社会開発調査部報告書

No. 18

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

PORT AUTONOME INTERNATIONAL DE DJIBOUTI
MINISTRY OF PORT AND MARITIME AFFAIRS
THE REPUBLIC OF DJIBOUTI

THE STUDY
ON
THE OIL-BERTHS RECONSTRUCTION
OF
PORT OF DJIBOUTI
IN
THE REPUBLIC OF DJIBOUTI

FINAL REPORT

MARCH 1994

PACIFIC CONSULTANTS INTERNATIONAL (PCI)
TOKO ENGINEERING CONSULTANTS LTD.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

PORT AUTONOME INTERNATIONAL DE DJIBOUTI
MINISTRY OF PORT AND MARITIME AFFAIRS
THE REPUBLIC OF DJIBOUTI

THE STUDY
ON
THE OIL-BERTHS RECONSTRUCTION
OF
PORT OF DJIBOUTI
IN
THE REPUBLIC OF DJIBOUTI

FINAL REPORT

MARCH 1994

PACIFIC CONSULTANTS INTERNATIONAL (PCI)
TOKO ENGINEERING CONSULTANTS LTD.

FOREIGN EXCHANGE RATE

1 US Dollar (US $)	=	107.85 Japanese Yen (J ¥)
	=	179.48 Djibouti Francs (FD)
1 FD	=	0.60 J ¥

(average rate from June 1 to November 30, 1993)

PREFACE

In response to a request from the Government of the Republic of Djibouti, the Government of Japan decided to conduct a study on the Oil-Berths Reconstruction of Port of Djibouti and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Djibouti a study team headed by Mr. Masaaki Goshima, of Pacific Consultants International and composed of members from this company and the company, Toko Engineering Consultants Inc., two times between August 1993 and January 1994.

The team held discussions with the officials concerned of the Government of Djibouti, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Djibouti for their close cooperation extended to the team.

March 1994

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

March, 1994

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency

Dear Mr. Yanagiya,

It is my great pleasure to submit herewith the Final Report for the Study on the Oil-Berths Reconstruction of Port of Djibouti in the Republic of Djibouti.

The report is the result of studies carried out by Pacific Consultants International and Toko Engineering Consultants Ltd. as per the contract with the Japan International Cooperation Agency (JICA). The study team conducted two field surveys between August 1993 and January 1994.

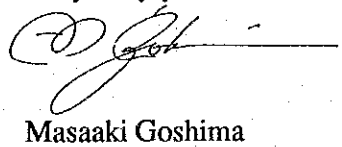
Based on the findings of these surveys and on data and information collected and analyzed in Japan, the preliminary design of Oil-Berths was formulated with a target year of 2010 including a feasibility study.

The study shows that rehabilitation of Oil-Berths is important and essential as a socioeconomic infrastructure not only to improve living standards in Djibouti but also to contribute to the improvement of regional economic disparity and the stability of public welfare in Djibouti. therefore, I earnestly hope that measures will be taken to implement this project.

