compared with Japanese dispersant, and it is recommended that they be replenished gradually according to consumption by other dispersant of less toxicity.

As mentioned before, dispersant may be applied only to the remainder of spilled oil that could not be recovered by the skimmer.

3) Execution Team

In preparation for disaster, it is prime requirement to organize execution teams equipped with effective communication and disaster control equipment and manned by experts on disaster control.

It is recommended that the organization be started with Transit Teams, as contemplated by SCA each consisting of 8 experts who work with the salvage in 3 areas of the three different districts, respectively, and Transit Teams should be the nucleus of disaster treatment execution teams under the Commanding Disaster Treatment that mentioned before.

4) Recovered Oil Disposal Basin

Disposal facilities which are inexpensive to construct and easy to maintain should be built immediately. These will be basic disposal basins which utilize the special geographical features of the region, particularly the vast desert. The minimize the cost of transporting recovered oil, one basin is considered necessary for each area. For the Port Said base, the basin will be located on the reclaimed land at the east branch on the Mediterranean coast. For the Suez base, it will be on the Sinai Peninsula side near the entrance and exit of the Canal. For the Ismailia base, it will be located on the southern coast of Great Bitter Lake.

5) Obligated Tug Boat Capacity

The existing Rule of Navigation provides regulations on the use of tug boats. However, no provision is made on the capacity of tug boats to be used. From the viewpoint that we should limit disasters to a minimum, it should be made mandatory to use a tug boat with appropriate firefighting capability for the tankers carrying crude oil and liquefied gas.

6) Equipment Handling Exercise

It is important to get personnel well trained so that they can use firefighting and disaster control equipment correctly and effectively. Always, accidents occur unexpectedly. In order to keep all the equipment and materials ready for use at any time and to maintain technical standards of the personnel at a required level, continuous exercise should be given to them to get themselves well acquainted with how to use equipment and materials and to repeatedly correct mistakes in handling them.

An exercise program must be implemented to train as many persons as possible.

In the first year, exercises will be conducted as stated on the following table. From the second year, the frequency of exercise will be reduced to 1/2, for trainees will be much more familiar with how they should use equipment and materials.

The time required for handling and preparing those equipments and materials will be reduced in direct proportion to the number of exercises given.

In the training diary, the date, place, natural conditions, number of participants, and summary of the training concudcted will be recorded.

In the service diary, the date, the person who handled the service work, servicing or inspection situations, records on malfunctioning parts, causes of malfunctions, repair work method, and opinions are recorded. In the history book, records of major incidents, dispatches made to the scene of accidents, amount of oil recovered, records of overhauling and of major repair works are kept.

These records will be inspected by a Transit Team once a month.

Table VII-2-(2)-1 Essential Items of Equipment Handling Exercise

Title of Exercise	Frequency	Documentation	Remarks
Handling of Oil Booms	Once in 2 weeks	Exercise diary	
Exercise on how to Operate a Skimmer	Once a week	Exercise diary, Servicing diary, History	Write on a big panel the principle and structure of a skimmer
Exercise on Bringing Non-self Propelled Skimmers to the Scene	Once in 3 weeks	Exercise diary	Towing exercise and loading and carrying exercise
Exercise on how to Handle Inflammable Gas Detectors and Breathing Apparatus	Once a week	Exercise diary and Servicing diary	Write on a big panel the principles and drawings of structure, and put down points of precaution
Exercise on how to Handle Fire Pump	Once in 2 weeks	Exercise diary	
Spraying of Water by Tug Boat and Dispatch of Tug Boat Personnel to the Ship Involved in an Accident and Fire-fighting Drill	Once in 3 weeks	Exercise diary	
Spraying by Firefighting Vessels and Dispatch of Firefighting Personnel to the Ship Involved in an Accident and Fire-fighting Drill	Once a week	Exercise diary Servicing diary History	

7) Comprehensive Drill

It is indispensable for minimization of disasters to conduct a comprehensive disaster drill using a accident scenario and get all parties well prepared for emergencies. At least, this type of drill must be conducted semi-annually. Local drill should be conducted at each district 4 times a year. Through repeated drills, individuals will become acquainted with how other people and equipment are working or used, and they can rectify shortcomings.

Disaster response could be compared to a football game.

Equipment handling drill is comparable to a training on how to handle the ball accurately on an individual basis. A comprehensive drill is a training requiring every player to cooperate with one another in their game, overcoming difficulties and to kick the ball in to the goal. In conducting regional drills, use the materials and equipment assigned to the district should be used. The drill includes processes of obtaining the first information on an accident, notifying personnel concerned to get ready for an emergency dispatch, implement of stopgap treatment, setting up concrete countermeasure plans, plus delivery of messages, and added with procedures until arrival of reinforcement from other districts.

To put into practice these drills, Egyptian instructors must be trained as soon as possible. If possible, it is desirable to have those who have attended seminars overseas and/or those candidates of Transit Teams attend the World Maritime University which was set up under the support of IMO and Swedish government to receive necessary trainings.

Those who are responsible for the safety of the Suez Canal which is one of the most important international passage should be well versed in, at least, firefighting and oil spill prevention and in every aspect pertaining to the world maritime safety. Therefore, it is necessary for them to be retrained at the World Maritime University which is regarded as the center of the most up-to-date information and technologie widely recognized by nations around the world. After giving them a re-education, a comprehensive drill plan optimal to the Suez Canal will be created, and training of SCA's middle class trainer-candidates will be put into practice and also special organization on accident will be set up.

VII-3 Measure for Prevention of Accidents

(1) Canal Topography

1) A comparison between PIANC recommendations and the current Suez Canal topography was carried out in Part IV and is evaluated as follows.

(i) As for the design depth of the Canal, the required dredged channel level is calculated as −19.6 m to −19.8 m for navigation of a 150,000 DWT class tanker. The present Suez Canal design depth of −19.5 m seems to be reasonable.

(ii) As for the width of the Canal, a width of 230 m is preferable for navigation safety for 150,000 DWT class tanker considering the PIANC standard and the situation in other canals in the world. The present width of the greater part of the navigation way of the Suez Canal can be concluded as being insufficient, except for the navigation way at the Port Said approach channel and in Great Bitter Lake.

2) 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-3-(1)-1.

Base lines of different widths should be linked together with 1,000 m (when the difference is more than 15 m) or with 500 m (when the difference is less than 15 m) by a straight line, or by an arc in curved sections. As for Hm 0^E ~ Km 1^E, although the additional width from the results of the risk analysis for J-1 is zero, an additional width of 20 m is required, because the additional width of the section to Hm 0^E is 20 m and of the section from Km 1^E is 15 m, and such a variation in a short distance is undesirable from the point of view of the maneuverability of the transit vessels.

Similarly, as for Km 52^W ~ 55^W and Km 83 ~ 85 for J-1 and Km 129 ~ 132 for J-3, additional widths of 15 m, 30 m and 20 m are required, respectively.

Table VII-3-(1)-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						

(2) Construction and Maintenance Works

1) The Second Stage Development Project

(i) Outline of Work

As for the Second Stage Development Project, the final plan has 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 the main channel, and the deepening dredging of anchorage areas in Great Bitter Lake by 3.5 m (hereafter referred to as the SCA plan).

The details of this plan are shown in Table V-1-(1)-1 and Fig. V-1-(1)-1.

In this study, the risk analysis was made based on the SCA plan. The result was that there is no objection basically, but it is necessary to widen partially the widths in addition to the SCA plan to obtain each acceptable risk level.

The locations to be changed versus the SCA plan are shown in Table VII-3-(1)-1 (referred to as the alternative plans).

When the alternative plans will be executed, it is necessary to collate in detail with the SCA plan.

In the case of the SCA plan, the contents of the work is dredging work only, but, in the case of the alternative plans, it is necessary to remove and reconstruct parts of the banks and/or mooring caissons.

The work volume of the SCA plan and the alternative plans are shown in Table VII-3-(2)-1.

Table VII-3-(2)-1 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

As for the dredging volume of the Second Stage Development Project, at present, SCA is conducting widening dredging and deepening dredging according to the SCA plan by SCA's dredgers. And, it is assumed that the widening dredging of the sections Km 1.5 ~ 61.0 and Km 115.0 ~ 122.0 will be finished according to the SCA plan by the beginning of the full scale execution of the Second Stage Development Project.

(ii) Implementation Plan

i) Preliminary Survey

Prior to the Second Stage Development Project, it is necessary to conduct a sounding survey of the whole Canal and to reconfirm the position and depth of structures such as siphons, submarine tunnels and mooring caissons so as to avoid accidents from dredging work.

It is also necessary to survey the locations of explosives in the reclamation areas and in the Canal to prevent accidents.

ii) Bank Work

(a) Removal of Banks

Stones and concrete blocks are removed by oil pressure shovels and clamshells, and are carried by dump trucks. The sheet piles are drawn out by vibration hammers.

(b) Constructionof Banks

The revetment will be executed on dry land. The excavation will be executed by bulldozers and clamshells to the depth of -1.0 m with the water drained by well pumps.

Sheet piles will be placed by a diesel hammer pile driver, and stones and concrete blocks installed on the revetment. Assuming that the works are to proceed as one unit, the capacity of execution for a unit should be determined by the capacity of sheet piling.

If 20 sheet piles are placed per day with pile drivers, the capacity will be 8 m/day and 200 m/month with 25 working days.

iii) Dredging Work

The monthly capacity of a cutter suction dredger is calculated based on the dredging results of the First Stage Development Project under the following procedures.

(a) By each dredger of each Lot under the First Stage Development Project, the total days (divided into operating days and periodical maintenance days), operating days (divided into working days and resting days), working hours (divided into dredging hours and resting hours), resting items (machine repairs, relocation of dredgers, waiting for convoys, obstructions, change of cutters, holidays etc.), and volume of dredging are investigated.

(b) The dredged volume per hour, converted into the capacity of 8,000 HP dredger in each LOT of the work is calculated.

(c) The monthly standard working hours under the Second Stage Development Project is determined after the analysis of the monthly average working and resting hours of the First Stage Development Project.

(d) The capacity of dredging is adjusted considering the difference of conditions in the shape of sections, depth of dredging and nature of soil, between the First Stage Development Project and the Second Stage Development Project.

(e) The monthly dredging volume of an 8,000 HP dredger is calculated by the hourly dredging volume, the monthly working hours and the correction coefficient of dredging efficiency for each LOT.

The monthly working hours under the Second Stage Development Project are about the same as for the First Stage Development Project. But, as for LOTs where the soil volume of dredging has a poor balance between widening and deepening, that is LOTs with a lot of deepening work, the amount of time not working while waiting for convoys increases significantly.

Considering the SCA Plan, dredging efficiency measured in dredging volume per hour will decrease during the Second Stage Development Project to the following percentages of First Stage Development Project efficiency:

	Widening & Deepening Dredging	Only Deepening Dredging
Shape	90%	90%
Depth	94%	83%
Soil	93%	92%
Total	79%	69%

As for the shape factor, because the width to be dredged under the Second Stage Development Project is smaller than the width of the First Stage Development Project, the dredging efficiency decreases by 10%.

As for the depth factor, as dredge pumping efficiency decreases by 10% at depths from 15 to 20 m and by 20% at depths from 20 to 24 m, the dredging efficiency decreases by 6% in the case of widening and deepening dredging and by 17% in the case of deepening dredging only.

As for the soil factor, because deeper soil strata are harder, the dredging efficiency decreases by 7% in the case of widening and deepening dredging and by 8% in the case of deepening dredging only.

The monthly dredging volume of SCA's dredgers is assumed to be less than that of the contractors' dredgers. Considering the working hours per day and working efficiency, the volume for SCA's dredgers is estimated as 80% of the contractors' dredgers volume.

20 days after the first 5,000 working hours and 40 days after the next 5,000 hours are necessary for the periodical maintenance of the contractors' dredgers.

2 months per year are necessary for the periodical maintenance of SCA's dredgers.

The distribution of dredgers is as follows.

Sections Hm 220 ~ 80, Hm 80 ~ Km 1.5, Km 1.5 ~ 61.0 and Km 115.0 ~ 122.0 except in the case of J-1 are dredged by SCA's dredgers, and the other sections are dredged by contractos' dredgers. Of the dredgers owned by SCA, the effective dredgers for the Second stage Development Project are 2 hopper suction dredgers of 6,000 m^3, 3 cutter suction dredgers of 10,000 HP and 1 cutter suction dredger of 5,500 HP, amounting to a total of 6 dredgers.

As for the dredging work in the approach channel and the Canal, both SCA's dredgers and contractors' dredgers have to start the dredging from positions which will not prevent the passage of transit vessels.

As for the dredging work in anchorage areas in Great Bitter Lake, sections of the anchorage area cannot be used during the dreading work. The order of dredging work will start from area E_4, and areas E_1, E_2 and E_5 will be dredged after the completion of area E_4. During the dredging of areas E_1, E_2 and E_5, areas E_3 and E_4 will be used as anchorage areas, and finally area E_3 will be dredged. Available dreading hours by Km in the fairway without preventing the passing of convoys were calculated according to the traffic diagram, and are shown in Table VII-3-(2)-2.

Table VII-3-(2)-2 Available Dredging Hours by Hm and Km in the Fairway

Km	Possible Hours		Available Hours	
	Main Channel	West Channel	Main Channel	West Channel
	hours	hours	hours	hours
Hm 220 ~ 80	17.3	–	14.6	–
Hm 80 ~ Km 1.5	16.6	17.4	12.8	15.1
Km 1.5 ~ 61.0	14.3	12.2	9.7	6.9
Km 61.0 ~ 79.0	12.6	–	8.8	–
Km 79.0 ~ 94.5	12.6	–	9.4	–
Km 94.5 ~ 101.0	17.9	17.9	15.9	14.0
Km 101.0 ~ 115.0	17.6	14.4	15.6	10.4
Km 115.0 ~ 122.0	18.3	18.3	16.3	14.3
Km 122.0 ~ 145.0	12.6	–	7.1	–
Km 145.0 ~ 162.25	12.6	–	6.5	–

Possible hours are calculated according to the traffic diagram, subtracting only the risk analysis.

Available hours are calculated assuming that 2 hours are required to shift outside of the navigation buoy line and to shift inside from there, and that dredgers can work at least one hour before the following shifting.

(iii) Construction Schedule

The starting time of the construction, which is an element of the work schedule, has not yet been decided, so it is assumed as follows.

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.

The dredgers owned by SCA start dredging in January of 1986, and the foreign contractors start dredging at the end of 1986. According to the construction schedule, the Second Stage Development Project will be finished 3 ~ 4 years after starting the contract dredging.

In the case of the SCA plan, the dredging work can start immediately after the preparation of the land discharge pipe line, but in the case of the alternative plans, banks or caissons must be removed before the dredging work begins.

The construction schedules are shown in Fig. VII-3-(2)-1 ~ 4.

The required maximum total dredger horse power is 195,000 HP including SCA's dredgers totalling 35,500 HP (in the case of alternative plan J-1, it is 225,500 HP including SCA's dredgers totalling 41,000 HP).

The work period shown in these schedules are for real working days and do not include time for preparation and arrangement. In the case of dredging work, about one month may be necessary prior to starting dredging for surveys and preparation of a discharge pipe line.

Also, a follow-up survey and other works will be necessary after the completion of dredging works, and several months might be required after dredging before the channel is ready for navigation.

Hm , Km		Works	Work Volume	1986	1987	1988	1989	1990	Remarks
Hm 220 ~ 80		Dredging	$36,100 \times 10^3 m^3$	11		7			SCA Hopper Drd $6,000 m^3 \times 2$
Hm 80 ~ Km 15		Dredging	$25,300 \times 10^3 m^3$	1 11					SCA Hopper Drd $6,000 m^3 \times 2$
Km 1.5 ~ 61.0		Dredging	$42,700 \times 10^3 m^3$	1 8			11		SCA Drd 15,500HP → 35,500HP
Km 61.0 ~ 79.0		Dredging	$30,200 \times 10^3 m^3$	12		6			Drd 32,000 HP
Km 79.0 ~ 94.5		Dredging	$21,300 \times 10^3 m^3$			6	11		Drd 32,000 HP
Km 94.5 ~ 101.0		Dredging	$11,700 \times 10^3 m^3$	12		1			Drd 16,000 HP
Km 101.0 ~ 115.0		Dredging	$19,000 \times 10^3 m^3$	12		9			Drd 32,000 HP
Km 115.0 ~ 122.0		Dredging	$4,300 \times 10^3 m^3$	1 8					SCA Drd 20,000HP
Km 122.0 ~ 145.0		Dredging	$36,600 \times 10^3 m^3$	12			7		Drd 32,000 HP
Km 145.0 ~ 162.25		Dredging	$25,100 \times 10^3 m^3$	12		1	10		Drd 16,000 HP → 32,000HP
Great Bitter Lake Anchorage	E_1	Dredging	$16,200 \times 10^3 m^3$			9	9		Drd 32,000 HP
	E_2	Dredging	$8,300 \times 10^3 m^3$			4	2		Drd 16,000 HP
	E_3	Dredging	$6,800 \times 10^3 m^3$				9	3	Drd 24,000 HP
	E_4	Dredging	$32,300 \times 10^3 m^3$	12		4			Drd 32,000 HP
	E_5	Dredging	$20,300 \times 10^3 m^3$			4		4	Drd 16,000 HP

Fig. VII-3-(2)-1 Construction Schedule (SCA Plan)

Hm.Km	Works	Work Volume	1986	1987	1988	1989	1990	Remarks
Hm220 ~80	Dredging	36,500×10³ m³		5	8			SCA Hopper Drd 6000m³×2
Hm80 ~Km1.5	Dredging	28,800×10³ m³	1					SCA Hopper Drd 6000m³×2
Km1.5 ~61.0	Bank Works	200m			7 8			
	Dredging	51,100×10³ m³	1				9	SCA Drd 38,000HP
Km51.477w ~60.8w	Bank Works	9300m			6			
	Dredging	4,200×10³ m³	5				12	SCA Drd 11,000HP
Km61.0 ~79.0	Bank Works	16,900m	7	12				
	Dredging	39,200×10³ m³	12		10			Drd 32,000HP
Km79.0 ~94.5	Bank Works	13,700m			1	6		
	Dredging	31,300×10³ m³			10		5	Drd 32,000HP
Km94.5 ~101.0	Dredging	16,000×10³ m³	12		4			Drd 16,000 HP
Km101.0 ~115.0	Dredging	20,400×10³ m³	12		11			Drd 32,000 HP
Km115.0 ~122.0	Bank Works	Caisson 16 Pieces	12	12				
	Dredging	24,300×10³ m³		3		6		Drd 16,000HP
Km122.0 ~145.0	Bank Works	Bank 10,500 m Caisson 36 pieces	12		12			
	Dredging	67,600×10³ m³		3			9	Drd 40,000HP
Km145.0 ~162.25	Bank Works	Bank 11,100m Caisson 5 Pieces	12		5			
	Dredging	29,400×10³ m³		3	4		10	Drd 16,000HP → 32,000HP
Great Bitter Lake Anchorage E1	Dredging	16,200×10³ m³			11	10		32,000HP
E2	Dredging	8,300×10³ m³			4	2		Drd 16,000HP
E3	Dredging	6,800×10³ m³				10	4	24,000HP
E4	Dredging	32,300×10³ m³	12		4			Drd 32,000HP
E5	Dredging	20,300×10³ m³			4		4	Drd 16,000HP

Fig. VII-3-(2)-2 Construction Schedule (Alternative Plan J-1)

Hm, Km		Works	Work Volume	1986	1987	1988	1989	1990	Remarks
Hm220 ~ 80		Dredging	36,500×10³m³		3	8			SCA Hopper Drd 6,000m³×2
Hm80 ~ Km1.5		Dredging	28,300×10³m³	1	3				SCA Hopper Drd 6,000m³×2
Km1.5 ~ 61.0		Bank Works	200m	10 11					
		Dredging	42,900×10³m³	1 3		1		7	SCA Drd 35,500HP →15,500HP→35,500HP
Km50.5w ~ 60.8w		Dredging	1,000×10³m³		1		9		Drd 5,500 HP
Km61.0 ~ 79.0		Bank Works	3,500m	12	12				
		Dredging	31,900×10³m³		3	9			Drd 32,000 HP
Km79.0 ~ 94.5		Bank Works	6,200m			1	6		
		Dredging	24,300×10³m³			9		1	Drd 32,000 HP
Km94.5 ~ 101.0		Dredging	13,300×10³m³	12		2			Drd 16,000 HP
Km101.0 ~ 115.0		Dredging	19,600×10³m³	12		10			Drd 32,000 HP
Km115.0 ~ 122.0		Bank Works	Caisson 16 Pieces	1 12					
		Dredging	18,200×10³m³	4		1			SCA Drd 20,000HP
Km122.0 ~ 145.0		Bank Works	Caisson 36 Pieces	12	12				
		Dredging	54,900×10³m³		3			7	Drd 32,000 HP
Km145.0 ~ 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	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
	E₆	Dredging	20,300×10³m³			4		4	Drd 16,000 HP

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

Hm , Km		Works	Work Volume	1986	1987	1988	1989	1990	Remarks
Hm220 ~ 80		Dredging	36,100×$10^3 m^3$	11		7			SCA Hopper Drd 6,000m^3×2
Hm80 ~ Km15		Dredging	25,300×$10^3 m^3$	11 11					SCA Hopper Drd 6,000m^3×2
Km1.5 ~ 61.0		Dredging	42,700×$10^3 m^3$	1 3	11			6	SCA Drd 35,500HP
Km61.0 ~ 79.0		Dredging	30,200×$10^3 m^3$	12		6			Drd 32,000 HP
Km79.0 ~ 94.5		Dredging	21,900×$10^3 m^3$			6	11		Drd 32,000 HP
Km94.5 ~ 101.0		Dredging	12,300×$10^3 m^3$	12		2			Drd 6,000 HP
Km101.0 ~ 115.0		Dredging	19,400×$10^3 m^3$	12		10			Drd 32,000 HP
Km115.0 ~ 122.0		Bank Works	Caisson 16 Pieces	12					
		Dredging	14,900×$10^3 m^3$	4	10				SCA Drd 20,000HP
Km122.0 ~ 145.0		Dredging	Caisson 36 Pieces	12	12				
		Dredging	47,300×$10^3 m^3$		3			4	Drd 32,000 HP
Km145.0 ~ 162.25		Dredging	25,100×$10^3 m^3$	12		2	10		Drd 16,000 HP → 32,000HP
Great Bitter Lake Anchorage	E_1	Dredging	16,200×$10^3 m^3$			10	9		Drd 32,000 HP
	E_2	Dredging	8,300×$10^3 m^3$			4	2		Drd 16,000 HP
	E_3	Dredging	6,800×$10^3 m^3$				10	3	Drd 24,000 HP
	E_4	Dredging	32,300×$10^3 m^3$	12		4			Drd 32,000 HP
	E_5	Dredging	20,300×$10^3 m^3$			4		4	Drd 16,000 HP

Fig. VII-3-(2)-4 Construction Schedule (Alternative Plan J-3)

Hm , Km		Works	Work Volume	Remarks
Hm 220 ~ 80		Dredging	$36{,}100\times10^3 m^3$	SCA Hopper Drd $6{,}000 m^3\times2$
Hm 80 ~ Km 1.5		Dredging	$25{,}300\times10^3 m^3$	SCA Hopper Drd $6{,}000 m^3\times2$
Km 1.5 ~ 61.0		Dredging	$42{,}700\times10^3 m^3$	SCA Drd 15,500HP → 35,500HP
Km 61.0 ~ 79.0		Dredging	$30{,}200\times10^3 m^3$	Drd 32,000 HP
Km 79.0 ~ 94.5		Dredging	$21{,}300\times10^3 m^3$	Drd 32,000 HP
Km 94.5 ~ 101.0		Dredging	$11{,}700\times10^3 m^3$	Drd 16,000 HP
Km 101.0 ~ 115.0		Dredging	$19{,}200\times10^3 m^3$	Drd 32,000 HP
Km 115.0 ~ 122.0		Dredging	$10{,}300\times10^3 m^3$	SCA Drd 20,000HP
Km 122.0 ~ 145.0		Bank Works	Caisson 13 Pieces	
		Dredging	$40{,}200\times10^3 m^3$	Drd 32,000 HP
Km 145.0 ~ 162.25		Dredging	$25{,}100\times10^3 m^3$	Drd 16,000 HP → 32,000 HP
Great Bitter Lake Anchorage	E 1	Dredging	$16{,}200\times10^3 m^3$	Drd 32,000 HP
	E 2	Dredging	$8{,}300\times10^3 m^3$	Drd 16,000 HP
	E 3	Dredging	$6{,}800\times10^3 m^3$	Drd 24,000 HP
	E 4	Dredging	$32{,}300\times10^3 m^3$	Drd 32,000 HP
	E 5	Dredging	$20{,}300\times10^3 m^3$	Drd 16,000 HP

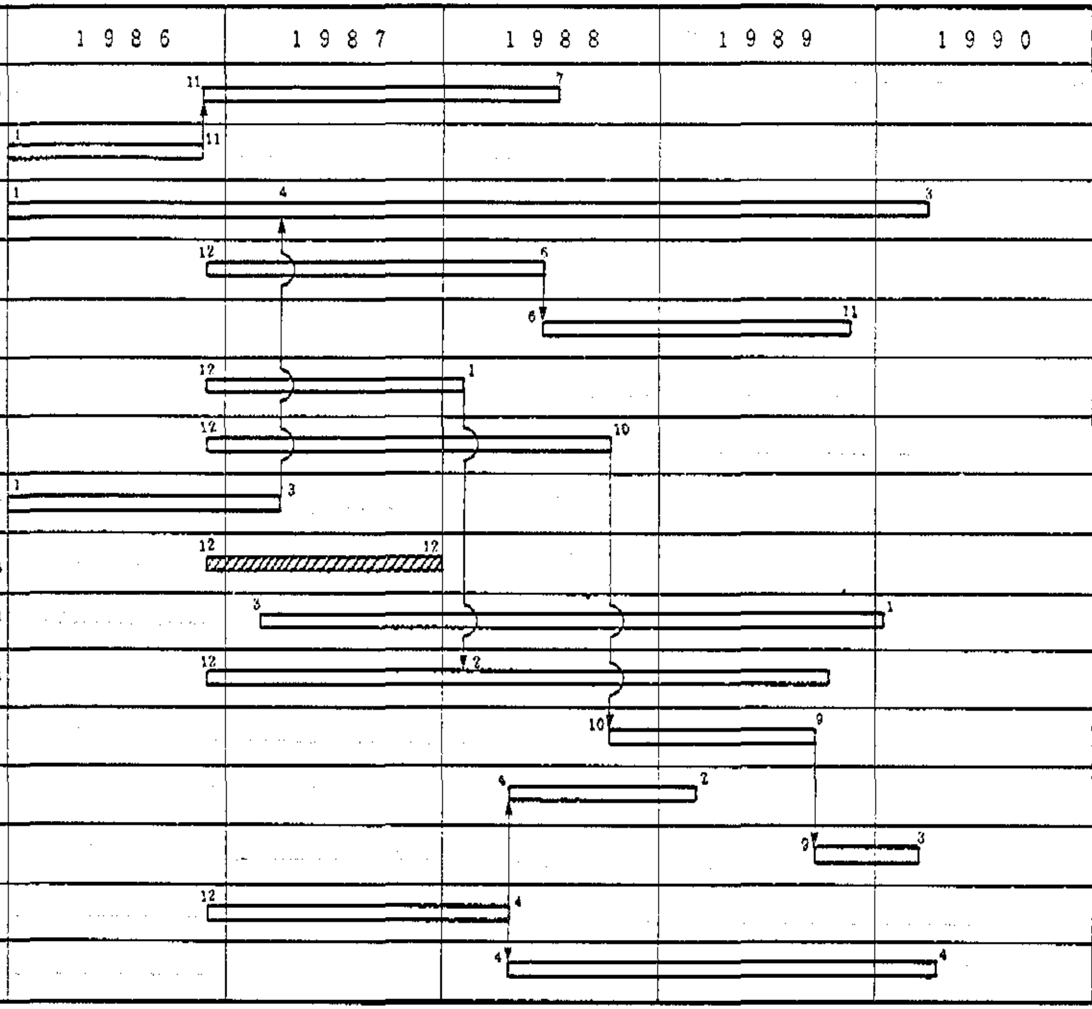


Fig. VII-3-(2)-5 Construction Scheudle (Alternative Plan J-4)

(iv) Construction Cost

i) Unit Cost

The construction cost of the Second Stage Development Project is estimated as follows.

The unit cost of contract dredging is calculated from the monthly dredging volume of each Lot under the Second Stage Development Project estimated based on the actual results of the First Stage Development Project, and from the dredging expenses for one month. Because the dredging expenses of SCA are unknown, the estimation method of the unit cost of SCA's dredging is assumed to be the same as for contract dredging.

The cost of removal of caissons is calculated with the unit cost based on the actual results of the First Stage Development Project, taking account of price hikes.

The unit cost includes a contingency of 10%, but does not include increases due to future inflation.

As for the allotment of local and foreign currencies, in the case of the contract dredging, the dredging expenses per one month are divided into local and foreign currencies, with the foreign currency calculated in Yen, under a conversion rate of ¥250 for 1 US$.

Works other than the contract dredging are divided into local and foreign currencies according to the ratio of cost in the First Stage Development Project.

ii) Construction Cost

The Construction cost of the Second Stage Development Project is shown in Table VII-3-(2)-3.

For LOTs where the soil volume of the deepening dredging is greater than that of widening dredging, dredgers have to wait for the passing of convoys to continue work involving loss of time and high cost.

Therefore, it is better to execute such dredging simultaneously whenever possible. The exchange rate of local currency (LC) and foreign currency (FC) used as a basis for this construction estimate is the average exchange rate of May 1985; 1.40LE = 1 US$ = 250 Yen.

iii) Disbursements for Each Year

The disbursements for each year of the construction schedules (Fig. VII-3-(2)-1 ~ 5) are shown in Table VII-3-(2)-4.

Table VII-3-(2)-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 x 10^3 US$		995,209 x 10^3 US$				833,743 x 10^3 US$				808,748 x 10^3 US$				788,796 x 10^3 US$			

Table VII-3-(2)-4 Cost Disbursement Schedule

Year	SCA Plan		Alternative Plan																	
			J-1						J-2						J-3					
	Dredging		Dredging		Bank Works		Total		Dredging		Bank Works		Total		Dredging		Bank Works		Total	
	LC	FC	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 \$	10^3 LE	10^3 \$
1986	40,539	56,731	39,246	42,210	5,436	1,183	44,682	43,393	38,506	37,415	392	475	38,898	37,890	38,676	46,985	148	425	38,824	47,410
1987	73,733	193,005	78,442	216,979	14,572	3,748	93,014	220,727	75,404	198,238	1,945	1,099	77,349	199,337	72,851	194,062	261	752	73,112	194,814
1988	65,191	186,673	74,490	208,216	10,210	2,495	84,700	210,711	69,217	188,645	2,423	499	71,640	189,144	64,940	187,304			64,940	187,304
1989	43,877	158,797	57,845	183,088	2,377	490	60,222	183,578	53,220	163,545	807	167	54,027	163,712	50,432	171,321			50,432	171,321
1990	1,844	17,106	33,699	110,859			33,699	110,859	17,895	58,082			17,895	58,082	12,399	36,680			12,399	36,680

Year	J-4					
	Dredging		Bank Works		Total	
	LC	FC	LC	FC	LC	FC
1986	10^3 LE	10^3 \$	10^3 LE	10^3 \$	10^3 LE	10^3 \$
	38,408	46,892	8	23	38,416	46,915
1987	72,320	193,763	94	271	72,414	194,034
1988	64,908	186,917			64,908	186,917
1989	50,073	169,234			50,073	169,234
1990	7,030	25,381			7,030	25,381

2) Maintenance Dredging

Although maintenance dredgings is necessary to keep the Canal functioning, the dredgers are obstructions for the transit vessels and are one of the factors causing accidents.

As accidents between dredgers and transit vessels are apt to block the Canal, maintenance dredging should maximize efficiency and minimize accidents by using as few dredgers as possible.

For this reason, it is necessary to do a detailed survey of the whole Canal so as to dtermine the appropriate locations and opportunities for maintenance dredging.

At present, as mentioned before, the Port Said approach channel area is being surveyed at 10 meter intervals using a survey boat equipped with the Sea Fix System, but the Canal area is being surveyed on the center line only.

In the case of a detailed survey, the percentage of the surveyed area covered would be very low if the survey were executed using the echo sounder (the narrow beam angle of the sonar is only 3 degrees) presently owned by SCA.

If the survey of the 19.5 meter deep channel is executed using the echo sounder mentioned above, the percentage covered would be as follows:

In the case of 25 meter pitch : 8 percent

In the case of 10 meter pitch : 20 percent

In hydrographic surveys in Japan we use a total of four sonars whose narrow beam angles are 8 and 3 degrees each and they are set as shown in Fig. VII-3-(2)-6.

As we are doing surveys making the non-sounding width less than 10 meters as shown in Fig. VII-3-(2)-7, the percentage covered by becomes more than 62 percent.

It seems that the Suez Canal should be surveyed using a similar coverage percentage.

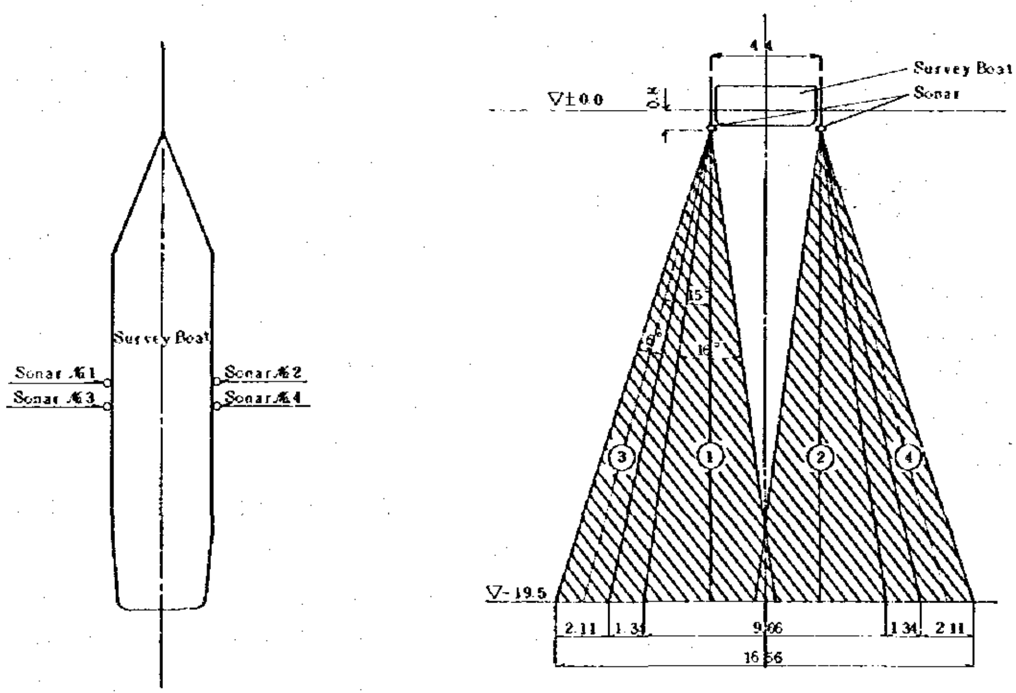


Fig. VII-3-(2)-6 Example of the Sonar Setting

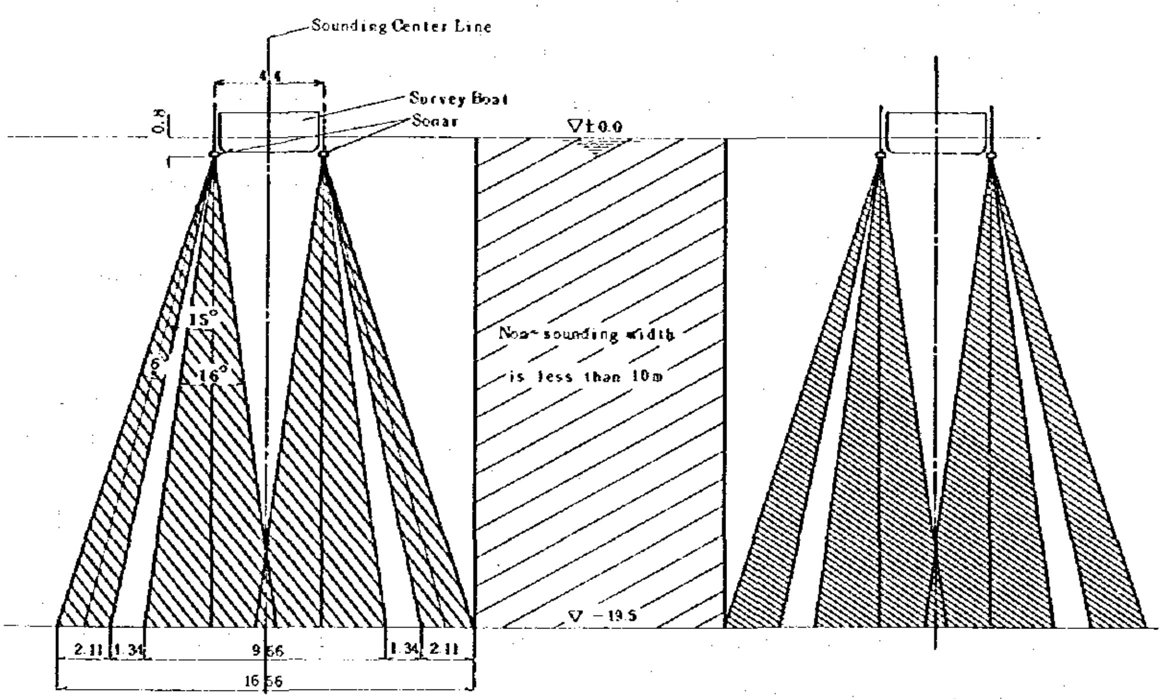


Fig. VII-3-(2)-7 Sounding Pitch

3) Measures for Prevention of Accidents

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

Of course, the work vessels engaged in this work should never interfere with the navigation of transit vessels, whatever may happen.

Still, it is a fact that accidents between dredgers and transit vessels are still occurring even now that the First Stage Development Project has been completed.

Accidents occurred involving dredgers and floating pipelines, but especially involving dredgers, in 1981 and 1982.

The main cause was the high speed of the transit vessels. Such accidents are apt to involve sinking and consequent Canal Blockage, so they must be avoided.

Measures for preventing accidents between dredgers and transit vessels are shown below.

(i) Common Items

i) Two hours prior to the expected time of passage of the transit vessels, the Transit Department communicates this information to the dredgers by wireless.

ii) In the case of the passing of transit vessels, in principle the dredgers and their accessories such as operation anchors are not left in the fairway of the Canal.

iii) The floating pipelines must be equipped with flashing red signal lights every 40 meters so that they will be readily visible, even at night, from transit vessels.

iv) Craft, such as service boats and anchor barges, must be moored on the bank side of the dredgers.

v) If there is some trouble during dredging works, the captain of the dredger must inform the Transit Department by wireless at once.

(ii) In the case of Deepening or Maintenance Dredging

i) Dredgers must be shifted completely outside the navigation buoy line at least 30 minutes prior to the expected time of passage of the transit vessels, and the dredgers must have an adequate monitoring system to be able to cope with any unexpected occurrences during the passage of the vessels.

ii) Should a dredger be unable to move due to some trouble, the captain must inform the Transit Department by wireless at once.

Following that, the Transit Department contacts the pilots who are on board the transit vessels by wireless. Pilots who receive such communications either reduce the speed of the transit vessels or stop, depending upon the situation, and wait for further instructions.

iii) Dredgers which are unable to shift completely outside the line due to the relation between the dredging depth and spud length should not be used for this type of work. Appropriate vessels which can shift outside the line should be chosen, or if necessary, vessels should be modified in some way so that they can shift outside the buoy line.

(iii) In the case of Widening Dredging

i) In these cases, it seems that there are no problems because the dredgers are already dredging outside the navigation buoy line.

However, it is necessary to check whether the floating pipelines are outside the line, and to adopt the same monitoring system mentioned above during the passing of the transit vessels.

ii) Even for widening dredging operations, officers of the Transit Department may determine that during the passage of certain transit vessels it is best to stop the dredging work. When the Transit Department officers make such a decision, they should inform the dredger by wireless.

(iv) Others

i) When submerged pipelines are to be used, the top level and the position of the lines must be verified before they can be used.

ii) Pilots on board transit vessels must be informed about the locations of dredgers each day and be given advance notice of locations which require special caution.

iii) The dredgers must not change execution methods without informing the Transit Department.

Although these safety countermeasures are included in SCA's measures for prevention against accidents which are customarily in use at present, a meeting of the persons concerned, i.e. pilots, captains of dredgers, and members of the transit department, should be held to be formalize SCA's safety countermeasures into written documents. Furthermore, it is necessary to make these guidelines clearly understood by all the staff members concerned.

(3) Navigation

1) Countermeasures Against Sandstorm

As stated in the section on the discussions of the accident records of the SCA, the curves showing the frequencies of collision and grounding accidents per month agree with those showing the occurrence of strong winds per month to a considerable degree. This clearly shows that sandstorms play a part in causing a considerable number of accidents, and hence it is necessary to establish effective countermeasures.

(i) Widening and Deepening of the Canal

When a comparison is made between the frequency of accidents and sandstorms during the periods before and after the First Stage Development Project, it is clear that the relationship has been considerably weakened since the completion of the work as far as the Canal water zone is concerned. This indicates that the widening/deepening of the Canal has played a considerable role in reducing the frequency of accidents due to sandstorms.

(ii) Critical Wind Velocity for Restricting Transit

Fig. VII-3-(3)-1 shows the relationship between the critical wind velocity and the ship speed of a fully loaded 150,000 DWT type tanker with a water depth/draught ratio of 1.3, under the effects of strong winds.

It is shown that when the vessel's speed is 7 knots, rudder angle 15°, and the relative wind direction to the vessels is 90°, the course-keeping ability of the vessel is lost at a relative wind velocity of 17 m/sec.

Fig. VII-3-(3)-2 shows how the relationship between the critical relative wind velocity and vessl's speed changes by type of vessel such as tanker, container vessel and PCC at a rudder angle of 15° and with a relative wind direction of 90°.

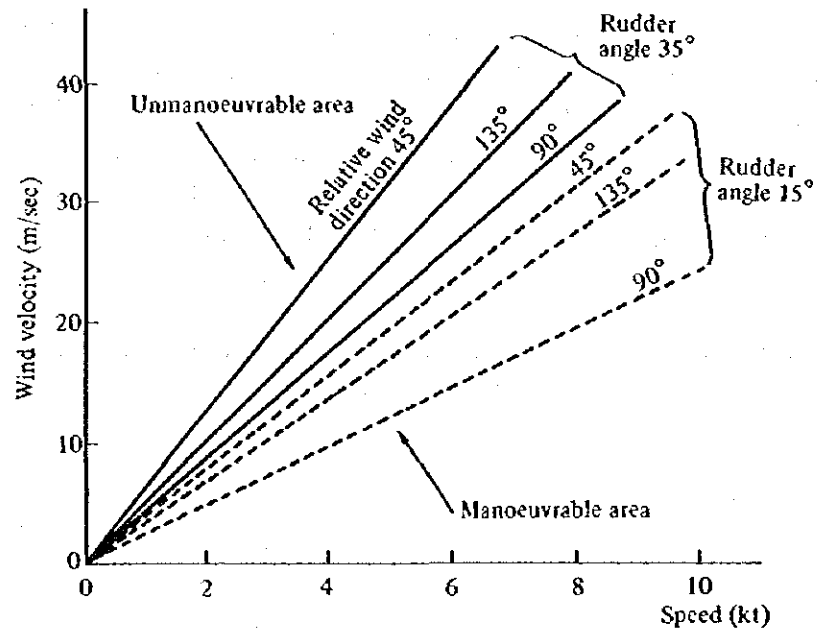


Fig. VII-3-(3)-1 Limit of Wind Velocity for Maintaining Manoeuvrability

Source: The Japan Association for Preventing Marine Accidents

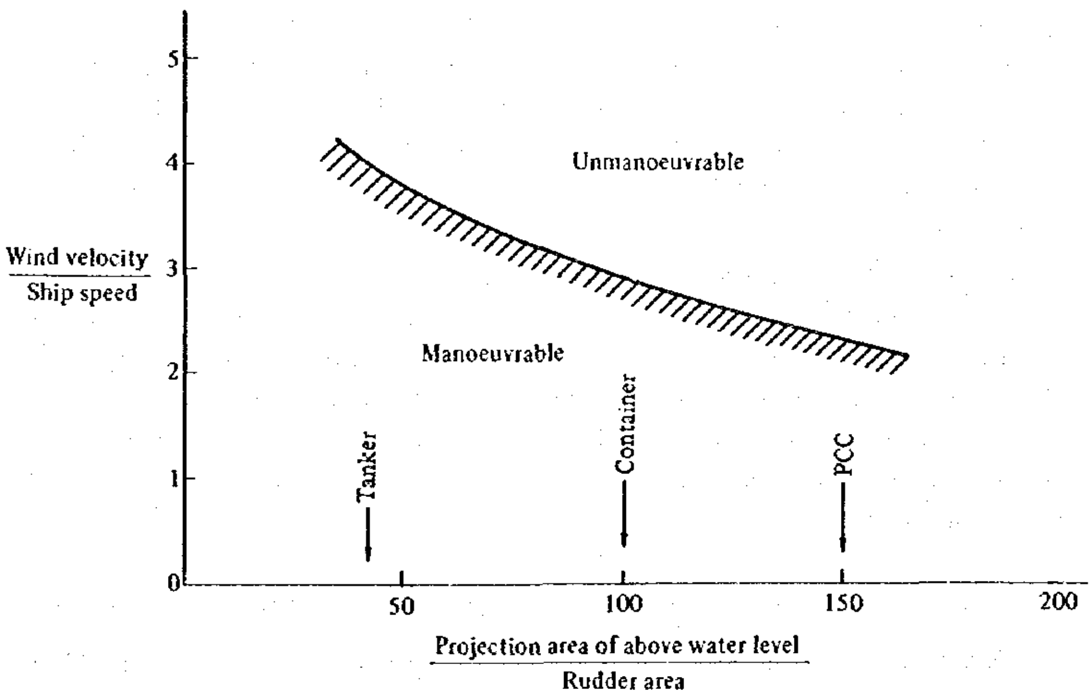


Fig. VII-3-(3)-2 Minimum Value of Critical Wind Velocity at a Rudder Angle of 15°

Source: Japan Captains' Association

It is shown that when the rudder angle is 15° and the relative wind direction to the vessel is 90°, the manoeuvrability is lost if the relative wind velocity is about 4 times the vessel's speed for tankers, about 3 times for container vessels, and about 2.3 times for PCC.

Therefore, in terms of true wind direction and wind velocity, the manoeuvrability of tankers is lost at the true wind direction of 104° and wind velocity of 14.9 m/sec, container vessels at 108° and 12.3 m/sec, and PCC at 114° and 9.8 m/sec as shown in Table VII-3-(3)-1.

Table VII-3-(3)-1 Critical Wind Direction and Velocity for Course-keeping Ability of Transiting Vessels

	Transit Speed	Relative		True	
		Wind Direction	Wind Velocity	Wind Direction	Wind Velocity
Tanker	13 km/h 3.61 m/sec	90°	14.4 m/sec	104°	14.9 m/sec
Container	14 km/h 3.89 m/sec	90°	11.7 m/sec	108°	12.3 m/sec
PCC	14 km/h 3.89 m/sec	90°	8.9 m/sec	114°	9.8 m/sec

(Wind direction: From ship's head)

The criterion for judging the closure of the Canal or for re-stricting vessels' transit presently referred to as the operational standards is 50 km/h (13.9 m/sec), and such a value is considered to be generally appropriate for tankers. However, the above criterion is not necessarily appropriate for those container vessels and PCC whose ratio of above water line longitudinal profile area to rudder area is 50 or more. In this connection, it is suggested that such relative wind velocity criteria be amended to roughly 12 m/sec for container vessels and 10 m/sec for PCC.

(iii) Visibility Criteria for Restricting Transit

It is normally said that the appropriate speed for vessels under restricted visibility is such that the vessels can stop in a distance corresponding to half the visibility for two-way traffic, or a stopping distance equal to the visibility for one-way mode traffic.

In the case of the Suez Canal, the transit speed of the vessels is fixed. Therefore, from the table given in Section II-4, Traffic and Anchorage Conditions, we can extract the data as shown below:

Deadweight	Initial speed	Necessary visibility (d)	d x 3
30,000	14 km/h	580 m	1,740 m
60,000	14 km/h	740 m	2,220 m
140,000	13 km/h	1,100 m	3,300 m
250,000	13 km/h	1,250 m	3,750 m

If we postulate that stopping distance in the Canal generally requires 3 times the ordinary stopping distance, then the necessary visibility is also 3 times greater under the same principle.

In the case of the Uraga Suido traffic route of Tokyo Bay, the visibility criteria for traffic restrictions have been established as below:

Vessel	Visibility
Vessels with a length of 200 m or more, and liquefied gas carriers of 25,000 GT or more	1 mile or below
Vessels of 10,000 GT or more other than the above	1,000 m or below

Considering the special conditions of the Suez Canal, it may be fairly difficult to establish appropriate visibility criteria, but in light of the concept shown above and the example of the Uraga Suido traffic route of Tokyo Bay, the current criterion of 300 m visibility for the closure of the Canal sounds too small.

We consider that further studies on this matter are necessary.

2) Safety Measures for Mooring Operation of Vessels in the Ballah West Channel

Accidents in waters in the vicinity of El Ballah are mostly groundings or contacting the Canal banks in the mooring operations of the 2nd southbound convoy vessels.

In association with the completion of the First Stage Development Project of the Canal, and the use of tug assistance in mooring operations, the frequency of accidents has been reduced considerably. However, 10 to 20 accidents are still occurring each year.

Unskilled ship manoeuvring techniques and the drifting force of wind may be considered as the probable causes of accidents, but the influences of bank suction and the effects posed by the inclined Canal bottom are also believed to be extremely large.

In view of the above, instructive guidance should be given to pilots serving in this area so that they can handle vessels safely by taking sufficient account of the effects of bank suction and the effects of the shallow inclined bottom. At the same time, improvement in tug assisting procedures should also be achieved by giving necessary instructions to those concerned.

Following are reference materials that help better understand the effects of bank suction and the effects of the shallow inclined bottom.

(i) Bank Suction Effect

The United States Navy conducted experiments in connection with the widening project of the Panama Canal on suction forces exerted on vessels by the banks of canals while vessels proceed through the canals, and the results of the experiments were summarized in convenient nomograms and made public.