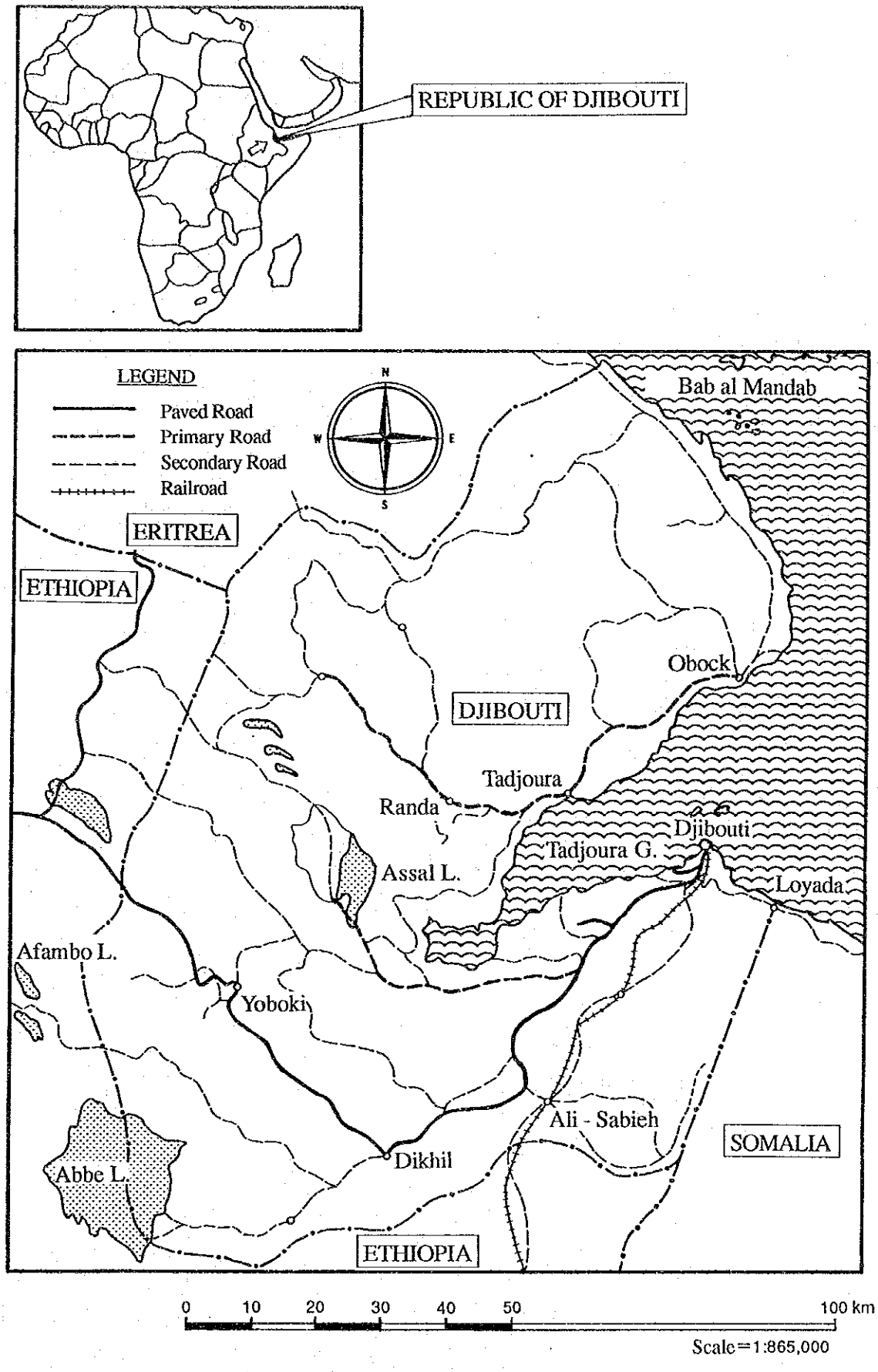
On behalf of the study team, we wish to take this opportunity to express our sincere gratitude for the generous cooperation, assistance and warm hospitality extended to the study team during their stay in Djibouti of Djiboutian Government firstly Port Autonome International de Djibouti of Ministry of Port and Maritime Affairs and other related organizations.

We also wish to express our deepest gratitude to the Japan International Cooperation Agency, the Ministry of Transport, the Ministry of Foreign Affairs and the Japanese Embassy in Paris and JICA France Office for their close advice and assistance during our study