Figs. VII-3-(3)-3 and 4 are parts of the nomograms.

Now a vessel is supposed to proceed along a canal in parallel with the centerline thereof at a distance y from the centerline at a speed v. In this case, if the vessel deviates along a course closer to the right-hand bank of the canal, then the vessel is subjected to a lateral force F acting on the vessel to bring her further to the right and moment M to swing the bow towards the centerline of the canal as shown in Fig. VII-3-(3)-5.

i) Lateral Force F

In Fig. VII-3-(3)-3, the relationships among coefficient C_F of lateral force F, the ratio of canal width b to vessel's breadth B, b/B, and the ratio of deviation y of the vessel's course from the centerline of the canal to the vessel's breadth B, y/B, are shown.

Lateral force F can be obtained by the formula below:

$$F = C_F \times 1/2\, \rho\, L d v^2$$

where

F : lateral force (kg)

ρ : density of water (SW ≒ 104.5, FW ≒ 102.0 $kg \cdot sec^2/m^4$)

L : length of vessel (m)

d : mean draft (m)

v : vessel's speed (m/sec)

Note, however, that Fig. VII-3-(3)-3 shows the case where the ratio of water depth h to mean draft d, h/d, is 1.40, and when the ratio is outside 1.40, corrections are necessary.

The coefficient of correction, α is shown in Fig. VII-3-(3)-4, and by multiplying C_F by α given in Fig. VII-3-(3)-4, C_F in cases where h/d is outside the value of 1.40 can be obtained.

ii) Turning Moment M

Turning moment M can be obtained by multiplying the lever of the moment by lateral force F as below:

$$M = F \times (L \times \beta)$$

where

β : to be obtained from Fig. VII-3-(3)-4

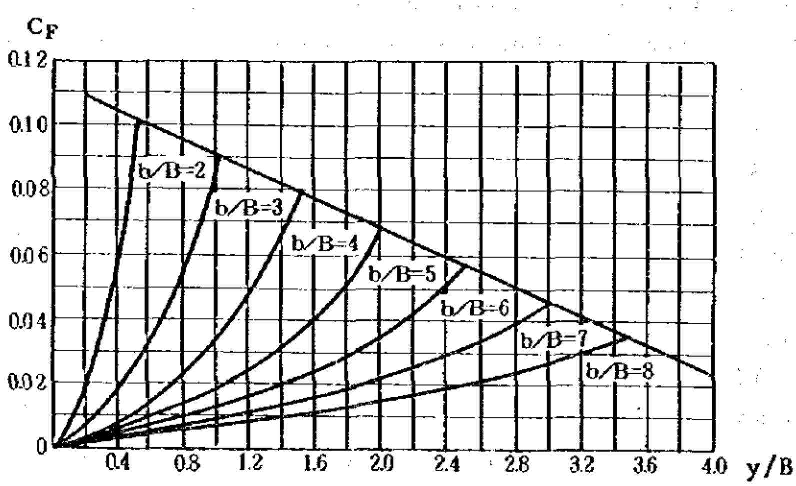


Fig. VII-3-(3)-3 Coefficient for Lateral Force (h/d = 1.40)

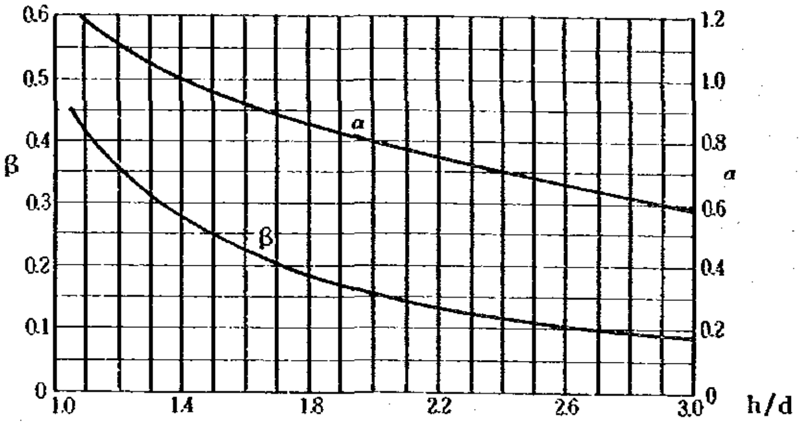


Fig. VII-3-(3)-4 Coefficient for Correction of Lateral Force and for Turning Moment

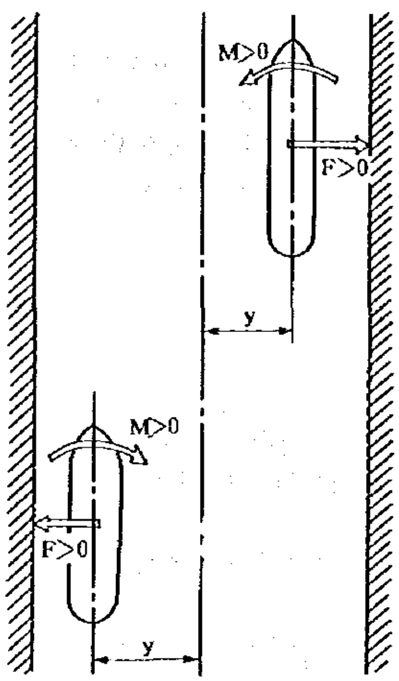


Fig. VII-3-(3)-5 Lateral Force and Turning Moment

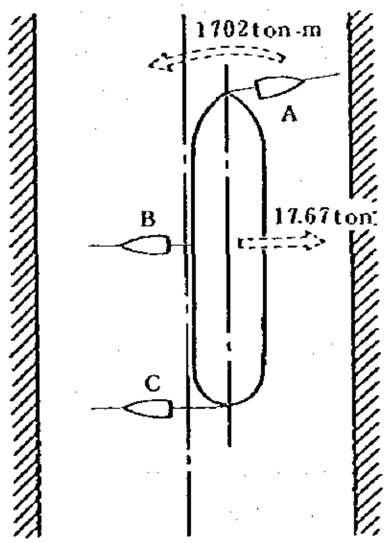


Fig. VII-3-(3)-6 Required Tugs for Cancelling Lateral Force and Turning Moment

iii) Calculation Examples

Lateral force and turning moment when
width of canal b = 300 m
water depth h = 20 m
ship's length L = 290 m
ship's breadth B = 47.5 m
draft d = 16 m
ship's speed v = 2.5 m/sec (approximately 5 knots)
distance of vessel's centerline from that of canal

$y = 50$ m

Can be obtained as below:

$y/B = 50/47.5 = 1.05$

$b/B = 300/47.5 = 6.32$

$h/d = 20/16 = 1.25$

From Fig. IV-3-(3)-3 $C_F = 0.0108$

From Fig. IV-3-(3)-4 $\alpha = 1.08, \beta = 0.332$

$$F = C_F\ 1/2\ \rho\ Ldv^2\ \alpha$$
$$= 0.0108 \times 104.5 \times 1/2 \times 290 \times 16 \times 2.5^2 \times 1.08$$
$$= 17673.9 \text{ kgs} \fallingdotseq 17.67 \text{ tons}$$

$$M = FL\beta$$
$$= 17.67 \times 290 \times 0.332$$
$$= 1701.6 \text{ ton m}$$

If two tugs A and C of equal pull are arranged at the bow and the stern for cancelling out the turning moment and another tug B is arranged for obtaining a state of lateral equilibrium against the lateral force depicted in Fig. VII-3-(3)-6, the required powers of these tugs can be computed as below assuming that 100 HP is equivalent to 1 ton:

Tugs A and C: 590 HP ca.

Tug B: 1,770 HP

(ii) Effects of Inclined Canal Bottom

When a vessel proceeds through shallow water involving an inclined sea floor along the contour line, the vessel is subjected to a turning moment, pushing the bow of the vessel towards the deeper side.

The measured rudder angles necessary for cancelling out such a turning moment are shown in Fig. VII-3-(3)-7.

This represents part of the results of an investigation conducted by the Royal Navy of the UK on the causes of grounding damage of naval craft.

The inclination vs. water depth/draught and the rudder angles necessary for proceeding in parallel with the contour line of the waterway are plotted for each speed.

It may be seen that the shallower the water depth, and the higher the vessel's speed, the greater the amount of check rudder.

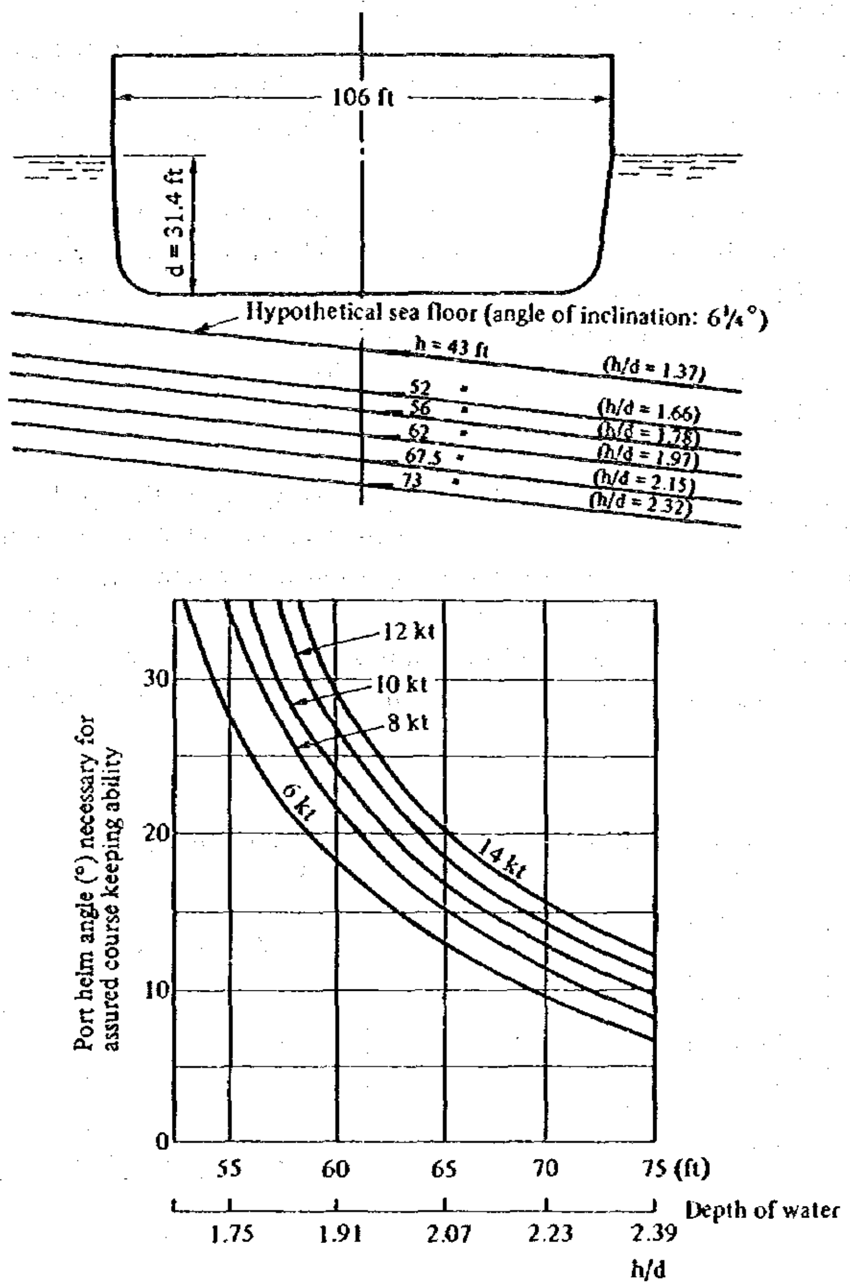


Fig. VII-3-(3)-7 Helm Angle Necessary for Cancelling Out Turning Moment Caused by Inclination of Sea Floor

3) Qualification, Fitness, Education and Training of Pilots

Given in Table VII-3-(3)-2 are the tanker accidents in the Panama Canal during the 3-year period from 1981 to 1983 classified by cause into those due to human error and those from other causes. From this table, we see that 84.6% of the total tanker accidents in question were caused by some human error.

Given in Table VII-3-(3)-3 are the collision accidents in the five major rivers and channels in Europe during the 5-year period from 1959 to 1963 classified likewise by cause into those by human error and those not by human error, where it is indicated that 73.9% of the total collision accidents in question were caused by ship operation errors.

Table VII-3-(3)-4 gives the marine casualties requiring rescue which occurred in the coastal waters of Japan during the 5-year period from 1978 to 1982 similarly classified by cause.

Here, 71.2% of the total accidents was human-caused.

In the case of the Suez Canal, as stated in the discussion on the accidents record in the Preliminary Study Team format, human error caused as high as 82.8% of the accidents. As was mentioned in the section dealing with the comparison of the frequency of accidents in the Suez Canal with those in other canals, strict statistical comparison can not be made due to differences in accident classifications and statistical procedures. However, the Suez Canal seems to be the second highest, after the Panama Canal, in terms of human-caused accidents.

Table VII-3-(3)-2 Tanker Accidents in the Panama Canal from 1981 to 1983

	Number of Accidents	Fault	Non Fault
1981	15	13	2
1982	20	18	2
1983	17	13	4
Total	52	44 (84.6%)	8 (15.4%)

Table VII-3-(3)-3 Causes of Collisions in 5 Waterways (Scheldt, Elbe, Thames, Maas and Wesser) from 1959 to 1963

Mistakes	73.9%
Course crossing, leaving harbour	12.4%
Wrong manoeuvre, bad seamanship	11.8%
Communications failure or no communication	10.8%
Unexpected manoeuvres	7.8%
Buoy, beacon or ship not seen or seen too late	6.9%
Too high speed	4.6%
Misjudgement of wind or current	4.0%
Unsuccessful evasion manoeuvre	3.6%
Wrong overtaking	3.6%
Wrong position finding	2.3%
Insufficiently equipped ship	1.6%
Other manoeuvre mistakes	4.6%
Non mistakes	13.7%
Cause unknown	12.4%

Table VII-3-(3)-4 Number of Marine Casualties in or Near Coastal Waters of Japan Requiring Rescue by Causes

		1978	1979	1980	1981	1982	Total
Marine Casualties by Human Causes	Navigational Error	1,275	1,079	1,159	1,048	1,129	5,690
	Wrong Machinery Handling	359	312	304	293	265	1,533
	Careless Handling of Flammable/Combustible Substances	122	106	75	93	86	482
	Wrong Cargo Stowage	36	48	37	30	37	188
	Sub Total	1,792	1,545	1,575	1,464	1,517	7,893
	(%)	76.0	72.0	66.0	70.9	71.0	71.2
Marine Casualties by Non-human Causes	Force Majeure	180	290	553	315	374	1,712
	Materials and Construction	265	233	200	213	195	1,106
	Cause Unknown	91	67	45	65	38	306
	Others	29	10	13	10	13	75
	Sub Total	565	600	811	603	620	3,199
	(%)	24.0	28.0	34.0	29.1	29.0	28.8
	Total	2,357	2,145	2,386	2,067	2,137	11,092

Although such marine casualties due to human causes are in many cases, due to errors or poor technique on the part of the crewmembers serving on the transit vessels, many of the accidents can be attributed to pilots' unskilled ship manoeuvring techniques and errors.

In recognition of the grave importance attached to the Suez Canal as an international waterway, it is imperative for the SCA to maintain the knowledge and techniques of those pilots engaged in pilotage services for vessels transiting the Canal at reasonably high levels.

It is therefore recommended that the SCA should exert its utmost effort for the proper maintenance of the technical skills of the pilots by taking the following items into account.

(i) Qualifications

As was mentioned in the section on the evaluation of the current status of the Canal, there is no age limit to enroll to become a pilot in the Suez Canal at present. However, it is desirable to establish a certain upper age limit, such as 35 years old, and qualifications should also be set for the Chief Mate's license for ocean-going vessels.

Under reasonable acceptance criteria, good candidate must be employed, and be subjected to special education and training for a period of one to two years.

(ii) Fitness

Under the special occupational requirements inherent to pilotage services involving duties late at night and early in the morning, long continuous manoeuvre service under tension, and other difficult conditions, pilots must be in good health both mentally and physically. Further, they are required to possess highly specialized knowledge, technique and experience. In this connection, they must all undergo periodical physical fitness examinations, and other periodic checks on their professional ability and skills so that their fitness can be warranted at all times.

To ensure the above, reasonable measures for those who fail to pass fitness examinations must be provided. For example, appropriate posts could be offered e.g., as instructors to educate and train candidates, and/or a system of pension for ex-pilots could be established.

(iii) Education and Training

For the maintenance and improvement of pilots' knowledge and techniques, opportunities should be offered for their periodic re-education and retraining.

The items to be covered under such re-education and retraining should include not only items related to technological innovations and new techniques, but also the necessary knowledge and procedures for communications and liaisons for emergencies likely to occur within the waters of the Canal, and specific knoweldge on the management and control services of the Canal.

For ship manoeuvring training, ship manoeuvring simulators must be introduced.

Training through the use of ship manoeuvring simulators is considered effective for the training of candidates as well as for the maintenance and retraining of ship manoeuvring techniques for experienced pilots.

Table VII-3-(3)-5 to VII-3-(3)-8 give an outline of the major ship manoeuvring simulators of the world, ship manoeuvring simulator training programme, training courses and trainees, and an overview of the on-going ship manoeuvring training through the use of such simulators.

Simulators are considered to be highly effective for exercising various items of training for ship manoeuvring without involving any difficulties in the actual passage through the Canal. Exercises can include mooring to the Canal banks, emergency stopping in the water of the Canal, mooring operations at the waiting buoy berth, and docking/undocking manoeuvres at quay.

Table VII-3-(3)-5 Major Ship Manoeuvring Simulators of The World

	Organization	Country	Name	Owner	Operator	Start date	Use	Cost of construction (including estimated cost in part) (billions of yen)	Location
USA	CAORF	USA	Computer Aided Operations Research Facility	DOC of USA Shipping Administration (non-private)	Grumman ADI Transportation Systems	Jan., 1976	Research (training)	5.0 to 7.0	Kings Point
USA	MSI	USA	Marine Safety International	MSI (private)	MSI	Nov.,1976	Training	about 0.5	New York
USA	Ship Analytics	USA	SIMSHIP	USCG Ship Analytics (semi-private)	Ship Analytics	Apr., 1980	Research and training	about 1.0	Stonington
USA	MITAGS	USA	Marine Institute of Technology and Graduate Study	MITAGS (private)	MITAGS	1981	Training	1.0 for No. 1 for day service 1.0 for No. 2 for night service (excluding the buildings)	Baltimore
Europe	The College of Nautical Studies, Warsash, Southampton	UK	Racal-Decca Ship Simulators	The College of Nautical Studies (non-private)	The College of Nautical Studies, Warsash, Southampton	1st Mar., 1977 2nd Feb., 1981	Research and training	about 0.2	Southampton
Europe	CARDIFF	UK	The CARDIFF Ship Simulator	DOI of UK (non-private)	UWIST*1 SGIHE*2	Early 1982	Research and training	about 1.0	Cardiff
Europe	Netherlands Ship Model Basin, Wageningen	Holland	Netherlands Ship Model Basin	Netherlands Ship Model Basin (non-private)	Netherlands Ship Model Basin	1st Nov., 1970 2nd Nov., 1976	Research and training	0.4 to 0.5	Wageningen
Europe	T.N.O.-Institute for Mechanical Constructions, Delft	Holland	SMS Ship Manoeuvring Simulator	T.N.O.-Institute for Mechanical Constructions (non-private)	IWECO-T.N.O.-Institute for Mechanical Constructions	Apr., 1968	Research and training	0.15 to 0.2	Delft
Europe	T.N.O.-Institute for Perception, Soesterberg	Holland	Simulator for the Study of Navigation and Driving Behaviour	T.N.O.-Institute for Perception (non-private)	T.N.O.-Institue for Perception	Jan., 1976	Research	0.15 to 0.2	Soesterberg

Major Ship Manoeuvring Simulators of The World (cont'd)

	Organization	Country	Name	Owner	Operator	Start date	Use	Cost of construction (including estimated cost in part) (billions of yen)	Location
Europe	Royal Netherlands Naval College	Holland	Manoeuvring Simulator	Royal Netherlands Naval College (non-private)	Royal Netherlands Naval College	Aug., 1975	Training	0.15 to 0.2	Den Helder
	Hochschule für Nautik Bremen	West Germany	Ship Handling Simulator	Hochschule für Nautik Bremen (non-private)	Hochschule für Nautik Bremen	Mar., 1975	Education of students and retraining of officers	0.2 to 0.3 for each one for day and night service	Bremen
	Fachhochschule Hamburg, Fachbereich Seefahrt	West Germany	SUSAN Schiffsfuhrungs-Simulator	Fachhochschule Hamburg, Fachbereich Seefahrt (non-private)	Fachhochschule Hamburg, Fachbereich Seefahrt	Mar., 1982	Research and training	1.5 to 2.0	Hamburg
	Swedish Maritime Research Centre	Sweden	SSPA Manoeuvring Simulator	SSPA (non-private)	SSPA	1967	Research and training	0.2 to 0.3	Göteborg
	Ship Manoeuvring Simulator, Trondheim	Norway	SMS- Ship Manoeuvring Simulator	Goverment of Norway (non-private)	Ship Manoeuvring Simulator, Trondheim	July, 1979	Retrainings of Masters, officers and pilots, and education and research at nautical college	0.5 or more	Trondheim
Japan	Ishikawajima-Harima Heavy Industries Co., Ltd., Tanashi	Japan	IHI Ship Manoeuvring Simulator	IHI (private)	IHI	June, 1975	Research and training	0.25	Tokyo

*1 UWIST-University of Wales Institute of Science and Technology

*2 SGIHE-South Glamorgan Institute of Higher Education

Source: Japan Captains Association

Table VII-3-(3)-6 Overview of Ship Manoeuvring Simulators of The World

Organization		Description
USA	CAORF	The world largest ship manoeuvring simulator. It enables the trainees to study ship manoeuvring techniques, Rules-of-the-Road, ports and harbours and waterways by postulating the seafarers and vessel as a man-machine system. The major research themes are: (1) ship manoeuvring in ports and waterways (waterway analysis), (2) standards for simulator training and licensing (demand for qualification and training), (3) evaluation and specification of wheelhouse, (4) watch-keeping standards, and (5) demand for ship manoeuvring response to ships (manoeuvring and navigation)
	MSI	The organization is a company which undertakes the training of seamen, and its objectives are to establish itself as an integrated training centre for sea-going personnel, utilizing a cargo operation simulator, a radar simulator, and an engine simulator as well as a ship manoeuvring simulator.
	Ship Analytics	The simulator was designed and manufactured by the company with the assistance of the USCG, and the company undertakes research work and training of seamen. In addition to the ship manoeuvring simulator, a cargo operation simulator (CGI-Color), and a bird's-eye view ship simulator are available.
	MITAGS	The construction and operating capital are mainly supplied by shipowners. In addition, oil companies, pilots, the ship masters' association and the officers' association have seemingly shared part of the expenses. This is an integrated training centre provided with two ship manoeuvring simulators (for day and night services), a radar simulator, a tanker cargo operation simulator, an engine simulator, and an LNG cargo operation simulator. Aside from the above, it is further provided with accommodations, dining rooms, a library, and an audio-visual training room invested at a total sum of 10 billion yen.
Europe	The College of Nautical Studies, Warsash, Southampton	This is a ship manoeuvring simulator for night service. Under the same specifications, similar facilities are now under construction at Glasgow and South Shields. The same training programme can be used at these new installations.
	CARDIFF	
	Netherlands Ship Model Basin, Wageningen	The Netherlands is well known as a pioneer in the use of simulators for ship manoeuvring training. Particularly, the Netherlands Ship Model Basin is famous. The NSMB represents the first full-fledged large simulator and is typical among those commercially operated at present. It is said that the training fee is in a range from one to two million yen for a one-week long course.

Overview of Ship Manoeuvring Simulators of The World (cont'd)

Organization		Description
Europe	T.N.O.-Institute for Mechanical Constructions, Delft	
	T.N.O.-Institute for Perception, Soesterberg	
	Royal Netherlands Naval College	
	Hochschule für Nautik Bremen	The Hochschule für Nautik Bremen is equipped with a navigation light simulator installed in March, 1978 in addition to the ship manoeuvring simulator, and it is operated under the spot light system (12 ~ 16 light spots, colour, radius of cylindrical screen is 6 m, screen angle is 315°) and is used for ship manoeuvring training of students.
	Fachhochschule Hamburg, Fachbereich Seefahrt	This is a large ship manoeuvring simulator under the C.G.L. system installed in the premises of the Fachhochschule Hamburg, Fachbereich Seefahrt in 1982.
	Swedish Maritime Research Centre	
	Ship Manoeuvring Simulator, Trondheim	This was installed at Trondheim in July, 1979 by the Government of Norway, and it is aimed at training ship masters, chief mates and pilots.
Japan	Ishikawajima-Harima Heavy Industries Co., Ltd., Tanashi	This is a medium-size ship manoeuvring simulator manufactured in 1975. Because of multiple faults found in this simulator, it is strongly desired to replace it with a full-fledged ship manoeuvring simulator.

Table VII-3-(3)-7 Training Courses and Trainees

	Organization	Training Course	Trainees/Course	No. of Trainees per Year	Qualification of Trainees	Purpose	Evaluation of Courses by Trainees
USA	CAORF	Simulator training course for Masters Training course for students of the Naval Academy Rules-of-the-Road training course for Masters	6 trainees/course (1979)	54 (1979) 18 (1979) 18 (1977)	Sea-going experience as Chief Mate holding Chief Mate license Senior class cadet (Kings Point) (Fort Schuyler) One year or more of sea-going experience boarding on VLCC holding Master or Chief Mate license	Upgrading ship manoeuvring skills Upgrading ship manoeuvring skills New international Rules-of-the-Road	Available
USA	MSI	Pre-command and fundamental ship manoeuvring simulator training course Training course for Lake and Harbour pilots and Dockmasters Training courses for VLCC and LNG Training courses for bridge watch Course for studying topographs and harbour facilities	4 2 (min) ~ 4 (max) 2 (min) ~ 4 (max) 4 2 (min) ~ 4 (max)	80 40 40 20 20 (200 in total)	Master or Chief Mate license Lake and Harbour Pilot or Dockmaster license Master, Chief Mate or Quartermaster license for LNG carrier Officer or student of Naval Academy Master or Chief Mate license	Upgrading ship manoeuvring skills in restricted water areas Docking ship manoeuvring training for various conditions Ship manoeuvring training for special vessels and on-the-job training of bridge watch Studies on bridge watch-keeping standards of IMO and exercise of bridge watch Training for decision-making in an emergency, ship manoeuvring training in specific ports under varying conditions	Available
USA	Ship Analytics						
USA	MITAGS	4 x 4 groups x 2 units of simulator 32 men for one time Training fee differs according to the status of membership. Organizations who deposit funds are registered as members. As this is an integrated training centre, 100 trainees can be accepted at all times.					
Europe	The College of Nautical Studies Southampton	Courses on bridge organization and team work Training course for pilots	16 (4 x 4 groups)	abt. 640 (16 x 40 weeks) A total of 1,200 trainees took the courses per year since 1977. Fully reserved for the next one year.	Young officer/Master As least two out of four must be senior officers or Masters.	General ship manoeuvring retraining/reeducation for Masters and officers Studies on new navigational knowledge and techniques	Available
Europe	CARDIFF						

	Organization	Training Course	Trainees/Course	No. of Trainees per Year	Qualification of Trainees	Purpose	Evaluation of Courses by Trainees
Europe (cont'd)	Netherlands Ship Model Basin Wageningen	Fundamental course for EUROPORT pilots Ship manoeuvring simulator training for VLCC Special training course	6 Fundamental course 4 or below Special training course	abt. 100 (20 weeks)	Fundamental course – Ocean-going Master, Pilot and Master of ferry Special course – Senior officer, Master and Pilot	Ship manoeuvring retraining Ship manoeuvring training on vessels of new type and within modern harbour facilities	nil
	T.N.O.-Institute for Mechanical Constructions Delft	Training course for: VLCC, LNG carrier, container and product carrier	6	150 (Masters, officers and pilots)	Master Officer Pilot	Exercise of manoeuvring performance per each ship type	
	T.N.O.-Institute for Perception Soesterberg						
	Royal Netherlands Naval College Den Helder	Fundamental training course Retraining course (higher grade)			Student of naval academy Reserved officer, petty officer Navy officer	Fundamental training Studies on higher grade ship manoeuvring techniques	
	Hochschule für Nautik, Bremen	Ship manoeuvring training course for students Training course of Masters and officers Training course for pilots	6 ~ 8 (in 2 groups) 6 (in 2 groups) 6 (in 2 groups)	220 ~ 250 36 ~ 48 24 ~ 36	Student Master and officer Pilot	Part of school education and training Ship Manoeuvring training for boarding special type ship which is incorporated in the simulator	Available
	Fachhochschule Hamburg Fachbereich Seefahrt						
	Swidish Maritime Research Centre	Training courses in combination of a) ship type, b) actual harbour facilities, and c) postulated harbour facilities	6 (in 2 groups)	12 ~ 60 Can accept 120 ~ 150 if new computer system is introduced	Ocean-going Master Sea-going Master for 20 years or more serving as officer	Ship manoeuvring training for boarding special type ship which is incorporated in the simulator	Available
	Ship Manoeuvring Simulator Trondheim		8 (4 x 2 groups) (per week)	336	Ocean-going Master or pilot (sea-going experience for 2 to 10 years) Chief Mate (ULCC, VLCC and freighter)	Training, obtaining qualification and promotion for boarding VLCC	nil
Japan	IHI-Tanashi	1-day course (Training for VLCC or PCC) 2-day course (Training for VLCC and PCC)	1982 4 x 3 days = 12 4 x 1 day = 4	7 times a year 84 28	Master or Chief Mate	Ship manoeuvring training for boarding special type ships (VLCC and PCC)	Available

Table VII-3-(3)-8 Training Programme

Region	Organization	Training Course	Period for One Unit of Training Course	Period of Simulator Training	Period of Pre-training Procedure Explanation and of Post-training Discussion	Execution of Examination	Issuance of Certificate	Remarks
USA	CAORF	Simulator training course for Masters	1-week (Tue-, Wed- and Thur- training)	15 hours/man (15 min/unit)		Evaluation test (60 min)	Certificate	
		Training course for students of the Naval Academy	9-week and 1-week periods	36 hours or 23 hours		Evaluation test (60 min)	Certificate	
		Rules-of-the-Road training course for Masters	4-week period	48 hours		Evaluation test (60 min)	Certificate	
	MSI	Pre-command and fundamental ship manoeuvring simulator training course	3 ~10 working days	85%	15%	Pre- and post-training evaluation tests	Certificate of course completion	
		Training course for Lake and Harbour pilots and Dockmasters	3~5 working days	90%	10%	Pre- and post-training evaluation tests	Certificate of course completion	
		Training courses for VLCC and LNG	5 working days	80%	20%	Pre- and post-training evaluation tests	Certificate of course completion	
		Training course for bridge watch	5~10 working days	70%	30%	Pre- and post-training evaluation tests	Certificate of course completion	
		Course for studying topographs and harbour facilities	3~5 working days	80%	20%	Pre- and post-training evaluation tests	Certificate of course completion	
	Ship Analytics							
	MITAGS		2-week in normal cases					
Europe	The College of Nautical Studies Southampton	Courses on bridge organization and team work Training course for pilots Courses to users' options	46 hours	1.5 hours for preliminary training and 17.5 hours for training, about 19 hours in total (8 training units)	1 1/4 hours for pre-training explanation for each unit of training and 1 hour for post-training discussion, about 18 hours in total	nil	Certificate of attendance	Meeting and pre-training explanation on Sunday night, 2 training units in am/pm on Tue-Thur, and post-training discussion on Friday
	CARDIFF							

	Organization	Training Course	Period for One Unit of Training Course	Period of Simulator Training	Period of Pre-training Procedure Explanation and of Post-training Discussion	Execution of Examination	Issuance of Certificate	Remarks
Europe (cont'd)	Netherlands Ship Model Basin Wageningen	Fundamental course for EUROPORT pilots Ship manoeuvring simulator training for VLCC Special training course	8 hours at minimum 1 week at maximum Normally 5-day course, 3-day course also available	1 hour or less per 1 unit of training	10 min or less each for pre-training explanation and post-training discussion	nil	nil	
	T.N.O.-Institute for Mechanical Constructions Delft	Training course for: VLCC, LNG carrier, container and product carrier	40 hours (5 days ~ 8 hours/day)	20 hours	15 hours for pre-training explanation and 5 hours for post-training discussion on 5 hours for ship operation	nil	Certificate of attendance	
	T.N.O.-Institute for Perception Soesterberg							
	Royal Netherlands Naval College Den Helder	Fundamental training course Retraining course (higher grade)	3.5 ~ 4 hours	2.5 ~ 3 hours	1 hour for pre-training explanation and post-training discussion	nil	nil	
	Hochschule für Nautik, Bremen	Ship manoeuvring training course for students Training course for Masters and officers Training course for pilots	30 hours (10~50 min/unit) 35 ~ 40 hours (5 days) 35 ~40 hours (5 days)	50% 50% 50%	50% (10% waiting) 50% (10 ~ 15% waiting) 50% (10 ~ 15% waiting)		Certificate of attendance Certificate of attendance Certificate of attendance	
	Fachhochschule Hamburg Fachbereich Seefahrt							
	Swedish Maritime Research Centre	Training courses in combination of a) ship type, b) actual harbour facilities, and c) postulated harbour facilities	35 hours (5 days)	50% 12% as observer in the simulator	38%	nil	Certificate	
	Norway Ship Manoeuvring Simulator Trondheim		48 hours (1 week)	30 ~ 90 min/unit of training	20 ~ 60 min/unit of training	nil	nil	
Japan	IHI-Tanashi	1-day course (Training for VLCC or PCC) 2-day course (Training for VLCC and PCC)	1 day 2 days	20 ~ 30 min/unit of training	10 ~ 15 min/unit of training	nil	Certificate of attendance	

4) Cost for Navigational Measures

The costs for the improvement of aids to navigation and manoeuvring simulator are tabulated in Fig. VII-3-(3)-9.

Table VII-3-(3)-9 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 Year	15		15		15		15		15			

(4) Traffic Control

1) Controls Over Anchorages

(i) Controls at Times of Anchoring and Heaving up Anchor

When transit vessels stay at anchor in the waiting areas of Port Said and Suez, and the anchorages of Great Bitter Lake and Lake Timsah, and when they heave up anchor, the current control procedures are considered insufficient.

The results of video tape analysis of the recorded radar observations in Port Said Waiting Area and Great Bitter Lake Anchorage also attest strongly to the need to improve the controls over anchorages.

To cope with the situation, it is necessary to realize closely attended control practices including the clear-cut designation of anchorages, instructions on the assigned passage up to the point of anchorage, verifications of time and place after casting off anchors, instructions and verifications for the course to be taken after heaving up anchors, and when necessary, making arrangements for certain vessels to wait, etc.

In exercising controls, information on items such as the estimated and on-going movements of other vessels should be given to the vessel in question to the fullest possible extent, and at the same time, the radars must be utilized to a maximum degree.

For controls, quite high levels of knowledge and experience are necessary, and pilots must serve the duty on a regular shift basis.

By observing these requirements, a significant reduction in collisions and contact accidents during the anchoring and heaving up operation of anchors is considered feasible.

(ii) Use of Anchorage

As was mentioned in the section dealing with the analysis of video tape records of radars, the anchorage of Great Bitter Lake is evenly used over its entire area, but the West side of the waiting anchorage in Port Said is not used so frequently.

In order that passages of other vessels in areas where vessels are engaged in their anchoring/heaving-up anchor operations, anchoring/heaving-up anchor operations of vessels in close proximity, and contact damages due to whirling motions of vessels staying at anchors can be minimized, controls over the anchorage should be made in such a way that anchorages can be used as evenly as possible.

(iii) Tracks in Anchorage

i) Great Bitter Lake Anchorage

In both cases of northbound vessels and southbound vessels, almost all the vessels proceed through anchorages without passing through the designated traffic routes after heaving-up anchor as well as before anchoring.

In some cases, vessels were found anchoring within the traffic route.

Passage through anchorages implies an increased possibility of collision and contact accidents with other vessels at anchor and those engaged in anchoring operations, also implies a contribution to make their risk levels higher.

Transiting vessels must use the traffic routes provided between the anchorages for the use of northbound and southbound vessels respectively as much as possible, and passage through anchorages should be minimized.

Anchoring in the traffic routes should be strictly prohibited.

ii) Port Said

In some cases, vessels heading to the shallow draught vessels' anchorage from the north make a detour around the east side of the anchorage for deep draught vessels, but we consider that this course should be controlled so that it would not cross the course of vessels heading to the channel from the anchorage, by detouring around the west side of the anchorage.

Further, we have noted that there were vessels heading to the anchorage for shallow draught vessels passing through the other anchorage for deep draught vessels, vessels heading to the channel by passing through the anchorage without anchoring, and vessels leaving the channel while passing through the anchorage. All of these unfavourable sailing practices are considered to be prohibited.

Concerning the course for vessels heading to the channel from the anchorage, passage through the anchorage should be avoided as much as possible, and for this reason, it is considered to be advisable that a traffic route be provided between the anchorage for shallow draught vessels and that for deep draught vessels so that they can proceed along the proposed traffic route till they get to the channel.

iii) Suez

With respect to Suez, no analysis could be made on the general condition of the anchorage due to the fact that radar there was not in operation. However, basically the same concept as in the case of Port Said should be employed for exerting controls over anchorage in Suez.

When the radar in Suez start its operation, analytical procedures as employed in dealing with the anchorages in Port Said and Great Bitter Lake in this report should also be employed for due analysis of the situation in Suez and for taking necessary safety measures.

iv) Lake Timsah

Due to the quite illegible radar images of the anchorage of Lake Timsah, no analytical assessments and investigations on the basis of video tape records could be made, but it is considered necessary to take safety measures similar to those suggested for other anchorages.

2) On SCVTMS

As mentioned in the section dealing with the evaluation of the SCVTMS, the Loran-C incorporated in this system is now problematic and this problem must be solved before it is placed in practical operation.

It also seems that the question of correspondence between those vessels' position obtained through the use of the Loran-C (Egyptian Grid) and geographical data available on the Canal maps (UTM) has been left unsolved.

If the SCVTMS becomes available for practical control of the Canal, we believe it would be extremely effective for the enhancement of the safety of the Canal, and hence a positive effort should be made for the early commencement of the practical operation.

Shown below are several hints for the solution of the problems:

(i) Practical Use of Systems Other than Loran-C System

Using the systems other than the Loran-C Position Fixing System, i.e., the Tracking Radar System, the Computer Network System and the Communication System, a periodical and emergency broadcasting service, an individual information providing service and a control service to the transit vessels as mentioned in the urgently-needed countermeasures should be started.

(ii) Mutual Cooperation between SCVTMS Engineering Staffs and Transit Operation Staffs

It seems that mutual cooperation between SCVTMS engineering staffs and transit operation staffs is insufficient at present.

To operate this SCVTMS, not only the training and education for the staffs concerned, but also the mutual understanding and cooperation are extremely important and indispensable.

(iii) Reviewal of SCVTMS

Geographical relationships among the master/slave stations and monitor station on the present Loran-C system, the type of radio waves used, the measuring method, the accuracy of readouts and other fundamental design items should be reviewed for the entire system whereby the viability of obtaining the required levels of position-fixing accuracy should be assessed. If it is feasible, the correlation between the Loran-C-based positional data and geographical data must be verified.

It is also a problem to put the CORT on transit vessels, but the problem may be solved by sharp miniaturization and weight reduction of the CORT.

Since the Loran-C is a relatively simple system, its operation, maintenance and control are all easy. However, negative opinions are dominant for the possibility of high position-fixing accuracy within few metres with the Loran-C system.

(iv) Employment of Other Position Fixing System

The feasibility of employing other position-fixing systems, such as a radar chain system in place of the Loran-C position-fixing system, should be studied.

In the case of a radar chain system, if radars of high accuracy are used, position-fixing accuracy as good as a few metres can be obtained relatively easily though the positional accuracy in the case of ordinary marine radars is in a range from 15 to 30 metres.

This system, however, requires a considerable number of radar units for obtaining the required levels of accuracy in the measurements, and a consequential increase in the burden for operation, maintenance and control of the system may be involved.

(5) Future Subjects for Consideration

The followings are presented as an additional service, and we hope that the SCA will consider these subjects in addition to the measures aforementioned.

1) Arrangement of Escort Boats

Table VII-3-(5)-1 gives the total value of frictional resistance, wave-making resistance, propeller resistance and increase in resistance due to bottom fouling of vessels in tons classified by deadweight when they are towed at a towing speed of 5 knots. Table VII-3-(5)-2 gives wind pressure, expressed in tons, when vessels are subjected to beam wind blowing at a velocity of 12 m/sec. Here, the vessels are also classified by deadweight.

Also, Fig. VII-3-(5)-1 shows the relationship between the braking power of tugs and stopping distance when fully loaded vessels, classified by deadweight, with a headway at speeds from 3 to 5 knots, are stopped by the towing force of the tug.

In the case of a 100,000 DWT vessel in her fully loaded condition, for instance, the towing resistance at the speed of 5 knots is 39.8 tons, the wind pressure of the beam wind blowing at a velocity of 12 m/sec is approximately 20 tons, and if the vessel is to be stopped while proceeding at a speed of 5 knots by applying 40 tons of braking power, then the stopping distance is 3.5 L, approximately 900 metres.

Although the SCA has changed the tonnage criteria for the arrangement of escort boats from 100,000 DWT to 110,000 DWT, this criteria should rather be lowered even below 100,000 DWT, if we take the forementioned towing resistance, wind pressure and braking power of tugs into account.

Table VII-3-(5)-1 Towing Resistance in Tons for 5 kt of Vessel's Speed by Classified Deadweight Tons

DWT ($\times 10^3$)	50	67	100	135	200	276
Light Condition	8.4	11.5	13.2	15.6	20.4	33.0
1/4 Load	14.0	17.7	21.6	26.4	34.0	40.3
Full Load	26.3	31.4	39.8	49.5	64.1	76.7

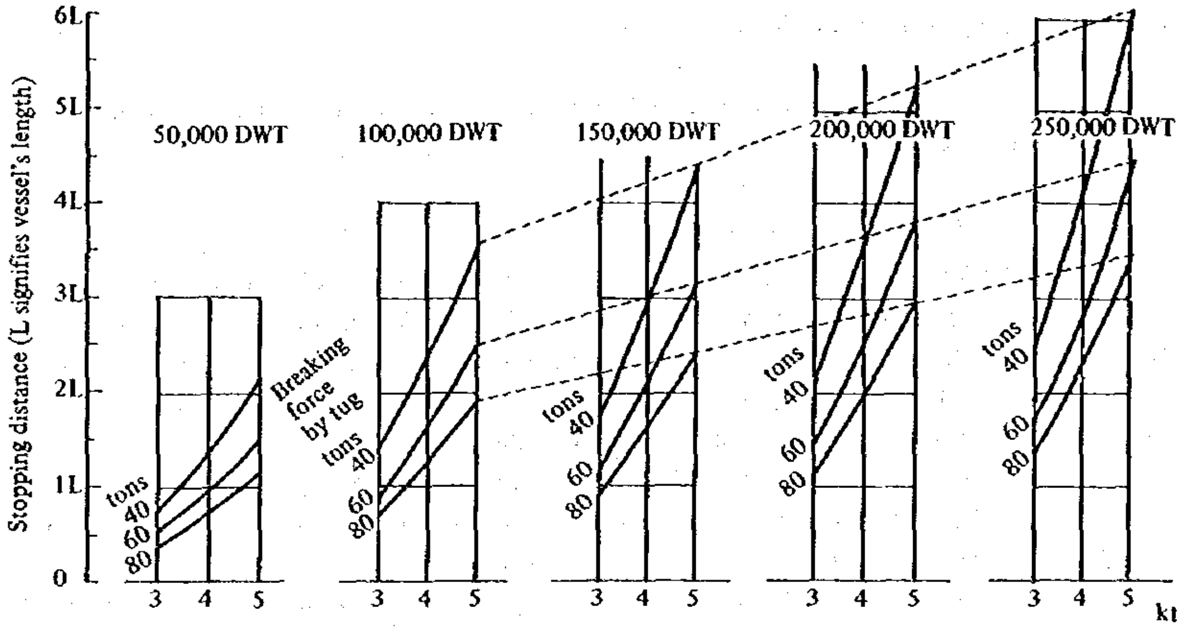
Source: Japan Dockmasters' Association

Table VII-3-(5)-2 Wind Pressure in Tons by Deadweight Tons

(Beam 90° 12 m/sec)

DWT ($\times 10^3$)	50	67	92	139	168	276
Light Condition	26.5	31.4	37.4	52.0	63.6	80.4
Ballast Condition	22.5	26.7	31.8	44.2	54.1	68.3
Full Load	13.3	15.7	18.7	26.0	31.8	40.2

Source: Japan Dockmasters' Association



Speed of vessel when a tug initiates it a braking operation
Source: The Japan Association for Preventing Marine Accidents

Fig. VII-3-(5)-1 Braking Effects by Tugs

2) Countermeasures for Preventing Collision within the Harbour of Port Said

The most significant feature of the accident statistics of the SCA is that the frequencies of collision and contact accidents in the harbour water of Port Said and its associated waters are extremely high.

Although the frequencies of accidents arising in the Canal zone have considerably decreased since the establishment of such highly effective safety measures as the First Stage Development Project, those in the harbour areas of Port Said and Suez are not comparable with the above where the new installation of Port Said Bypass is the only exception. Accordingly, the frequencies of accidents in these areas of water have remained almost unchanged.

The new installation of the Port Said Bypass has not proved itself to be instrumental to the prevention of accidents within the harbour waters of Port Said, but such a situation is considered to be attributable to the fact that most of the accidents involving collision and contacts were caused during the mooring/unmooring operations to or from the waiting buoy berth by southbound vessels.

In VII-2 Urgently Needed Countermeasures, a proposal is made for the reduction of accidents within the harbour waters of Port Said through maximum utilization of the Port Said Bypass for reducing the number of vessels passing the particular harbour water. When use of the waiting buoy berths which are under construction by the SCA on the south part of the Port Said West Channel is initiated, it is anticipated that those collision and contact accidents with vessels other than the transit vessels at the time of mooring/unmooring operations of southbound vessels can largely be avoided with a consequential decrease in the frequency of accidents within the harbour waters.

In this connection, early initiation of the use of the new waiting buoy berth is strongly desired.

Other proposals for preventing accidents within the harbour waters of Port Said are to make the channel of Port Said Bypass duplicate, and to restrict the passage through the West Channel for the purpose of transiting the Canal, or to distribute those vessels calling at Port Said to some other ports e.g., the Port of Alexandria and the Port of Damietta as much as possible by changing the goods circulation system and mechanism, reducing the capacity of Port Said as a trade port, and minimizing the number of vessels and craft operated within the harbour waters.

It is considered necessary to organized a committee of scholars and experts for in-depth studies on these matters.

VII-4 Measures for Dealing with Accidents

Additional proposed plans to complete the countermeasure for dealing with accidents related to cargo are as follows.

(1) Allocation of Equipment

1) Fire-fighting

(i) Foam Concentrate

Assuming that the affected area of a crude-oil fire is 2045 m^2, the required amount of foam·water to extinguish is 4 ℓ/min per m^2 and the hit rate is 1/3. In this case, the required foam·water ejection capacity is 24540 ℓ/min. Also, assuming that it takes 25 minutes to extinguish the fire, the required amount of a 3% foam concentrate is 18405 ℓ. However, if a 6% foam concentrate is used, the requirement is doubled. Monitors, high enough to reach the upper deck of a burning vessel, are also required in order to inject the foam·water into a break made in a tank. The largest loaded crude-oil tanker that has ever transited the Suez Canal was a 260,000 deadweight-tons class, which had a 25 m high upper deck with a light-loaded draft. The higher a monitor, the easier is its operation.

(ii) Dry Chemical Powder

Assuming that the target surface area of a liquified gas fire is 580 m^2, the required amount of dry chemical powder is 5.8 tons since the dry chemical powder requirement for extinguishing a fire is 10 kg per m^2 according to studies conducted by the Japan Association for Preventing Marine Accidents.

The necessary shot range is about 100 m since it is possible to approach as near as 5.7 R to the center of such a fire, assuming that a water curtain can shield 70% of the radiated heat.

(iii) Fire-fighting Vessel

Enbodied fire-fighting vessel (referred in Urgently-Needed Counter-Measures) with the above mentioned fire-fighting capacity is as follows.