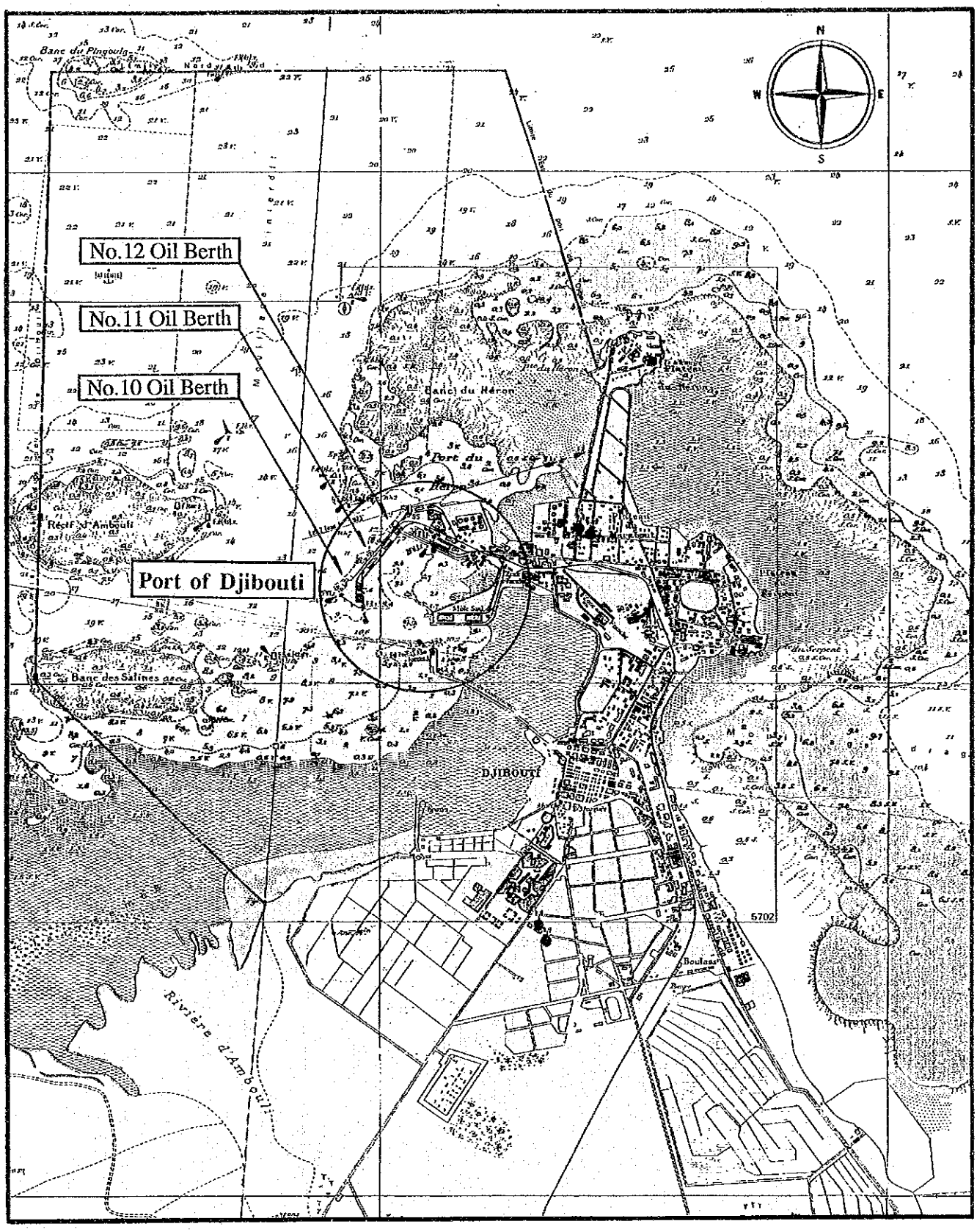
Very truly yours,



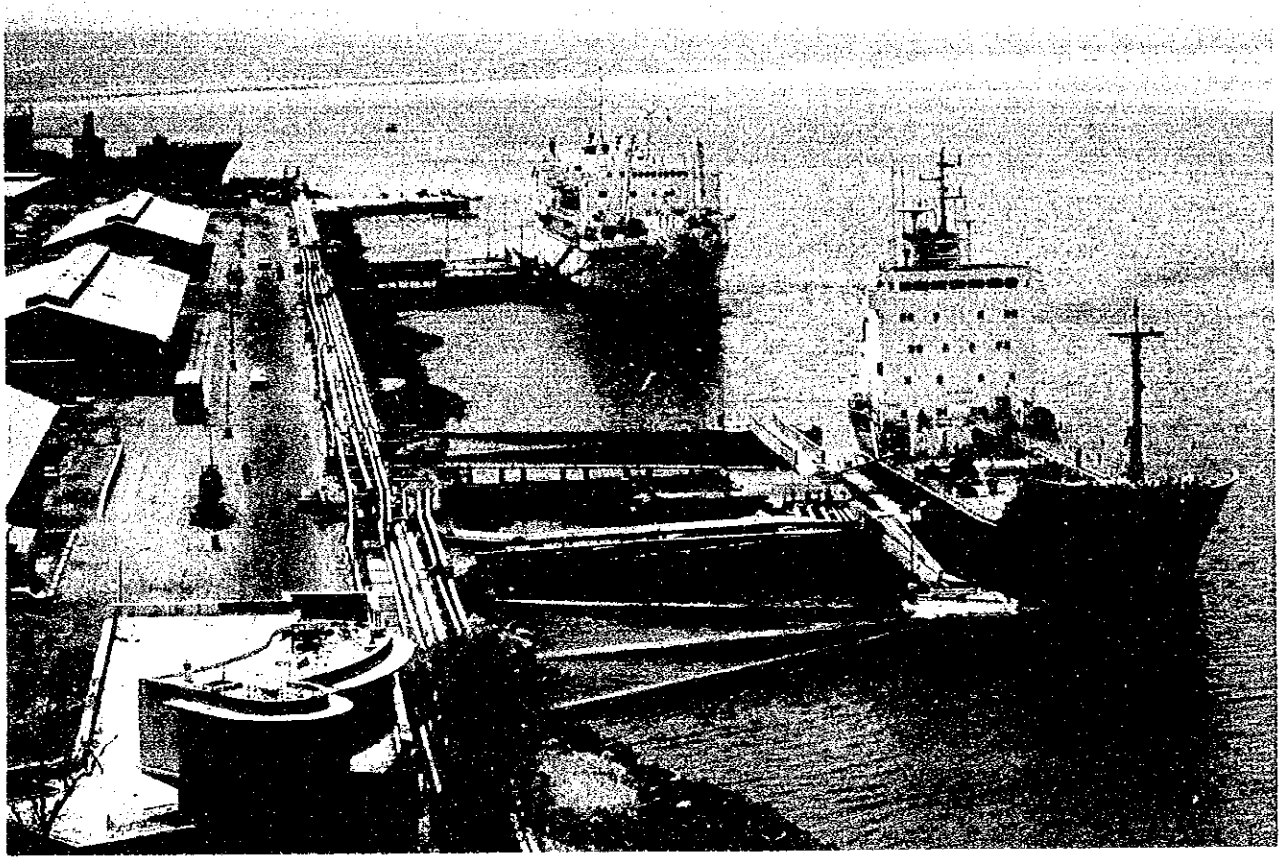
Masaaki Goshima
Team Leader
Japanese Study Team for the Development Study
on the Oil-Berths Reconstruction of Port of Djibouti
Pacific Consultants International



LOCATION MAP (I)