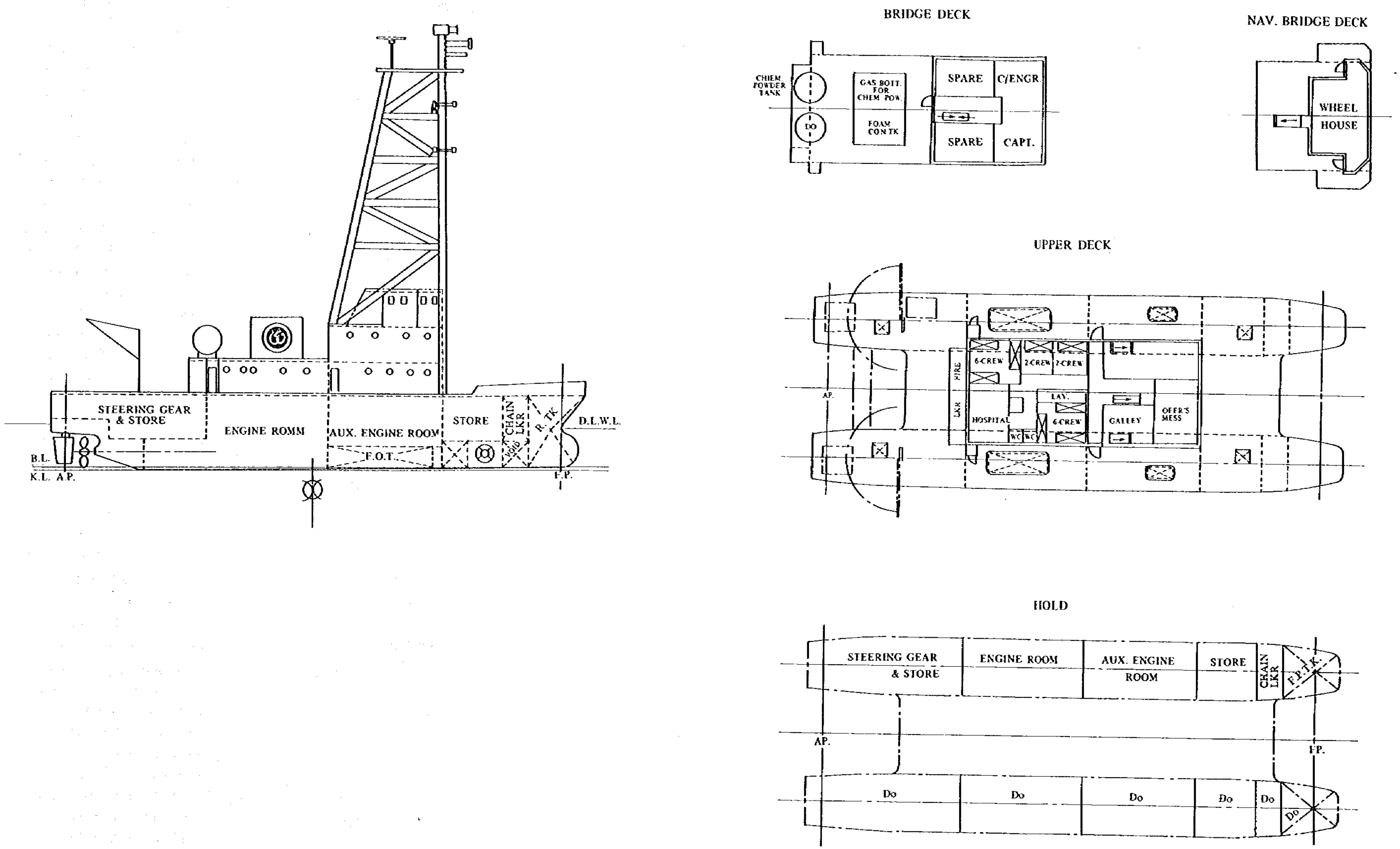


Fig. VII-4-(1)-1 Fire-fighting Vessel

Outline of a Fire-fighting vessel (designed by Maritime Safety Agency)

i) Type of Vessel
Catamaran

ii) Hull Material
Steel

iii) Speed, Range and Endurance

(a)	Speed	Abt. 14 knots (normal cond. 85% output)
(b)	Range	500 miles at 14 knots
(c)	Endurance	7 days

iv) Principal Dimensions

(a)	Length	(overall)		36.7 m
(b)	Length	(water line)		35.000 m
(c)	Breadth			13.500 m
(d)	Breadth	(demihull)		4.000 m
(e)	Depth			5.000 m
(f)	Draft	(normal cond.)		2.900 m
(g)	Trim			0.400 m
(h)	Displacement	(normal cond.)	Abt	500 t
(i)	Gross tonnage		Abt	400 t

v) Main Engine and Propeller

(a)	Main engine	1,500 ps x 2 sets
(b)	Propeller	CPP x 2 sets

vi) Accommodation
Officers
Crew
Total 20

vii) Tank Capacity
Fresh water 21 m^3 (150 ℓ/man-day)
Fuel oil 61 m^3

* Fuel oil is enough for 500 miles crousing and 4 days fire-fighting.

viii) Fire-fighting Equipment

(a) Main fire pumps
1500 m^3/h x 17 kg/cm^2 2 sets
Driven by main engines

(b) Foam concentrate pumps
30 m^3/h x 21 kg/cm^2 2 sets

(c) Foam concentrate and dry chemical powder
a) Foam concentrate 30 m^3
b) Dry chemical powder 10 m^3

(d) Monitors (controlled in steering house)
a) Water/foam monitors

3%/6% ejector	12,500 ℓ/min x 2	(25 m W.L Height)
b) Water monitors	10,000 ℓ/min x 2	(22 m W.L Height)
c) Dry chemical powder monitor	100 kg/sec x 1	(25 m W.L Height)
(e) TV monitor		
(f) Water curtain	200 ℓ/min/m² x 40	

ix) Deck Machinery

Capstan		3 sets
Steering gear		2 sets
Bow thruster	150 PS	2 sets

x) Generator

Diesel generator	2 sets

xi) Navigation and Radio Equipment

Magnet compass	1 set
Echo sounder	1 set
Radar	1 set
Radio equipment	1 set

xii) The following Optional Facilities can be Installed in order to Efficiently Utilize a Vessel.

(a) Dispersant spray ejectors and a 10-ton capacity dispersant tank.

(b) An adjustable weir-type oil skimmer, capable of skimming 100 m^3/h of inflowing oil between the two hulls of a catamaran-type vessel.

(c) A hospital which can be used as a medical treatment facility for the wounded in accidents.

These fire-fighting vessels should be located in Port Said, Ismailia, and Suez, and should always be ready for accidents.

(iv) Inlets for the Containment of Damaged Vessel

Inlets or strong mooring buoys at separated safety areas should be provided for the disposal of vessel and cargo which have caused uncontrollably large accidents by other unimaginable reason, such as a big fire on a liquified-gas tanker.

In the case of the Yuyo-maru No.10 accident in 1972, the ship was fully loaded with LPG and was towed about 50 miles from Tokyo Bay to the Pacific Ocean in spite of the danger of continuous spreading small explosions and big fires. She was sunk to a depth of 3,000 meters using gunshot.

Such a situation is not desirable in the Mediterranean Sea or the Red Sea.

The dimensions of the areas necessary for containment should be the same width and depth as the Suez Canal and long enough in length to enable safe blockading operations at the entrance and exit of the areas.

The suggested locations of the areas are: the east side of the terminal of route at Port Said, the north side of Qadd El-Tawila at Suez, and the natural Inlet area at the opposite side of Kabret at Bitter Lake. However you need not above mentioned inlet if you have any other place where you can dispose dangerous vessel safely in accordance with accident conditions.

(v) Others

Vessels which are loaded with dangerous substances should hang wireropes both fore and aft in order to facilitate towing operations in the event of a large fire accident.

2) Oil Spill Control

It is difficult to definitely decide which type of oil spill control equipment is the best as there are many types and comparative examinations have not been carried out under controlled conditions. At least, capacity of each equipment will vary respectively under the given condition. For example, some types are useful under quiet-sea condition, but inadequate in a windy sea. Other types can not be used in shallow water and others show remarkable fluctuations in skimming efficiency, depending on the kind of oil and age of the oil spill.

Accordingly, the application of case-by-case countermeasures is required for workers who must deal with accidents. Thus, several types of equipment should be provided and actually used during practice and experiments or for small oil-spill accidents in order to become familiar with their features. Then, the most efficient combinations of equipment can be used according to the conditions of each accident. Here, some specific types of equipment are shown as an example. However, any type of equipment will be OK if its capacity is equivalent.

(i) Oil Boom

Assuming that the maximum amount of an oil spill is 30,000 m^3, the extended radius of the oil will become 753 m after 6 hours. The total length of an oil boom is calculated as 4,729 m in order to contain the oil by a single deploy.

Therefore, it is recommended that another 3,569 m is added to each base since the length of stored oil booms for urgently-needed countermeasures was found to be 1,160 m per one base.

(ii) Oil skimming

Additional oil skimming equipment should be the specialized exclusive use of a skim boat in order to enable their rapid deployment. Although there must be a lot of arguments as to whether a boat should be self-propelled or towed, towed skim boat is recommended for this purpose when we give consideration to the disadvantages regarding maintenance and expense as the boat must be on standby for a indefinite time for a big oil spill. Also, SCA has a lot of tug boats. The oil-skimming capacity of an additional skim boat is simply calculated as 344 m^3/h based on the following assumptions:

i) A maximum amount of the spilt oil is 30,000 m^3, 80% of which can be skimmed.

ii) All of the skimming equipment from the three bases are fully used and the oil is skimmed for 3 days.

iii) The distances from Port Said to Ismailia and from Ismailia to Suez are 80 km, respectively.

iv) The fire-fighting vessels will have a skimming capacity of 100 m^3/h and an average speed of 13 knots. The 60 m^3/h skimmers which are proposed as urgently-needed countermeasures are brought with the vessels.

v) The towed speed of an additional skim boat is 9 knots.

vi) The skimming efficiency is 50% and the work is for 12 hours a day.

(iii) Dispersant

Assuming that a dispersant is used to disperse an unrecovered 20% of the oil and that the dispension ratio to oil is 30%, the required amount of dispersant is 1,800 kℓ. As SCA already has possession of 233 kℓ of dispersant, there is a shortage of 1,567 kℓ. A low-toxicity oil dispersant should be added and equally divided (about 2,612 barrels each) for the three bases and stored in stock yards which provide sun shades.

(iv) Oil-spill Control Boat

We recommend to possess oil spill control boats which have before mentioned capacity of oil skim boats and oil booms. They should be allocated at Port Said, Ismailia, and Suez. An example is shown as follows.

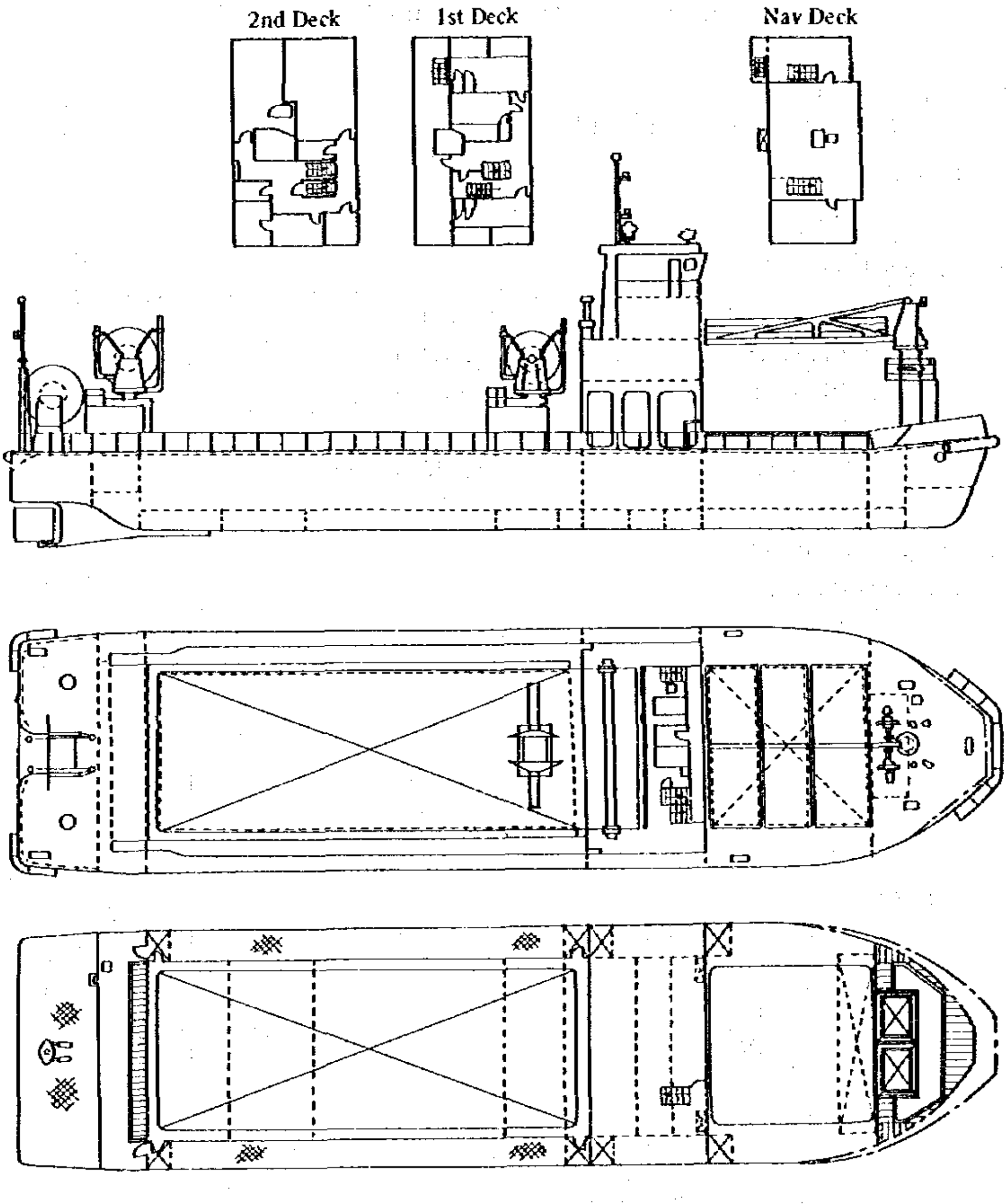


Fig. VII-4-(1)-2 Oil-spill Control Boat

Outline of an Oil-spill Control Boat

i) Type of boat

Steel-hull disaster treatment barge

ii) Class

NK, NS

iii) Principal Dimension

Length (over all)	49,000 m
Length (water line)	48,000 m
Breadth (over all)	12,000 m
Depth	4,000 m
Loaded draft	1,400 m
Gross tonnage	417 t

iv) Machines on Board

(a) Oil skimmer

Sea-skimmer type	100 (100 m^3/h)	3 sets
Sea-skimmer type	50 (50 m^3/h)	1 set
Driver		4 sets

(b) Oil boom

Permanent type	450 x 600	1,800 m
Inflatable	450 x 700	1,800 m
Ancillaries		1 set

(c) Crane

2.95 t x 9.5 m x 12 m	1 unit

(d) Control gear

1 t – m	
AC 220V	1 set

(e) Hydraulic-hatch cover

4.9 t – m	1 set
(size of hatch way 8.5 m x 21.0 m)	
(size of hatch way 8.0 m x 8.2 m)	

(f) Anchor winch

4.5 t x 9.0 m/min	1 unit

(g) Oil-boom tender and returning machine

Fixed winch	Wind up	1.5 t x 20 m/min
	Wind off	0.75 t x 40 m/min

(h) Travelling wheel winch

Wind up	1.0 t x 15 m/min
Travelling machine	1.8 t x 2.5 m/min
Swivel	0.5 t – m
Travelling wheel	2.7 t x 15 m/min

(i)	Mooring machine (Hydraulic)	1.5 t x 3 t x 30 m/min / 15 m/min	

v) Engine Room

(a) Main generator	50kVA x 220V x 60V 65PS	1 set
(b) Hot-water boiler	63,000 kcal/h	1 set
(c) De-oiler	0.15 t/h	1 set
(d) Bilge and drain pump	30/60 m^3/h x 10 m/40 m	1 unit
(e) Fire-water and bilge pump	30/60 m^3/h x 10 m/40 m	1 unit
(f) Fresh-water pump	45 ℓ/min x 0.4 kW	1 unit
(g) Fuel-transfer pump	0.5 m^3/h x 3 kg/m^3	1 unit
(h) Engine-room ventilation fan	100 m^2/h x 20 mm/Aq	2 units

vi) Electric and Radio Equipment

(a) Main distributor 50 KVA parallel-operation dead-front type		1 unit
(b) Transformer	220V ~ 100V 15KVA	1 unit
(c) Anemometer		1 unit
(d) Search light	1 KW	1 unit
(e) Explosion proof VHF	20W	1 unit
(f) SOS buoy		1 unit
(g) Loud-speaker system	30W	1 unit
(h) Gas detector		1 unit
(i) Explosion proof transceiver		4 units

(v) Others

i) Although oil-control operations are conducted off shore, it is anticipated that oil will reach the shore due to various reasons (such as the weather, sea conditions etc.). On shore oil treatment operations require much effort, especially at locations where it is difficult to secure a firm footing. Therefore, it is necessary to construct small ponds in areas where spilt oil is likely to reach in order to carry out efficient operations even if the oil is washed to the shore.

The places where oil is likely to reach are the beach along the east side of Port Fuad, and the shore of the far southern part of Great Bitter Lake. In addition, it is more efficient if equipment is allocated near such ponds i.e. a bollard; 300 m oil boom; a 20 m^3/h oil skimmer, a recovered oil transfer system consist with generator, transfer pumps and hoses.

ii) SCA now possesses cleaning equipment such as forkliftes, tank trucks, truck cranes, drums, portable generators, submersible pumps, etc.

In addition to the above, the following material should be stored and used at each base: about 500 buckets, about 100 shovels, about 100 dippers, and about 100 drums with open top covers. These are necessary until other emergency equipment is delivered.

iii) It is recommended that a new basin be located on the deepest southern shore of Great Bitter Lake in addition to the three other basins proposed as urgently needed countermeasures, and it is also recommended to arrange 2 sets of recovered oil transfer system for each base respectively.

iv) It is supposed that two lightering barges (3,200 tons) will be allocated to Port Said and Suez in relation to mooring facilities.

(2) Execution Team

1) Organization and its Staff

It is recommended to form six Transit Teams as Execution Teams on the basis of "Urgently-needed Countermeasures". Then, two Teams each will be allocated to Port Said, Ismailia and Suez.

The two Teams at Port Said and Suez will work in two shifts of 24 hours on each bases. One out of the two Teams at Ismailia will perform general supervision. The other will perform training and education. In the event of an accident, one Team (each) at Port Said and Suez will stay in the base for routine work while the other four Execution Teams will work in shifts day and night according to their schedule on the site of the accident. The following figure shows a diagram of the Organization of Disaster Control of the Headquarters for Accident Control in times of emergency.

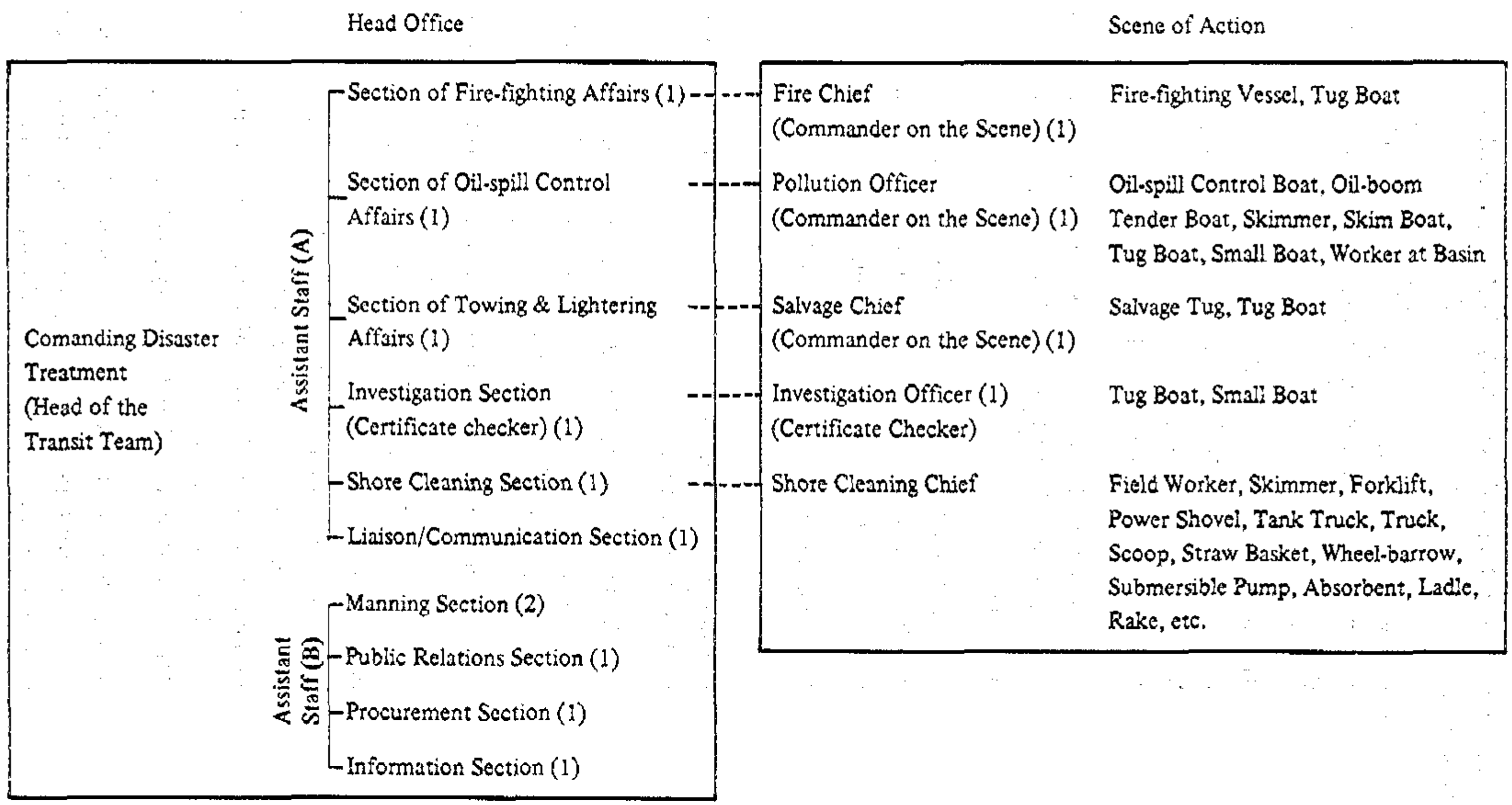


Fig. VII-4-(2)-1 Organization of Disaster Treatment at the Headquarters for Accident Control

The following items are the details regarding assistant staffs' work performed under the direction of the Head of the Transit Team.

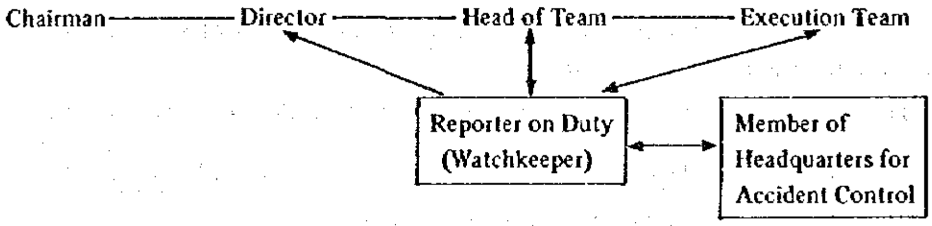
Fire-fighting Section	Guard against a fire, fire extinction and the check of its spread and the prevention of a secondary disaster due to fire.
Oil-spill Control Section	The control of spilled oil, using oil booms, skimmers, skim boats, oil-spill control boats, dispersant, pumps, barges, basins, etc. Lightering and towing of the damaged vessel.
Towing & Lightering Section	Containment of the damaged vessel at an inlet or mooring buoy and the blockade of the inlet in cooperation with dredgers.
Investigation Section	Field investigations required for disaster control such as weather and hydrographic conditions, and the conditions of the Canal, damaged vessels and cargoes.
Liaison/Communication Section	Communication and liaison required for disaster treatment.
On-land Cleaning Section	Cleaning of affected areas on shore removal of oil and prevention of pollution.
Manning Section	Check the movements of field workers and official workers inside and outside the SCA and business negotiations with them in preparation for accidents.
Public Relations Section	Negotiations, contracts and communication with outside organizations (military groups, police stations, fire defence agencies, companies, etc.) International negotiation Request for deployment of aircraft Communication with commissioners, councellers and consulting companies Arrangement of urgent and ordinary meetings
Procurement Section	Survey of current equipment and materials required for disaster control, purchasing and/or borrowing, preparation of such resources and delivery to the scene of action in the time of an emergency.
Information Section	Announcements at press conferences and to the staff and residents in the surrounding area.

The assistant Staff (A) of the Head Office will be composed of both the Port Officer and the watch keeper of SCVTMS. The persons on duty must be well trained and given full instructions about their related fields in order to fulfill their two-fold duties. However, one of the Transit Teams must be deployed to the Investigation Section. On the other hand, it should be remembered that for the Assistant Staff (B) some experts on the related fields should be selected from inside the Office and assigned to each of their posts.

2) Communication, Stationing and Calling Out System

(i) Communication System

Upon the receipt of a message from the scene of an accident the communication system must perform its function as shown in the following figure.



The numbers above indicated show the ascending order of communication.
In the event of a big accident or if an accident has a good chance of developing into a big disaster, the chairman will take the place of the derector and become a direct commander (the director becomes his assistant).

Fig. VII-4-(2)-2 Communication System in the Event of an Accident

Communication must be made in principle over the phone but a wireless phone may be used where necessary, according to the emergency address table prepared in advance.

Receivers of first message from the scene of an accident will tape-record the content of the message and gather any information required for disaster control using a check list (regarding each different type of accident) prepared in advance.

Then, if the staff needs any additional information, for example, from aircraft, they should request the related agency. They should also instruct the pilot where to airdrop packages of information (Polaroids, etc.).

After that, the Execution Team must communicate with the Head Office via UHF, in principle, though they can switch to VHF (case-by-case).

(ii) Stationing and Calling Out

It should be expected that Transit Teams on duty stand by at the nearest watch keeping house from the base after finishing their daily work until the next morning. Transit Teams, if informed of an outbreak of an accident, should make themselves ready for quick dispatch.

After being instructed to hurry to the scene of the accident, they usually leave the base swiftly aboard a fire-fighting vessel or a oil-spill control boat. If by chance either the vessel or the boat is out in action, they must proceed to the ship by mean of available transportation while keeping contact with the related vessel or boat to be boarded.

Thus, finally they are to start for the scene of action while all the necessary boats such as tugs, launches, etc. are requested to rush to the scene using radio communication.

3) Education and Training

(i) Disaster Treatment Manual

Manuals for disaster treatment should be prepared in order to make effective use of personnel, equipment and materials.

The disaster treatment manual should be comprehensive, include the following items. An incessant update of data is necessary due to changes in data. Especially those available equipment, man in charge, location to be communicated and methods of communication, is highly changeable. Information of "Outside Forces Available" and "Sea Conditions", must be gathered on day-to-day basis. Especially estimation of sea surface current plays a major role for treatment of spilled cargo.

Therefore, a continuous accumulation of data regarding tides is desirable.

i) Properties of Dangerous Substances which are carried by Transit Vessels.

ii) The Scale of an Accident to be Expected

iii) Degree of Risk after the Spill of Oil

iv) Prediction of Oil Behavior after a Spill

v) Forecast of Weather/Sea Conditions

vi) Resources Available
- A list of equipment & materials currently available
- How to use the equipment & materials
- Organization, role of different sections and a table for emergency liaison and communication
- A list of outside forces available
- Current condition of topography which are useful for the containment of spilled oil

vii) Emergency Response
- How to notify and what to be included in a first message of an accident.
- A checklist for each of the different types of accidents.
- Methods of transmission & communication.
- Decision criteria for investment of forces.

viii) Method of Treatment
- How to control oil spill
- How to extinguish fire

(ii) Training

In order to perform actual disaster treatment based on disaster treatment manual, it is essential to repeat following various type of training.

Training for emergency Calling out and Rushing to the Scene	The success or failure in the disaster treatment depends largely upon the time required to get to the scene of an accident. Regardless of day or night or holidays or weekdays, training for calling out must be repeated to reduce the time required for a series of actions from receiving an emergency message to dispatch through the calling up of needed members. Telephones and Wireless phones (as well) are to be used according to the emergency address table.
Training for the Right Communication	Training for the control of frequency range to be used information-classification and establishment of a fixed time call, etc. In order to communicate smoothly even in the confusion of the accident.
Training Regarding the Handling of Equipment & Materials	Long and repeated training is necessary in order to get accustomed to the handling of various types of equipment & materials such as fire fighting vessels, oil-spill control boats, oil boom tender boats, skim boats, skimmers, oil boom, dispersant sprayers, fire pumps, transfer pumps, etc.
Training for Oil-spill Control	Training for the control of oil at sea, using oil-spill control boats, oil boom tender boats, skim boats, skimmers, oil boom, dispersant sprayers, barges, recovered-oil transfer pumps, basins, etc.
Fire-fighting Exercise	Spray water, foam and dry chemicals onto the target, using fire fighting vessels and tug boats. Dispatchment of fire man to the vessels involved in an accident to extinguish fire.
Local Comprehensive Drill at Each Base	Small comprehensive drills should be done, using own currently available equipment & materials in each base.
On the Desk Comprehensive Exercise	At first, operating and judging groups are located in a council room with a large chart on the wall. Then, a simulating group is established in a separate room and communication is established by phone between two groups. Thus, a line of comprehensive imaginary operation exercises are given from the outbreak of an accident to the end of the accident control.

Comprehensive Drill	Practical and comprehensive drills on the sea in reference to the desk exercise mentioned above.

Until enough skill is acquired to respond to accidents well, these drills and exercises must be repeated periodically according to a yearly schedule prepared in advance. Also, a meeting for review after each exercise must be held in order to improve control techniques.

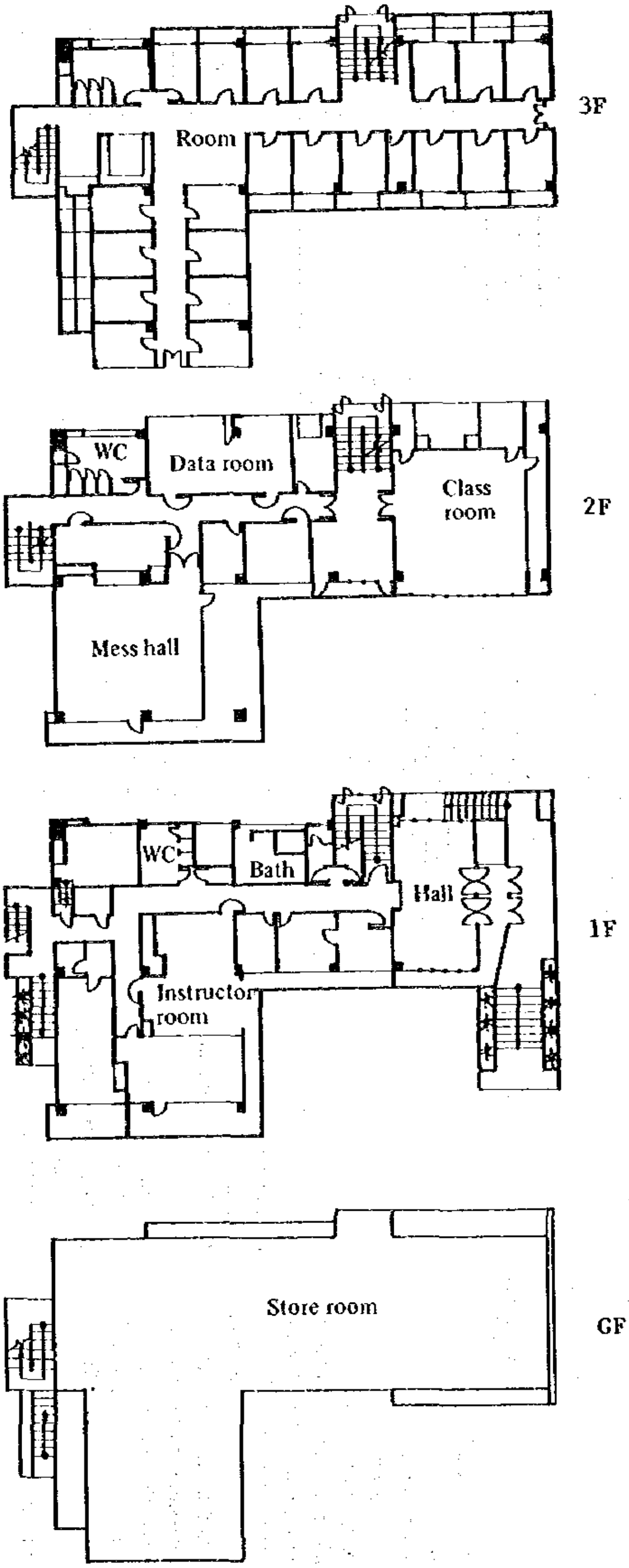
Since the best education and training is found in the experience of actual accidents, it is recommended to make best use of small accidents as a training ground.

(iii) Training School

As an accident in the Canal is not easy to handle you should perform effective training and good education with adequate materials in order to move against with effective combination of your staff fully utilizing their ability.

Each of the following facilities are examples for above mentioned purpose, but they can also be used for any purpose other than disaster treatment.

Hence, those facilities should be built at such a place as to be provided with the proper anchoring facilities which belong to the section of Ismailia.

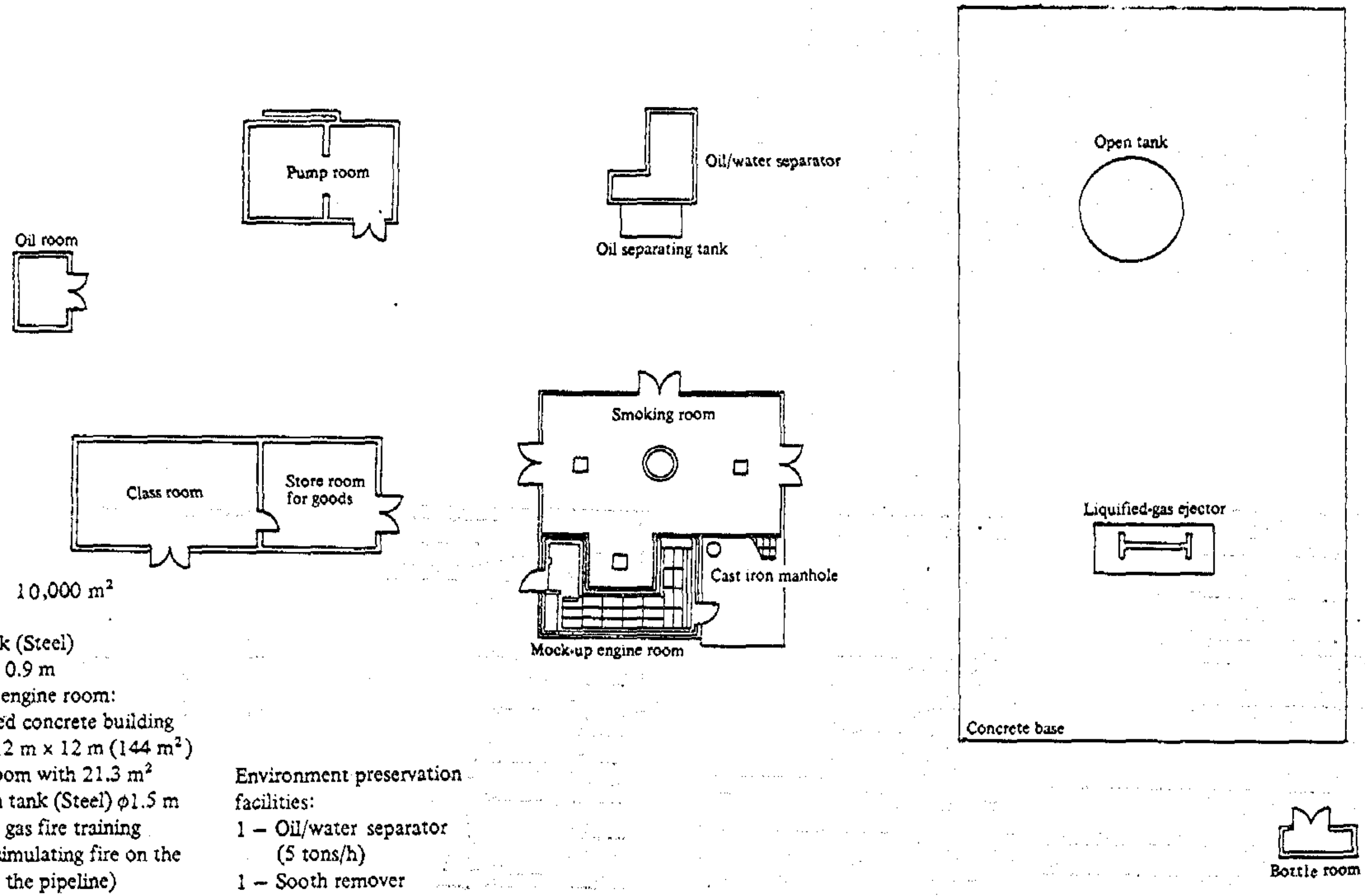


Size of site: 902.71 m^2

Building: Reinforced concrete building

GF:	Store room	90 m^2
	Machinery space	27 m^2
1F:	2 – Class rooms	45 m^2
	1 – Instructor room	32 m^2
	General office	28 m^2
	Management Office	28 m^2
	Caretaker's quarter	37 m^2
	Bathroom	27 m^2
	and other auxiliaries	
2F:	1 – Class room (60 persons) equipped with audio & visual equipment	107 m^2
	2 – Class rooms	30 m^2
	1 – Display room	45 m^2
	1 – Library	16 m^2
	1 – Mess hall	110 m^2
	and some store space	
3F:	20 rooms (each for 2 persons) and other auxiliaries	12 m^2 each

Fig. VII-4-(2)-3 Training School



Size of site: 10,000 m²
Facilities:
1 – Open tank (Steel)
  ϕ4.5 m x 0.9 m
1 – Mock-up engine room:
  Reinforced concrete building
  5.3 m x 12 m x 12 m (144 m²)
  Smoke room with 21.3 m²
  1 – Open tank (Steel) ϕ1.5 m
1 – Liquified gas fire training facility (simulating fire on the flange on the pipeline)
  Height 1.93 m
  Length 2.70 m
1 – Class room and store room 70 m²

Environment preservation facilities:
1 – Oil/water separator (5 tons/h)
1 – Sooth remover (Water fog spray)
3 – Oil/water setting tanks 120 m³
1 – water tank 5.5 m³

Fig. VII-4-(2)-4 Training Facilities

(3) Contingency Plans

There exists no one fixed form of response for disaster treatment. Because, usually, accidents to be dealt with has different and complex condition with many factors tangled each other such as its kind, scale and conditions, conditions of its scene, weather & hydrographic *conditions, night, day, equipment & material, worker's condition, elapsed time.*

This being the case, in order to work out any measures against an accident, we must always possess proper equipment and materials, set up execution teams and prepare for emergencies repeating basic training based on "disaster-treatment manual" while gathering and putting in order any information regarding the treatment of accidents within our territory. In addition to the above, it is essential to control accidents flexibly adapting case by case.

Each of the following three scenarios gives an example of what measures we should take in the event of a large scale accident.

1) Oil-spill Control (Great Bitter Lake)

"Just now, a northbound Crude oil tanker (half-loaded vessel, 260,000 DWT) has collided with a southbound cargo vessel near North Light at Great Bitter Lake.

A large amount of crude oil is flowing out to the south from the cargo tank. No details are available at this moment."

The above message arrived at the Transit Dep't from the pilot and the captain aboard the tanker via UHF and VHF.

Immediately, the Transit Dep't instructed the Execution Teams that were standing by at tug bases in Ismailia and Suez to rush to the scene. They prohibited strictly the use of any kind of fire in the area of the accident and instructed to halt all of the vessels transitting through the Canal and to stop their engines, while announcing that Ismailia's Transit Team as Disaster Treatment Execution Team should take a full commend of all forces on the scene of action.

At the same time, the Transit Dep't instructed Port Said to make ready for dispatching assistance.

(i) Tug boats that received the above message transmitted over UHF and VHF, rushed to the scene of the accident carefully checking the vapor concentration using Gas Detectors.

(ii) The damaged Tanker had already stopped engine and put out all sources of fire when she recognized the accident.

(iii) All the vessels which were sailing nearby the scene of the accident stopped engine and cast anchor.

(iv) From the bases in Ismailia and Suez, fire fighting vessels, oil-spill control boats and oil boom tender boats started on their way to the scene, with the Execution Teams aboard the tug boats. Then, work boats, barges and basin personnel were dispatched to the scene.

Five minutes after the accident, a second message arrived: Wind direction – NNE, Wind Velocity – 8 m/sec, Velocity of Spilled Oil – Approximately 0.5 knot/h, the oil was spreading around.

The first tug boat arrived at the scene under the direction of the Execution Team positioned itself on the wind ward of the damaged tanker and readied itself for foam spray.

It was reported from Signal Station at Deversoir and Kabrit that the result of gas detection was nil, and the stations were instructed to alert residents in the surrounding area by danger warning.

The third report was received from the damaged tanker that the spill of oil had stopped and the amount of the spilled oil was estimated to be more than 20,000 m^3.

SCA set up a Headquarters for a Big Accident Control and initiated staff mobilization, while requesting the contracted agency to dispatch a helicopter for a survey of the accident. Later, the helicopter flew back every two hours above the Head Office of SCA to airdrop a package of Polaroid prints with inscribed date and time.

The Head Office estimated the conditions of the scene and their possible development in the future from the polaroid prints, and advised the pullution officer of their forecast. After examining a flow of overall movements, pollution officer appointed the job to person in charge of each floating equipment.

While early arrived tug boats waiting for the new arrival of other tug boats, the Execution Team, fire fighting vessels, oil-spill control boats, oil-boom tender boats and skim boats arrived at the scene. After careful gas detection, they were positioned on the lee side of the spilled oil. Oil booms were deployed in a U shape configuration towed by 2 work boats. A skimming boat was connected on the bottom of the U curve for recovery of oil. On the other hand, oil-spill control boats, which were positioned upward, began to enclose the spilled oil with their oil booms in cooperation with the tug boats and set out to recover the confined oil. Outside the oil boom a floating crane started unloading the skimmer on the sea.

The recovered oil was transferred to a barge and discharged into the basin area with cooperation of basin personnel.

Thin film of oil escaping out of the oil booms and the skim boats was treated with dispersant sprayed from tug boats.

1,000 workhands for shore cleaning including supervisers arrived at the sand beach near Fanara and the Southern end of Great Bitter Lake.

They prepared ladles, buckets and drums, dug a hole 2 m deep and 5 m^2 large, connected it to the sea, constructed an emergency pond and then floated a submersible pump on the sea water in it, extending a guide boom along the outside of the emergency pond and thus preparing for the worst. They also extended an oil boom as a guide from the previously prepared pond nearby, set a skimmer in position and readied themselves for transfer of recovered oil into a basin.

Mixtures of oil and sea water, which have been discharged into the basin, are first settled, and then the sea water is drained out of the basin.

After incinerated together with gasoline applied to it, the residual is left alone for a long while until it hardens and is buried in the desert after that.

2) Crude-Oil Fire (Suez Bay)

"VLCC and a general cargo vessel have caught fire near Conry Rock. The fire on the cargo vessel looks relatively small. We will go off to extinguish the fire of VLCC. Arrival at the scene 10 minutes later is expected".

The above message was sent out to the Transit Dep't from the fire chief aboard a fire fighting vessel patrolling along in the Suez Bay.

At the same time, the following message arrived from the captain and the pilot aboard the transitting VLCC (full loaded with Crude oil). "About one mile south of Conry Rock a cargo vessel collided with the port side of our tanker, and fire has broke out in the tank No. 3.

Though we have taken emergency actions it seems that the fire will range out of our control sooner or later. Ask for your help. We'll abandon ship.

(i) The VLCC is moving astern slowly so that she could reduce the effect of flame and heat of fire spreading over the surface of the sea to her accommodation.

(ii) The neighbouring ships, which recognized the fire, started away from the burning tanker.

(iii) An escort tug, which had positioned itself on the starboard side of the affected tanker, began shooting a spray of water as far as possible into the damaged area in an attempt to cool her body.

(iv) Crews aboard the VLCC tried to escape out of the tanker by using a liftboat hanging on the starboard side of the ship after their failure to take an emergency measure against the fire, but by mistake dropped off the boat with none aboard, now clustering around the upper deck behind.

(v) Next, the escort tug on the right side of the tanker headed toward tanker's stern while engaged in extinguishment by cooling, and after pressing the tug's bow firmly to her stern, they led the crew gathering above into the tug by using a Jacob's ladder.

(vi) A small fire on the cargo vessel was extinguished by the crew aboard the vessel.

A fire fighting vessel sailed its way from the wind ward toward the burning tanker along her starboard side, thus avoiding a fire which had spreaded out over the surface of the sea, and after passing around her stern, positioned itself at the left side and the back of her body, continually shooting a water-curtain all the while.

Then while keeping pace with the backward speed of the tanker, they swept away residual sea surface fire still drifting along the tanker by using a spray of sea water and also shot a cooling spray over her upper deck and her side hull.

At the same time after ensuring the position of holes through which flame blows out by using a TV monitor at the top of the mast, they started to shoot a foam water into the holes in an attempt to cover completely the surface of crude oil contained in the tank with layers of foam.

While engaged in a spray of foam, a small explosion occurred in tank No.2 at the tanker's side, and as a result, part of the upper deck was nearly ripped open. Then, they sprayed foam water into the ripped hole.

Although the fire was put out some 20 minutes later (after the start of fire fighting) they continued to spray sea water to cool over the upper deck and the side of the hull.

The damaged tanker was handed over to her crews at last.

SCA had already worked out measures for a long-term fight with a fire and had also established a "Headquarters for Accident Control." However, after receiving the message regarding the control of a fire, they instructed salvages to head to the scene in a attempt to transfer the crude oil remaining in the broken tanks.

3) A Big Fire on an LNG Tanker (Port Said)

"Just now a general cargo vessel (approximately 20,000 DWT) bound for Port Said, has collided a northbound LNG tanker (loaded with 125,000 m^3 of LNG) right in the middle of LNG tanker near HM85 in Port Said. Both ships are on a big fire."

The above message arrived at the Transit Dep't via VHF.

Immediately after confirming the fire by sight, the Transit Dep't instructed the Execution Team to rush to the scene, and at the same time gave a warning for danger to all the ships sailing near the scene and to the residents in Port Said & Port Fouad.

According to the report of the Execution Team arriving at the scene the fire became worse and blocked access to the tanker within 300 m of its port side owing to the intensive heat radiation of the ranging flame. Attempting to approach from the starboard side, they found 3 crew members alive and 3 dead bodies drifting at sea.

They lifted up both groups out of the sea into their vessel.

It was reported, direction of wind: N, wind velocity: 5 m/sec. the LNG tanker has grounded 1 km east of Km80 with its bow directed toward the west, the general cargo vessel is travelling slowly toward the west and tug boats are now fighting with the fire.

SCA instructed all fire-fighting vessels and tug boats to rush to the scene, carrying all fire extinguishing materials available. They set up the "Headquarters for a Big Accident Control" making contact with their consultants.

After that, the Execution Team on board a fire fighting vessel succeeded in approaching to the starboard side of the LNG tanker involved in the accident. Spraying a water onto the cargo tanks to cool them and rescued 5 crews (the pilot and the captain were included) from the tanker.

Remarks of the 5 crews provided the following facts:

(i) None left in the tanker.

(ii) A fire wire rope is hanging out in proper position at her stern.

(iii) Water spraying onto her cargo tanks is still going on.

(iv) The damaged tank is tank No.3 only. Other tanks remains undamaged and fully loaded.

Among the five survivors, two were left as assistants to the Execution Team and the rest were sent back to the Head Office.

(After a continual spray of water onto the cargo tanks from the fire fighting vessel, a faint but perceptible sign was observed that flames from the vent mast went down.)

The fire, however, showed stable condition, diving investigations were conducted according to their judement on the scene in order to examine the possibility of fixing a towline on the bottom of the tankers. It turned out to be possible.

SCA decided after referring to an concensus of experts who were members of expert meeting which has been held periodically by SCA, to contain the affected tanker in an inlet nearby before gas in the tank burned itself out.

Tug boats forced the tanker carefully off the ground with a wire of an adequate length and began to tow it by dead slow to the inlet at the north section. Positioning the tug boat on the wind ward and the tanker on the lee ward, all the works were done very carefully with dead slow.

But the attempt to drift the tanker along with the wind to the entrance of the inlet, was quite a difficult job, and the Execution Team was forced to repeat the same attempt again and again.

After leading the LNG tanker into the inlet, blockading work was done by dredgers.

The damaged LNG tanker should be left untouched for a long time.

If air stealing into the cargo tank should trigger a big explosion and cause damage and hazard. But the damage would be limited within the area of the inlet.

(In case of abandonment on mooring buoy at safe place, you should prepare strong bridle wire rope.)

(4) Costs

Costs for measures for dealing with accidents are indicated as follows:

Table VII-4-(4)-1 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 Contrbl 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 Sooops 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 × 10³ US$	65,890	40,034	15,680	3,505	3,459	3,212	1,586	
Total × 10³ LE	46,060	4,634	37,453	1,397	1,397	1,179	152	

VII-5 Evaluation of Measures

(1) Project Evaluation

The aim of this evaluation is to clarify whether or not the project is worth being carried out, and the evaluation is generally conducted from the viewpoint of the national and international economy. It must be considered that the purpose of this evaluation is to evaluate the value of the project itself, and not to calculate the income produced for the project executive body. The latter is a matter of finance rather than economy. So, it can be said, in this sense, that it is minor who bears the project costs or who reaps the benefits. Rather, it is important to find out what and how the project can contribute to the nation and to the world directly and indirectly in monetary and non-monetary terms.

For the evaluation, the project life is assumed to be 20 yeara as follows:

Lead time: 5 years

The lead time before the project comes into full effect, that is the period of investment, is considered as the five years from 1986 to 1990.

Effective time: 15 years

Facilities, equipment and materials provided by the project are estimated to last for an average of 15 years. After this time, most of them will have to be replaced.

The study cases are the same as those chosen for risk analysis. Table VII-5-(1)-1 shows the risk levels by location and by type of accident for the SCA plan and for the four alternatives.

From the Table VII-5-(1)-1, it is clear that the level of grounding in Port Said & Suez and in Ballah Bypass, and the level of collisions in Ballah Bypass, are lower for the SCA plan than for the four alternatives.

Figures presented for collisions in Port Said & Suez, and in the Great Bitter Lake, are total levels, not levels per kilometer. The analysis of these areas could not be conducted in terms of risk level per unit length because these are waiting areas and the accidents in these areas do not occur directionally.

Table VII-5-(1)-1 Estimated Risk Levels

Area / Accident / Risk Level / Case		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.

It is convenient to use figures in terms of the risk reduction of the number of accidents per transit when performing Cost/Benefit analysis. Table VII-5-(1)-2 shows the risk reductions for each type of accident for each of the four alternative plans in these terms.

Table VII-5-(1)-2 Risk Reduction of the Number of Accidents per Transit (Other Parts)

Accident \ Plan	J-1	J-2	J-3	J-4
Grounding	4.32 10^{-4}	3.27 10^{-4}	1.56 10^{-4}	0.89 10^{-4}
Collision	3.16 10^{-6}	2.28 10^{-6}	1.84 10^{-6}	1.15 10^{-6}

As indicated in PART I, the IRR (Internal Rate of Return) is applied for project evaluation using three discount ratios, 5%, 10%, and 15%. Thereafter, graphical analysis which shows the relation between the proposed risk level and the cost plus damage loss is conducted to find the optimum acceptable risk level. The results of this graphical analysis determine whether or not the project is fessible and which risk level should be taken as the acceptable risk level for the project.

1) Cost Calculation

The costs of the project are calculated separately for each of the three major countermeasures: canal widening, improvement of aids to navigation, and preparing to respond to disasters. The costs for each of the alternative plans are presented in Table VII-5-(1)-3.