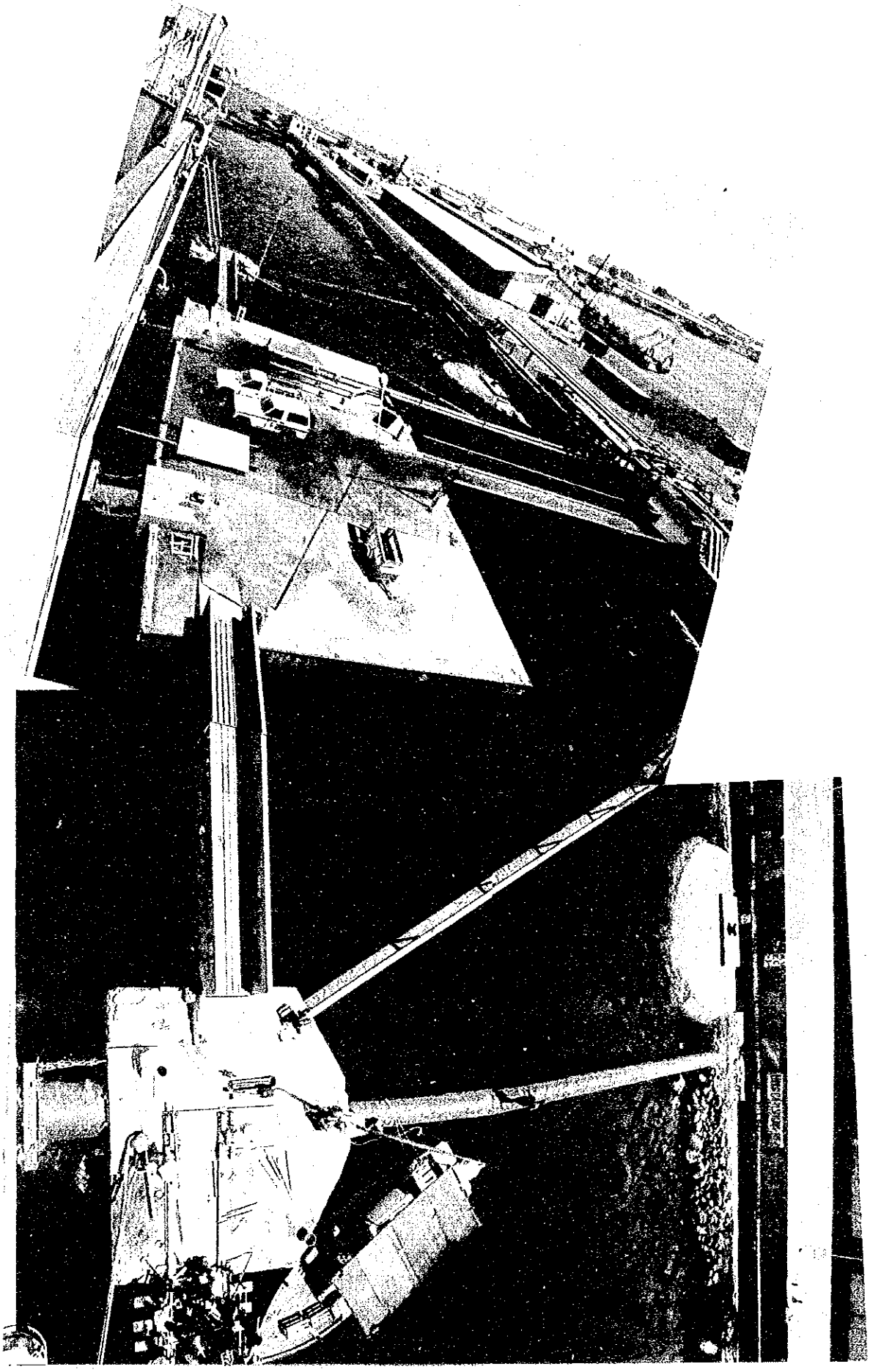


LOCATION MAP (II)