(i) Total Cost

It is important to note that all the costs are estimated at current prices for both foreign and local currency components. Thus, for the purpose of evaluating the project, the Net Present Value (NPV) is used. However, the actual costs will vary depending on the time when the project is implemented. In other words, the prices will have to be adjusted for inflation.

The project costs are also divided into local and foreign currency. This division is necessary. Generally speaking, it is difficult or impossible for developing countries to provide all the items necessary for a project such as this. Necessary items include hardware as well as intangible items such as engineering technology, management systems, and various types of expert knowledge.

The cost of items which cannot be obtained within the country must be paid in foreign currency. The reserves of foreign currency in developing countries are generally quite limited, so the amount of foreign currency necessary to implement a project is a significant, and sometimes a limiting factor.

In the Table VII-5-(1)-3, the total costs are presented in terms of U.S. dollars. When converting local currency to dollars, an exchange rate of 1.40 LE = 1US$ is used to account for the socalled "shadow price" which indicates the real strength of the local currency. The official exchange rate is currently 0.82 LE = 1US$. However, the LE has been weakening compared with the dollar, and the current black market exchange rate is generally about 1.35 LE to 1.45 LE per dollar.

Table VII-5-(1)-3 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.

Furthermore, the cost of labor and fundamental goods is regulated by the Egyptian government. This results in wage rates that are probably higher than they would be in an open labor market, except for such ones as of engineers and specialists. This is another reason why the shadow price is a reasonable and necessary factor for calculating project cost. Here again, the shadow price is assumed in order to make a fair evaluation of the costs and benefits of the project. The actual costs will be different.

In addition to the initial costs listed in Table VII-5-(1)-3, the maintenance costs necessary to make the project effective throughout the project life must also be considered. The maintenance costs are also estimated in LE and US$. These are not actually part of the project cost itself; however, they are closely related costs which are important to consider when evaluating the project.

We should reiterate that all the costs presented in this analysis are costs above and beyond the costs involved in the Second Stage Development Project being conducted by SCA. The estimated costs for the four alternative plans are additional costs for additional work.

(ii) Investment Schedule

Investment throughout the project life is shown in Table VII-5-(1)-4. As for the widening of the Canal, the schedule takes into account the current work underway by SCA which goes beyond the Second Stage Development Project. In other words, some of the work is taking place now, so the expenses for this work will be paid before the following projects begin.

The figures in Table VII-5-(1)-4 are also presented in current prices. When considering the project benefits, the investments are evaluated using various discount ratios.

As shown in Table VII-5-(1)-4, the investments for aids to navigation and for preparing to respond to potential disasters are the same for each of the four alternatives. It is very difficult to analyze quantitatively how much these measures will reduce the risk level. Nonetheless, they will certainly reduce the level significantly, and they are essential.

One might think that these expenditures could be reduced as the safety of the Canal improves. However, this is not the case. Whether disasters occur once a year or once in twenty years, the expenditures for training personnel and for regular drills will not change.

The emergency teams must be ready to respond to disasters whenever they may happen, and the frequency of drills and the associated expenses cannot be reduced as the frequency of accidents decreases. Similarly, the expenses for maintaining aids to navigation will not decrease.

Thus, although we cannot quantitatively measure the benefits of these items, the expenses for preparing to respond to potential disasters and maintaining aids to navigation will not change, and are absolutely necessary. We consider these expenses as the indispensable, minimum measures necessary to achieve an acceptable risk level.

This sort of concept is quite common in evaluating projects like this. Such concepts are often used in improving the levels of safely, comfort and beauty, items which are difficult to evaluate quantitatively and which depend upon human impressions.

Table VII-5-(1)-4 Investment Schedule

(Unit: Thousand US$)

Study Case	J-1				J-2				J-3				J-4			
Year \ Item	Canal Dredging	Aide to Naviga-tion	Disaster Response	Total	Canal Dredging	Aide to Naviga-tion	Disaster Response	Total	Canal Dredging	Aide to Naviga-tion	Disaster Response	Total	Canal Dredging	Aide to Naviga-tion	Disaster Response	Total
1986	△10,379	3,483	43,344	36,448	△20,013	3,483	43,344	26,814	△10,546	3,483	43,344	36,281	△11,332	3,483	43,344	35,494
1987	41,494	2,755	42,432	86,681	8,915	2,755	42,432	54,102	1,366	2,755	42,432	46,553	87	2,755	42,432	45,274
1988	37,972	280	4,503	42,755	7,077	280	4,503	11,860	451	280	4,503	5,234	41	280	4,503	4,824
1989	30,456	138	4,457	41,051	12,165	138	4,457	16,760	17,206	138	4,457	21,801	14,862	138	4,457	19,457
1990	116,507	138	4,054	120,699	52,441	138	4,054	56,633	27,113	138	4,054	31,305	11,979	138	4,054	10,171
1991	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833
1992	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833
1993	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833
1994	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833
1995	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833
1996	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833
1997	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833
1998	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833
1999	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833
2000	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833
2001	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833
2002	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833
2003	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833
2004	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833
2005	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833	–	138	1,695	1,833

2) Benefit Calculation

The potential benefits of the four alternative plans, J-1, J-2, J-3, and J-4, are considered as the reduced losses due to a reduction in the number of estimated accidents. In other words:

Benefit of Alternative Plan	=	Losses after Completion of the Second Stage Development Project	−	Estimated Losses Under the Alternative Plan

The benefit calculation results are shown in Table VII-5-(1)-5, and all items to be considered for calculation of loss are shown in Table VII-5-(1)-6. This classification table first divides accidents into those which involve vessels carrying dangerous cargoes, and those which involve other vessels. Accidents involving dangerous cargo carriers are further subdivided into accidents in which some of the cargo is spilled, and accidents without cargo spill. These divisions are made because the measures necessary to respond to these different types of accidents are significantly different.

Table VII-5-(1)-5 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-5-(1)-6.

Table VII-5-(1)-6 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.

(i) Item 1

Damage loss in this category always occurs, that is, this kind of damage is common to all types of accidents.

i) Damage to the Accident Vessel(s)

Damage to the accident vessel itself depends upon the type and size of the vessel as well as the scale of the accident. According to accident records in Japan, in the case of collisions between a 250 thousand DWT class tanker and a 20 thousand DWT class container ship, monetary loss is estimated as US$35.6 thousand and US$537.6 thousand, respectively, at current prices. In the study, considering the size of vessels which actually transit the Canal, we estimate the damage to the vessels themselves as US$286.8 thousand per accident.

As for grounding accident, the loss to tankers is estimated as US$200.0 thousand, and the loss to general cargo ships as US$205.8 thousand. Considering the actual ratio of the vessels passing through the Canal, we estimate an average damage or US$204.8 per grounding.

ii) Damage to the Canal

Damage to the Canal is estimated for seawalls, bitts and buoys which are considered to comprise the majority of the monetary loss. The loss is probabilistically summed up as US$112.8 thousand per accident.

iii) Accident Surveillance and Rescue Expenses

When accidents occur, it is necessary to closely observe the accident area, and it is sometimes necessary to rescue passengers and crew using vessels, helicopters, etc. The expenses incurred in observing accident sites and carrying out rescue operations must be considered as part of the monetary losses caused by accidents. These expenses are generally equal to 5.0% of the damage to the accident vessel(s), that is US$14.4 thousand for collisions and US$10.4 thousand for groundings.

(ii) Item 2

Damage in this item is for all dangerous cargo carrier accidents. Here, we assume that the carrier is a large tanker.

i) Expenses for Cargo Transferring

When tankers collide with other vessels, stick to a bank, or ground in the Canal, it is necessary to transfer their cargo to other vessels to minimize danger while responding to the accident and trying to free the tanker. Most of this expense is the cost of hiring tankers, which is estimated as US$320.00 thousand for collision accidents, and US$160.00 thousand for groundings, including auxiliary expenses. For this estimate we assume oil volumes which have to be transferred of 20 thousand tons and 10 thousand tons, respectively.

ii) Expense for Tank Cleaning

To prevent explosions, the tanks of tankers involved in accidents must be cleaned after the cargo is transferred. The costs for cleaning 20 thousand ton and 10 thousand ton tanks are estimated as US$200.0 thousand for collision accidents, and US$100.0

thousand for groundings corresponding to each tank size.

(iii) Item 3

Damage losses in this category are only for those accidents involving the spill of dangerous cargo.

i) Expense for Treatment of Spilled Cargo

This includes the necessary expenses for such activities as using oil booms, gathering spilled oil, and operating working vessels. Naturally, the amount of expenditure depends upon the volume of oil spilled. In the cases of 20 thousand and 10 thousand ton spills, costs are estimated as US$15.2 thousand and US$7.6 thousand, respectively.

ii) Expense for Oil Disposal

Spilled oil must be disposed of after it has been skimmed and gathered.

The collected oil must either be burned, or separated from water for practical use. The expense involved also varies depending upon the volume spilled. For 20 thousand and 10 thousand ton spills, the costs are estimated as US$41.2 thousand and US$20.8 thousand for collisions and groundings, respectively.

iii) Expense for Fire Fighting

When fires occur due to spilled cargo, appropriate countermeasures must be taken. Fire fighting vessels, water pumps, chemical foam and other similar equipment are all used in responding to fires. Of course larger fires are more expensive than smaller ones, but we estimate an average cost of US$54.0 thousand per fire.

iv) Losses due to Oil Pollution

Pollution from oil spills adversely affects various activities including fishing, and swimming and other marine sports. The various environmental damages are difficult to assess in monetary terms. Here, we assume a total pollution damage of US$96.4 thousand per spill.

v) Fires caused by spilled cargo sometimes spread to the land areas near canals and can damage private houses and public facilities. These damages are estimated as US$230.0 thousand per spill.

vi) Losses by Regulations

When accidents occur, emergency regulations are put into effect. These regulations involve detours of transit traffic, including land traffic nearby the Canal, as well as temporary closures of some transit facilities. The losses due to this re-routing and/or temporary stopping of traffic are estimated as US$0.8 thousand per accident.

(iv) Item 4

Under Item 4 we consider; i) the costs of refloating and salvaging vessels which sink; and ii) monetary losses due to waiting whenever the Canal is closed for any reason.

i) Refloating and Salvage Work

When vessels sink at an angle to the center line of the Canal, they block transit and must be salvaged. Many types of vessels, equipment, and manpower are necessary to salvage submerged vessels. Considering various scenarios and the actual mixture of ships passing through the Canal, we estimate a total cost of US$2,445.6 thousand per ship for refloating and salvaging work.

ii) Loss due to Waiting

Whenever the Canal is closed, vessels trying to transit the Canal are forced to wait. When the Canal is closed for some time, the loss to transiting vessels is significant. Presently the Canal is large enough to accommodate all the vessels which need to pass. Thus if the Canal is closed for hours, or even for days, the closure will most likely result in no monetary loss whatsoever to the SCA. However, the costs to the shipping companies are substantial. From the viewpoint of the overall world-wide economy, closure of the Canal results in financial loss. Thus, a reduction in the number of accidents necessitating closure of the Canal is an important benefit and must be included in the overall cost/benefit analysis. The estimated loss per closure due to waiting is calculated as US$14,826.4 thousand until 1999 and US$15,375.6 thousand from 2000, assuming that the convoy mixture is the same as at present, and that convoys will be forced to wait an average of 10 days at both entrances.

(v) Summary of Benefits

All the benefits which have been calculated item by item are listed in Table VII-5-(1)-7 separately for collision and grounding accidents. Table VII-5-(1)-8 lists the total benefits of each of the alternative plans per year. In order to calculate the yearly benefits of each of the alternatives, we multiply the figures from Table VII-5-(1)-2, the risk reduction in the number of accidents per transit, by the estimated number of transit tankers or total transit vessels (depending upon the item) in 1990 and 2000. For calculation purposes, we assume that the transit volume from 1991 to 2000 is equal to the volume in 1990, the volume from 2001 to 2005 is equal to the volume in 2000.

Table VII-5-(1)-7 Summary of Benefits (per Accident)

(Unit: 10^3 US$)

Item	Contents	Collision	Grounding
1	Accident Vessel	286.8	204.8
	Canal	112.8	112.8
	Observation	14.4	10.4
	Total	414.0	328.0
2	Cargo Transferring	320.0	160.0
	Tank Cleaning	200.0	100.0
	Total	520.0	260.0
3	Treatment of Spilled Cargo	15.2	7.6
	Oil Disposal	41.2	20.8
	Fire Fighting	54.0	54.0
	Oil Pollution	96.0	96.0
	Fire	230.0	230.0
	Regulations	0.8	0.8
	Total	437.2	409.2
4	Salvage Works	2,445.6	2,445.6
	Waiting	14,826.4 15,375.6	14,826.4 15,375.6
	Total	17,272.0 17,821.2	17,272.0 17,821.2

Note: The numerals under "waiting" are for 1990 (upper) and 2000 (lower).

Table VII-5-(1)-8 Total Benefits of the Alternatives per Year

(Unit: 10^3 US$, Total Million US$)

Study Case / Accident / Item	J-1				J-2				J-3				J-4			
	Colli-sion	Ground-ding	Total		Colli-sion	Ground-ing	Total		Colli-sion	Ground-ing	Total		Colli-sion	Ground-ing	Total	
			~ 1999	2000 ~			~ 1999	2000 ~			~ 1999	2000 ~			~1999	2000 ~
1	1.30	141.7	3.9	4.0	0.90	107.3	2.9	3.1	0.80	51.2	1.4	1.5	0.50	29.2	0.8	0.8
2	1.60	112.3	0.5	0.6	1.20	85.0	0.4	0.4	1.00	40.6	0.2	0.2	0.60	23.1	0.1	0.1
3	1.40	176.9	0.8	0.9	1.00	133.9	0.6	0.7	0.80	63.9	0.3	0.3	0.50	36.5	0.2	0.2
4	54.00 56.30	7,461.5 7,698.8	35.0	37.0	39.40 40.60	5,647.9 5,827.5	26.5	28.4	31.80 32.80	2,694.4 2,780.1	12.7	13.6	19.9 20.5	1,537.2 1,586.1	7.3	7.8
Total			40.2	43.0			30.4	32.6			14.6	15.6			8.4	8.9

Note: 1. The numerals of Collision and Grounding are benefits per transit.
2. The numerals in Item 4 show benefits both in 1990 and 2000.

3) Evaluation of the Alternatives

(i) Cost-Benefit Ratio (B/C Ratio)

As the costs and benefits of each plan have already been calculated in current prices, it is possible to evaluate the four alternatives compared with each other.

As mentioned before, three annual rates are applied for discounting, 5%, 10% and 15%, and the net present value (NPV) for each year is shown in Table VII-5-(1)-9(1) ~ (4) throughout the project life, for each alternative. From the Tables, it is clear that the larger the discount ratio is, the smaller the NPV becomes for every year of all the alternatives.

Table VII-5-(1)-10 shows the summary of these results and B/C ratios and Fig. VII-5-(1)-1 shows the results graphically.

Table VII-5-(1)-9(1) NPV of Cost and Benefit throughout the Project Life (J-1)

(Unit: Million US$)

Item / Discount Ratio / Year	Cost				Benefit			
	Current	5%	10%	15%	Current	5%	10%	15%
1986	36.4	36.4	36.4	36.4				
1987	86.7	82.6	78.8	75.4				
1988	42.8	38.8	35.3	32.3				
1989	41.1	35.5	30.8	27.0				
1990	120.7	99.3	82.4	69.0				
1991	1.8	1.4	1.1	0.9	40.2	31.5	25.0	20.0
1992	1.8	1.4	1.0	0.8	40.2	30.0	22.7	17.4
1993	1.8	1.3	0.9	0.7	40.2	28.6	20.6	15.1
1994	1.8	1.2	0.9	0.6	40.2	27.2	18.8	13.1
1995	1.8	1.2	0.8	0.5	40.2	25.9	17.0	11.4
1996	1.8	1.1	0.7	0.5	40.2	24.7	15.5	9.9
1997	1.8	1.1	0.6	0.4	40.2	23.5	14.1	8.6
1998	1.8	1.0	0.6	0.3	40.2	22.2	12.8	7.5
1999	1.8	1.0	0.5	0.3	40.2	21.3	11.6	6.5
2000	1.8	0.9	0.5	0.3	43.0	21.7	11.3	6.1
2001	1.8	0.9	0.4	0.2	43.0	20.7	10.3	5.3
2002	1.8	0.8	0.4	0.2	43.0	19.7	9.4	4.6
2003	1.8	0.8	0.4	0.2	43.0	18.8	8.5	4.0
2004	1.8	0.8	0.3	0.1	43.0	17.9	7.7	3.5
2005	1.8	0.7	0.3	0.1	43.0	17.0	7.0	3.0
NPV	355.1	308.2	273.4	246.3	619.8	350.8	212.4	136.1

Table VII-5-(1)-9(2) NPV of Cost and Benefit throughout the Project Life (J-2)

(Unit: Million US$)

Year \ Discount Ratio \ Item	Cost				Benefit			
	Current	5%	10%	15%	Current	5%	10%	15%
1986	26.8	26.8	26.8	26.8				
1987	54.1	51.5	49.1	47.0				
1988	11.9	10.8	9.8	9.0				
1989	16.8	14.5	12.6	11.0				
1990	56.6	46.6	38.7	32.4				
1991	1.8	1.4	1.1	0.9	30.4	23.8	18.9	15.1
1992	1.8	1.4	1.0	0.8	30.4	22.7	17.2	13.1
1993	1.8	1.3	0.9	0.7	30.4	21.6	15.6	11.4
1994	1.8	1.2	0.9	0.6	30.4	20.6	14.2	9.9
1995	1.8	1.2	0.8	0.5	30.4	19.6	12.9	8.6
1996	1.8	1.1	0.7	0.5	30.4	18.7	11.7	7.5
1997	1.8	1.1	0.6	0.4	30.4	17.8	10.7	6.5
1998	1.8	1.0	0.6	0.3	30.4	16.9	9.7	5.7
1999	1.8	1.0	0.5	0.3	30.4	16.1	8.8	4.9
2000	1.8	0.9	0.5	0.3	32.6	16.5	8.6	4.6
2001	1.8	0.9	0.4	0.2	32.6	15.7	7.8	4.0
2002	1.8	0.8	0.4	0.2	32.6	14.9	7.1	3.5
2003	1.8	0.8	0.4	0.2	32.6	14.2	6.4	3.0
2004	1.8	0.8	0.3	0.1	32.6	13.5	5.9	2.6
2005	1.8	0.7	0.3	0.1	32.6	12.9	5.3	2.3
NPV	193.7	165.8	146.6	132.4	469.2	265.5	160.7	103.0

Table VII-5-(1)-9(3) NPV of Cost and Benefit throughout the Project Life (J-3)

(Unit: Million US$)

Item / Discount Ratio / Year	Cost				Benefit			
	Current	5%	10%	15%	Current	5%	10%	15%
1986	36.3	36.3	36.3	36.3				
1987	46.6	44.3	42.3	40.5				
1988	5.2	4.7	4.3	4.0				
1989	21.8	18.8	16.4	14.3				
1990	31.3	25.8	21.4	17.9				
1991	1.8	1.4	1.1	0.9	14.6	11.4	9.1	7.3
1992	1.8	1.4	1.0	0.8	14.6	10.9	8.2	6.3
1993	1.8	1.3	0.9	0.7	14.6	10.4	7.5	5.5
1994	1.8	1.2	0.9	0.6	14.6	9.9	6.8	4.8
1995	1.8	1.2	0.8	0.5	14.6	9.4	6.2	4.2
1996	1.8	1.1	0.7	0.5	14.6	9.0	5.6	3.6
1997	1.8	1.1	0.6	0.4	14.6	8.5	5.1	3.1
1998	1.8	1.0	0.6	0.3	14.6	8.1	4.7	2.7
1999	1.8	1.0	0.5	0.3	14.6	7.7	4.2	2.4
2000	1.8	0.9	0.5	0.3	15.6	7.9	4.1	2.2
2001	1.8	0.9	0.4	0.2	15.6	7.5	3.7	1.9
2002	1.8	0.8	0.4	0.2	15.6	7.1	3.4	1.7
2003	1.8	0.8	0.4	0.2	15.6	6.8	3.1	1.4
2004	1.8	0.8	0.3	0.1	15.6	6.5	2.8	1.3
2005	1.8	0.7	0.3	0.1	15.6	6.2	2.6	1.1
NPV	168.7	145.6	130.2	119.1	225.0	127.4	77.1	49.4

Table VII-5-(1)-9(4) NPV of Cost and Benefit throughout the Project Life (J-4)

(Unit: Million US$)

Year	Cost				Benefit			
	Current	5%	10%	15%	Current	5%	10%	15%
1986	35.5	35.5	35.5	35.5				
1987	45.3	43.1	41.2	39.4				
1988	4.8	4.4	4.0	3.6				
1989	19.5	16.8	14.6	12.8				
1990	16.2	13.3	11.0	9.2				
1991	1.8	1.4	1.1	0.9	8.4	6.6	5.2	4.2
1992	1.8	1.4	1.0	0.8	8.4	6.3	4.7	3.6
1993	1.8	1.3	0.9	0.7	8.4	6.0	4.3	3.2
1994	1.8	1.2	0.9	0.6	8.4	5.7	3.9	2.7
1995	1.8	1.2	0.8	0.5	8.4	5.4	3.6	2.4
1996	1.8	1.1	0.7	0.5	8.4	5.2	3.2	2.1
1997	1.8	1.1	0.6	0.4	8.4	4.9	2.9	1.8
1998	1.8	1.0	0.6	0.3	8.4	4.7	2.7	1.6
1999	1.8	1.0	0.5	0.3	8.4	4.5	2.4	1.4
2000	1.8	0.9	0.5	0.3	8.9	4.5	2.3	1.3
2001	1.8	0.9	0.4	0.2	8.9	4.3	2.1	1.1
2002	1.8	0.8	0.4	0.2	8.9	4.1	1.9	1.0
2003	1.8	0.8	0.4	0.2	8.9	3.9	1.8	0.8
2004	1.8	0.8	0.3	0.1	8.9	3.7	1.6	0.7
2005	1.8	0.7	0.3	0.1	8.9	3.5	1.5	0.6
NPV	148.7	128.8	115.8	106.7	129.0	73.1	44.3	28.4

Table VII-5-(1)-10 Summary of NPV and B/C Ratio

(Unit: Million US$)

Item \ Study Case / 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

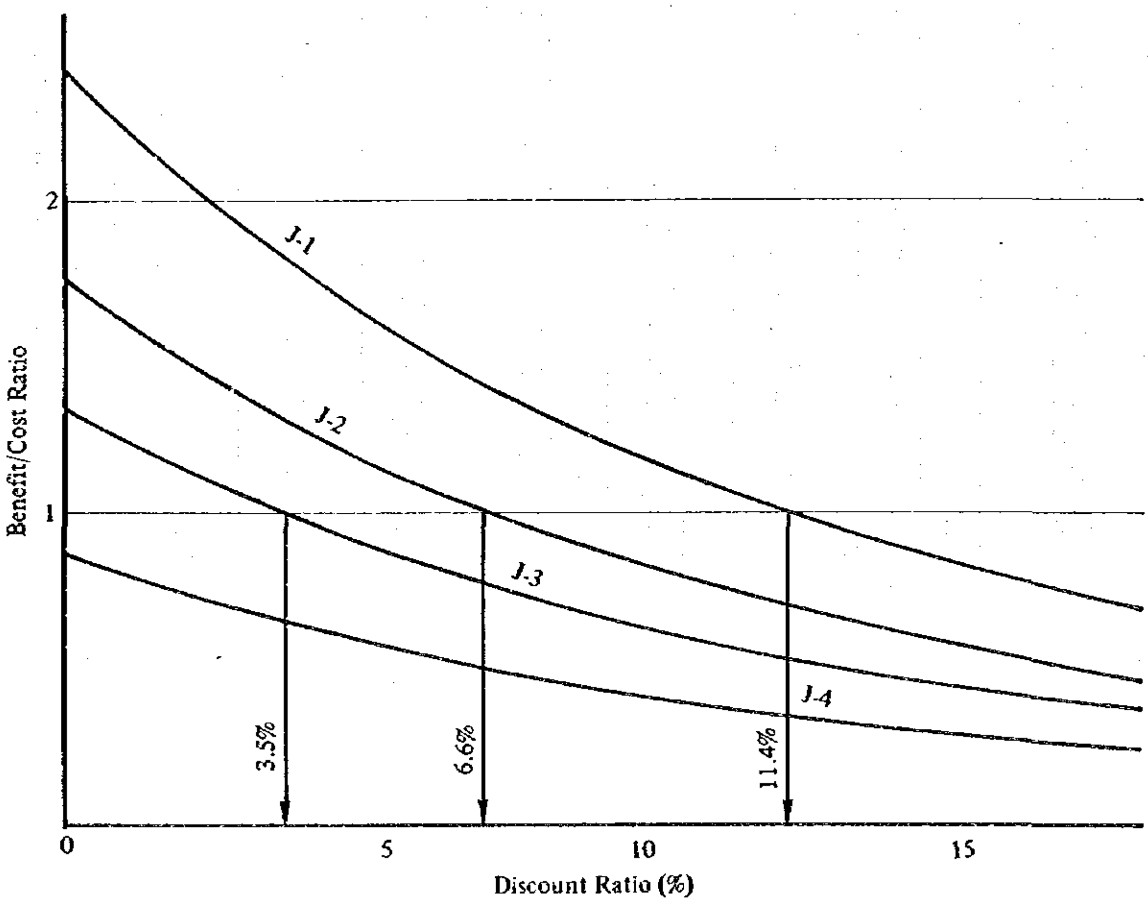


Fig. VII-5-(1)-1 B/C Ratio by Discount Ratio

The internal rate of return (IRR) can also be calculated for each alternative, and the result is 6.6% for J-1, and 11.4% for J-2, and 35% for J-3 as shown in Table VII-5-(1)-11. As for J-4, even if its benefit is compared with its cost in current prices, in other words, at a 0% discount ratio, the valve is less than 1.0, and thus plan J-4 is not considered feasible because of insufficient benefit.

Table VII-5-(1)-11 IRR of the Alternatives

J-1	J-2	J-3	J-4
6.6%	11.4%	3.5%	–

(ii) Acceptable Risk Level

The loss remained after the completion of the Second Stage Development Project can be obtained in the same way as benefits calculation, and based on this, the loss sum of each alternative can also be calculated as shown in Table VII-5-(1)-12.

From the data calculated above, the graph which shows the relation between acceptable risk level and loss sum can be described as shown in Figs. VII-5-(1)-2(1) ~ (3). This loss sum means the total of cost and loss which is still remained after execution of each alternative (refer to Fig. VII-5-(1)-3) . The acceptable risk levels are calculated for the three discount ratios as shown in Table VII-5-(1)-13.

It is already presented graphically in PART I which relation is to be expected between acceptable risk level and loss, cost of countermeasures and loss sum. Figs. VII-5-(1)-2(1) ~ (3) show the same pattern as mentioned before.

Acceptable risk level can be determined as the level which indicates the minimum loss sum, and the value is varied in accordance with discount ratios which is used to change a current price to net present value. In case of 5% discount ratio, the optimum acceptable risk level is 0.34 x 10^{-3}, of 10% discount ratio, 0.38 x 10^{-3} risk level and of 15% discount ratio, 0.40 x 10^{-3} risk level, and they are all nearly equal the acceptable risk level of J-2 plan.

By this analysis, it can be concluded that the acceptable risk level is about 0.40 x 10^{-3} and that J-2 plan is the most feasible one among the four alternatives.

Table VII-5-(1)-12 Loss Sum of Alternatives

(Unit: Million US$)

Case	J-1			J-2			J-3			J-4		
Item \ Discount Ratio	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
Loss	666.5	403.6	263.8	751.8	455.3	291.9	889.9	538.9	345.5	944.2	571.7	366.5
Total	974.7	677.0	510.1	917.6	601.9	424.3	1,035.5	669.1	464.6	1,073.0	687.5	473.2

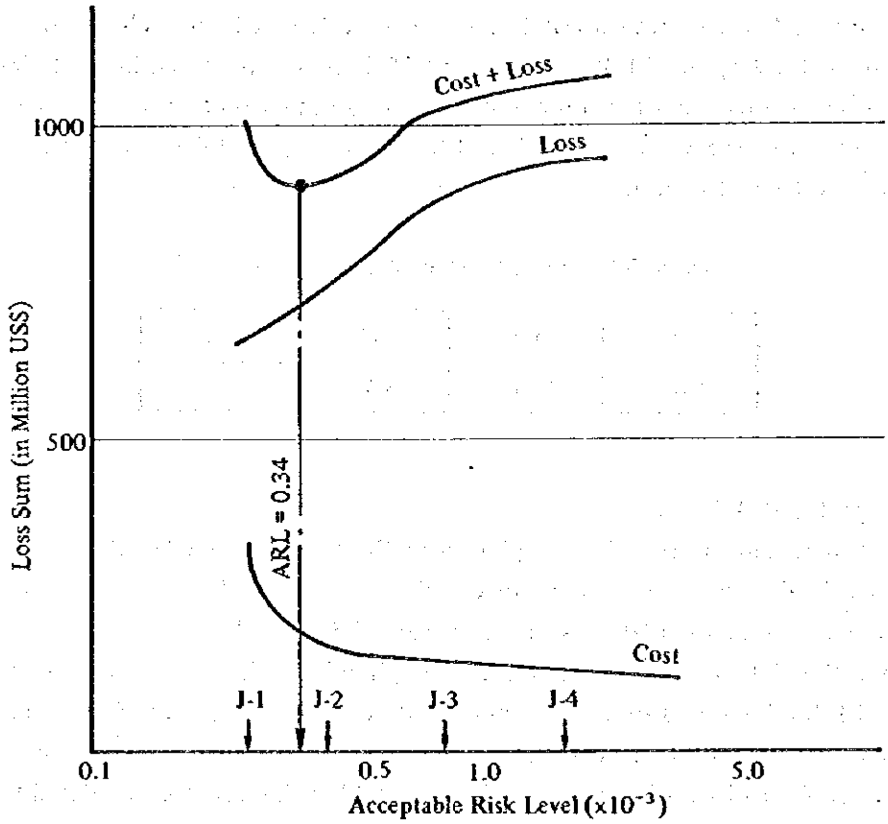


Fig. VII-5-(1)-2(1) Relation between Acceptable Risk Level and Loss Sum (Discount Ratio 5%)

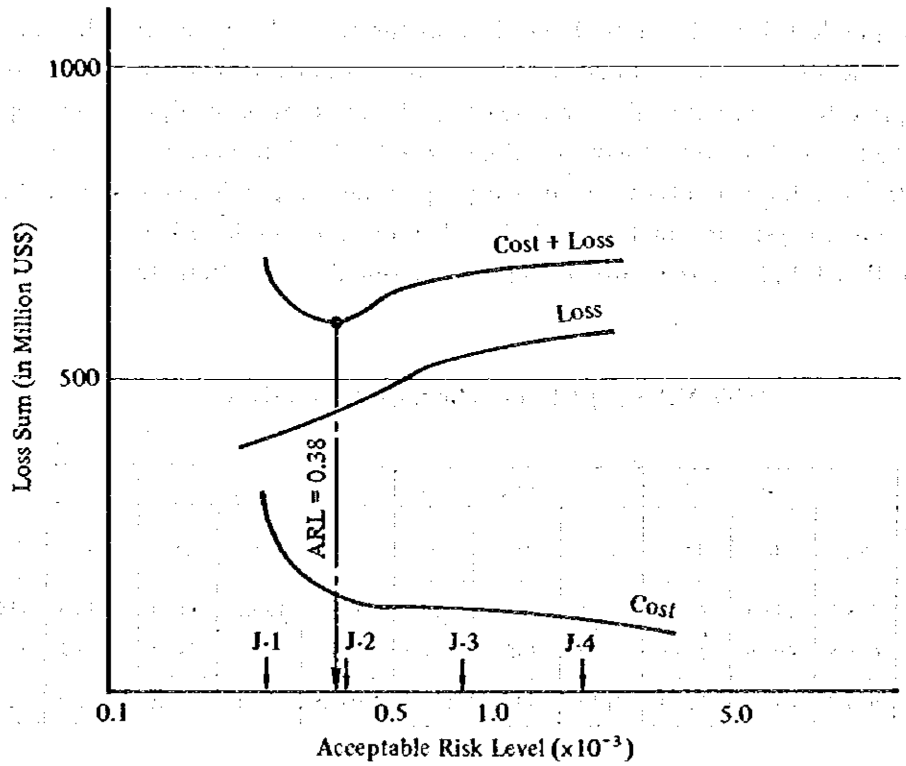


Fig. VII-5-(1)-2(2) Relation between Acceptable Risk Level and Loss Sum (Discount Ratio 10%)

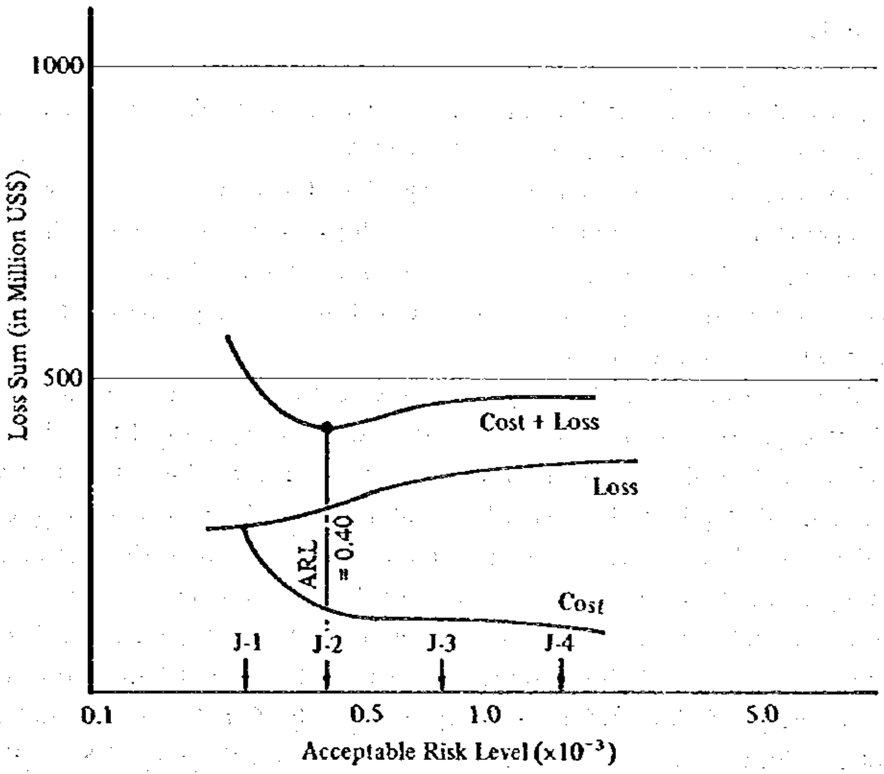


Fig. VII-5-(1)-2(3) Relation between Acceptable Risk Level and Loss Sum (Discount Ratio 15%)

Table VII-5-(1)-13 Acceptable Risk Level

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

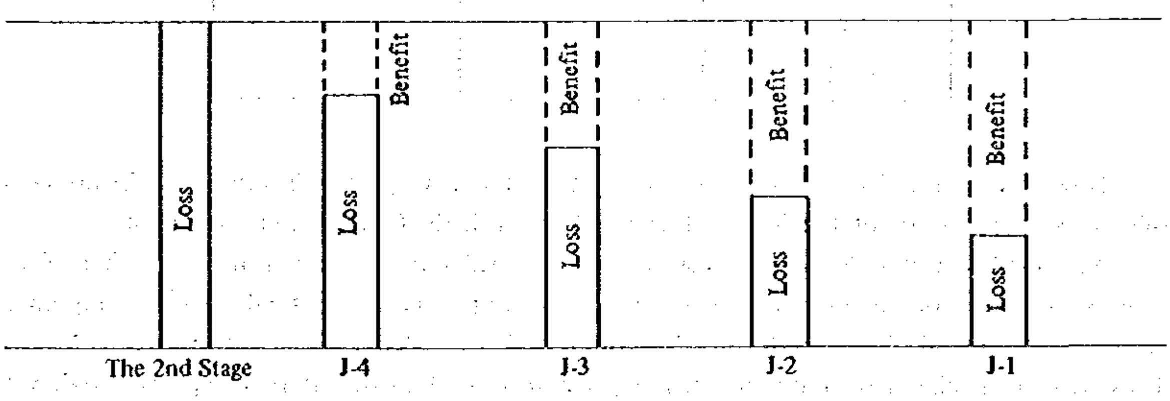


Fig. VII-5-(1)-3 Relation between Benefit and Loss

(2) Financial Analysis

The project must also be evaluated from a financial viewpoint. That is to say we must evaluate the affect of the project on the financial state of SCA.

First, it is essential to understand that the capacity of the Canal at present and in 1990 and 2000 is more than enough to handle all the traffic which will pass through the Canal. Thus, if the Canal were closed for a period of time, for example a period of 50 days which is assumed for this analysis, all of the vessels waiting to pass through the Canal during the period of closure could easily pass through the Canal after it is reopened.

So, the annual income of the SCA would not decrease from a temporary closure of the Canal due to lack of capacity to handle all the transit vessels. During a usual fifty day period, about 3,000 vessels pass through the Canal. However, the Canal were closed for 50 days, it is unreasonable to assume that all of these vessels would wait for the reopening of the Canal. Theoretically all these vessels could pass through after reopening by increasing the number of vessels per convoy up to the limit of the Canal's capacity. But for economic and other reasons, many of these vessels would take other routes or otherwise not wait for the reopening of the Canal. In this study, we assume that all the waiting vessels which arrive at both entrances from beginning of the closure to 5 days before the reopening of the Canal, would abandon their planned passage of the Suez Canal in accordance with the report on the Second Stage Development Project.

The weighted average of the toll rate per ship based on convoy mixture is about US$50,000. The total number of vessels estimated to pass through the Canal in 1990 and 2000 is 27,262 and 28,273, respectively. Consequently the number of transit vessels per day is 74.7 in 1990 and 77.5 in 2000. Thus, we can calculate the average lost income per 50 day Canal closure as follows: Average income per ship ($50,000) x number of ships per day x 45 days. Table VII-5-(2)-1 lists the expected losses per 50 day closure.

Table VII-5-(2)-1 Estimated Total Loss Per 50 Day Closure

(Unit: Million US$)

Year	1990	2000
Total Loss	168.1	174.3

Now, the financial benefits which each of the alternative plans will bring to SCA are considered as the reduction of the losses which would occur if the Canal were to be closed.

To calculate this reduction of loss, we must consider the reduction in the number of accidents from each of the alternative plans. Of course, not every accident will result in temporary closure of the Canal. We estimate that 10% of all tanker accidents will result in such a closure. Thus, we can calculated the reduction of loss per year for each of the alternative plans as follows: Reduction of number of accidents per year x percent of accidents which would result in temporary closure (10%) x total loss per closure. Table VII-5-(2)-2 lists the estimated reduction of losses per year for each of the alternative plans.

Table VII-5-(2)-2 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

The expenditures for each of the alternative plans are as calculated under the section on economic analysis. As when calculating the IRR, the FRR (Financial Rate of Return) of the project is calculated using discount rations of 5%, 10%, and 15%. Please note that the financial evaluation is carried out in comparison with the conditions after the completion of the Second Stage Development Project, and all the factors other than those directly concerned with the project are assumed not to change.

Tables VII-5-(2)-3(1) ~ (4) show the income and expenditures year by year for each of the alternatives at each of the discount ratios. Table VII-5-(2)-4 shows the income and expenditure, and the ratio of the two. From these results, we calculate the FRR of each alternative as 4.6% for J-1, 9.0% for J-2, and 1.4% for J-3 as shown in Figs. VII-5-(2)-1 and VII-5-(2)-5. The FRR of J-4 is negative.

From this FRR we conclude that J-2 plan is the most profitable among four alternatives from a financial viewpoint, and that the 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-5-(2)-3(1) Expenditure and Income through Project Life (J-1)

(Unit: Million US$)

Item / Discount Ratio / Year	Expenditure				Income			
	Current	5%	10%	15	Current	5%	10%	15%
1986	36.4	36.4	36.4	36.4				
1987	86.7	82.6	78.8	75.4				
1988	42.8	38.8	35.3	32.3				
1989	41.1	35.5	30.8	27.0				
1990	120.7	99.3	82.4	69.0				
1991	1.8	1.4	1.1	0.9	34.1	26.72	21.17	16.95
1992	1.8	1.4	1.0	0.8	34.1	25.45	19.25	14.74
1993	1.8	1.3	0.9	0.7	34.1	24.23	17.50	12.82
1994	1.8	1.2	0.9	0.6	34.1	23.08	15.91	11.15
1995	1.8	1.2	0.8	0.5	34.1	21.98	14.46	9.69
1996	1.8	1.1	0.7	0.5	34.1	20.93	13.15	8.43
1997	1.8	1.1	0.6	0.4	34.1	19.94	11.95	7.33
1998	1.8	1.0	0.6	0.3	34.1	18.99	10.87	6.37
1999	1.8	1.0	0.5	0.3	34.1	18.08	9.88	5.54
2000	1.8	0.9	0.5	0.3	36.7	18.54	9.66	5.19
2001	1.8	0.9	0.4	0.2	36.7	17.65	8.79	4.51
2002	1.8	0.8	0.4	0.2	36.7	16.81	7.99	3.92
2003	1.8	0.8	0.4	0.2	36.7	16.01	7.26	3.41
2004	1.8	0.8	0.3	0.1	36.7	15.25	6.60	2.97
2005	1.8	0.7	0.3	0.1	36.7	14.52	6.00	2.58
NPV	355.1	308.2	273.4	246.3	527.1	298.18	180.44	115.60

Table VII-5-(2)-3(2) Expenditure and Income through Project Life (J-2)

(Unit: Million US$)

Item / Discount Ratio / Year	Expenditure				Income			
	Current	5%	10%	15	Current	5%	10%	15%
1986	26.8	26.8	26.8	26.8				
1987	54.1	51.5	49.1	47.0				
1988	11.9	10.8	9.8	9.0				
1989	16.8	14.5	12.6	11.0				
1990	56.6	46.6	38.7	32.4				
1991	1.8	1.4	1.1	0.9	25.8	20.21	16.02	12.83
1992	1.8	1.4	1.0	0.8	25.8	19.25	14.56	11.15
1993	1.8	1.3	0.9	0.7	25.8	18.34	13.24	9.70
1994	1.8	1.2	0.9	0.6	25.8	17.46	12.04	8.43
1995	1.8	1.2	0.8	0.5	25.8	16.63	10.94	7.33
1996	1.8	1.1	0.7	0.5	25.8	15.84	9.95	6.38
1997	1.8	1.1	0.6	0.4	25.8	15.08	9.04	5.55
1998	1.8	1.0	0.6	0.3	25.8	14.37	8.22	4.82
1999	1.8	1.0	0.5	0.3	25.8	13.68	7.47	4.19
2000	1.8	0.9	0.5	0.3	27.8	14.04	7.32	3.93
2001	1.8	0.9	0.4	0.2	27.8	13.37	6.66	3.42
2002	1.8	0.8	0.4	0.2	27.8	12.74	6.05	2.97
2003	1.8	0.8	0.4	0.2	27.8	12.13	5.50	2.58
2004	1.8	0.8	0.3	0.1	27.8	11.55	5.00	2.25
2005	1.8	0.7	0.3	0.1	27.8	11.00	4.55	1.95
NPV	193.7	165.8	146.6	132.4	399.0	225.69	136.56	87.48

Table VII-5-(2)-3(3) Expenditure and Income through Project Life (J-3)

(Unit: Million US$)

Item / Discount Ratio / Year	Expenditure				Income			
	Current	5%	10%	15	Current	5%	10%	15%
1986	36.3	36.3	36.3	36.3				
1987	46.6	44.3	42.3	40.5				
1988	5.2	4.7	4.3	4.0				
1989	21.8	18.8	16.4	14.3				
1990	31.3	25.8	21.4	17.9				
1991	1.8	1.4	1.1	0.9	12.4	9.7	7.7	6.2
1992	1.8	1.4	1.0	0.8	12.4	9.3	7.0	5.4
1993	1.8	1.3	0.9	0.7	12.4	8.8	6.4	4.7
1994	1.8	1.2	0.9	0.6	12.4	8.4	5.8	4.1
1995	1.8	1.2	0.8	0.5	12.4	8.0	5.3	3.5
1996	1.8	1.1	0.7	0.5	12.4	7.6	4.8	3.1
1997	1.8	1.1	0.6	0.4	12.4	7.3	4.4	2.7
1998	1.8	1.0	0.6	0.3	12.4	6.9	4.0	2.3
1999	1.8	1.0	0.5	0.3	12.4	6.6	3.6	2.0
2000	1.8	0.9	0.5	0.3	13.3	6.7	3.5	1.9
2001	1.8	0.9	0.4	0.2	13.3	6.4	3.2	1.6
2002	1.8	0.8	0.4	0.2	13.3	6.1	2.9	1.4
2003	1.8	0.8	0.4	0.2	13.3	5.8	2.6	1.2
2004	1.8	0.8	0.3	0.1	13.3	5.5	2.4	1.1
2005	1.8	0.7	0.3	0.1	13.3	5.3	2.2	0.9
NPV	168.7	145.6	130.2	119.1	191.4	108.4	65.8	42.1

Table VII-5-(2)-3(4) Expenditure and Income through Project Life (J-4)

(Unit: Million US$)

Item / Discout Ratio / Year	Expenditure				Income			
	Current	5%	10%	15	Current	5%	10%	15%
1986	35.5	35.5	35.5	35.5				
1987	45.3	43.1	41.2	39.4				
1988	4.8	4.4	4.0	3.6				
1989	19.5	16.8	14.6	12.8				
1990	16.2	13.3	11.0	9.2				
1991	1.8	1.4	1.1	0.9	7.1	5.6	4.4	3.5
1992	1.8	1.4	1.0	0.8	7.1	5.3	4.0	3.1
1993	1.8	1.3	0.9	0.7	7.1	5.1	3.6	2.7
1994	1.8	1.2	0.9	0.6	7.1	4.8	3.3	2.3
1995	1.8	1.2	0.8	0.5	7.1	4.6	3.0	2.0
1996	1.8	1.1	0.7	0.5	7.1	4.4	2.7	1.8
1997	1.8	1.1	0.6	0.4	7.1	4.2	2.5	1.5
1998	1.8	1.0	0.6	0.3	7.1	4.0	2.3	1.3
1999	1.8	1.0	0.5	0.3	7.1	3.8	2.1	1.2
2000	1.8	0.9	0.5	0.3	7.6	3.8	2.0	1.1
2001	1.8	0.9	0.4	0.2	7.6	3.7	1.8	0.9
2002	1.8	0.8	0.4	0.2	7.6	3.5	1.7	0.8
2003	1.8	0.8	0.4	0.2	7.6	3.3	1.5	0.7
2004	1.8	0.8	0.3	0.1	7.6	3.2	1.4	0.6
2005	1.8	0.7	0.3	0.1	7.6	3.0	1.2	0.5
NPV	148.7	128.8	115.8	106.7	109.5	62.3	37.5	24.0

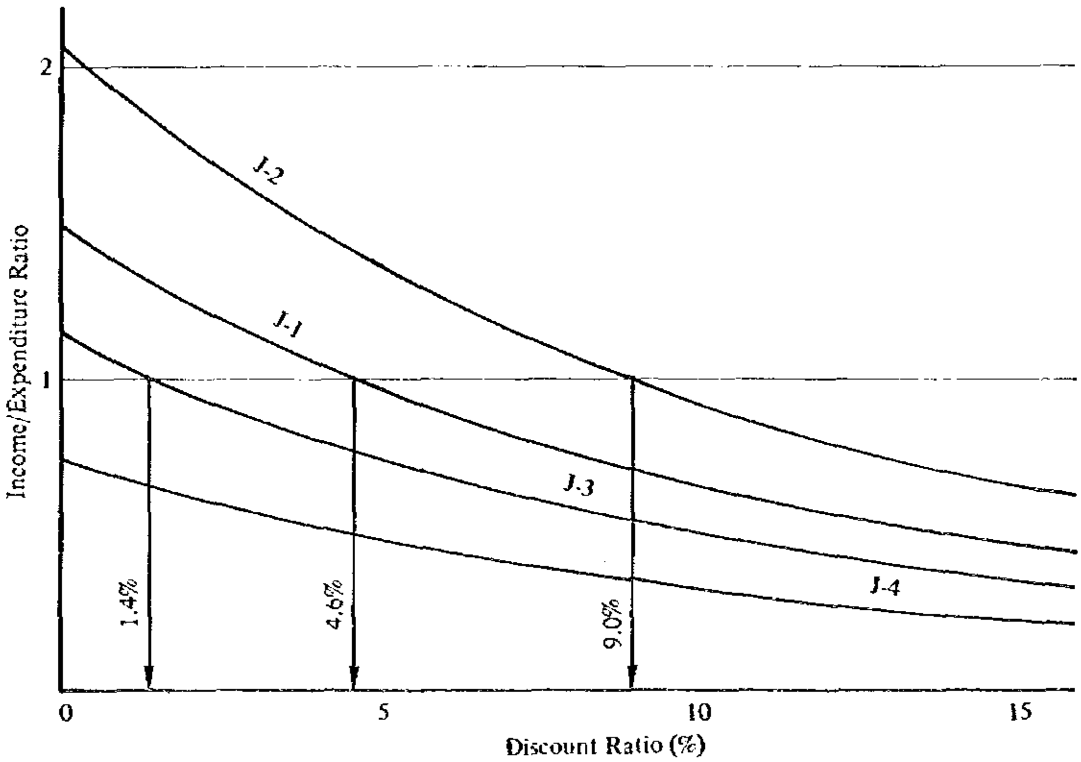


Fig. VII-5-(2)-1 FRR of the Alternatives

Table VII-5-(2)-4 Ratio of Income and Expenditure

(Unit: Million US$)

Item \ Alternative / Discount Ratio	J-1			J-2			J-3			J-4		
	5%	10%	15%	5%	10%	15%	5%	10%	15%	5%	10%	15%
(A) Expenditure	308.2	273.4	246.3	165.8	146.6	132.4	145.6	130.2	119.1	128.8	115.8	106.7
(B) Income	298.2	180.4	115.6	225.7	136.6	87.5	108.4	65.8	42.1	62.3	37.5	24.0
(B)/(A)	0.967	0.660	0.469	1.361	0.932	0.661	0.745	0.505	0.353	0.484	0.324	0.225

Table VII-5-(2)-5 Results of FRR Calculation

J-1	J-2	J-3	J-4
4.6%	9.0%	1.4%	–