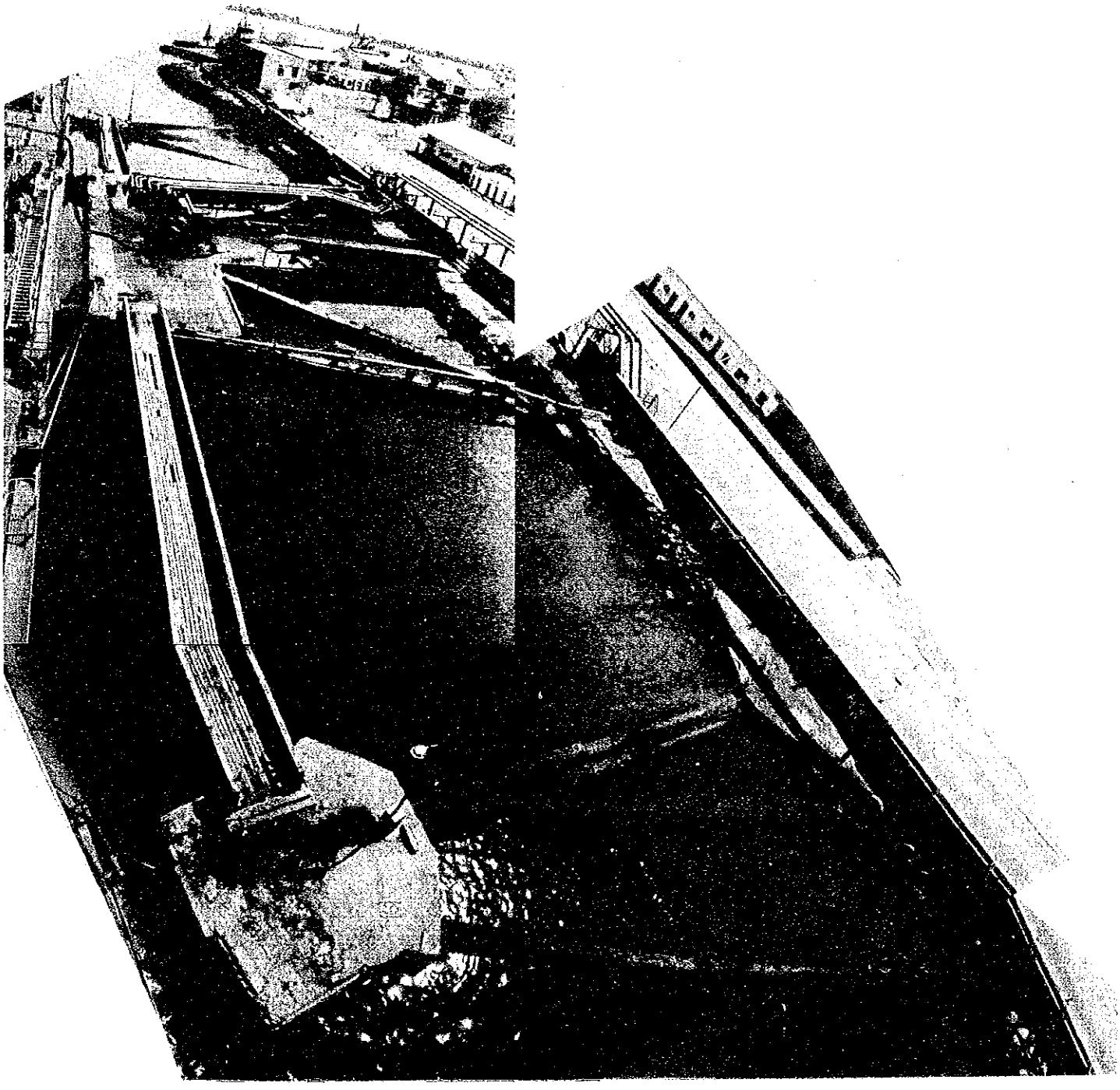


Port of Djibouti

General View of Oil-Berth Nos. 10, 11 and 12 (Sept. 26, 1993)



General View of Oil-Berths No. 11 (Oct. 6, 1993)



General View of Oil-Berths No. 12 (Sept. 17, 1993)

Summary

SUMMARY

1 The purpose of the Study is to formulate a plan for the Reconstruction of the Oil-Berths No. 11 and No. 12 for the demand in the target year of 2010. The Study proposes the following three main points:

(1) Confirmation of the necessity for the reconstruction of the oil-berths;
(2) Formulation of a reconstruction plan of oil-berths; and
(3) Technology transfer to counterparts on the Djibouti side.

2 As a result of the field investigation and succeeding studies, it is concluded that the existing Oil-Berth Nos. 11 and 12 are no longer serviceable from a technical point of view and they should be completely reconstructed at their present location instead of their rehabilitation that will be more difficult and costly.

3 In parallel with the above structural examination on the existing berthing facilities, a demand forecast study on the oil products to be handled at the Port of Djibouti was made for the target year of 2010 and concluded as follows:

Description	Present Demand in 1992	Forecasted Demand in 2010
	(1,000 cu.m)	(1,000 cu.m)
Domestic Consumption	114.8	304.6
Bunker Supply	149.4	231.8
Transshipment	141.7	341.1
Total	406.0	877.6
(Equivalent in thousand tons)	(341.1)	(741.3)

4 The required number, size and layout of the Oil-Berths are determined to meet the above demand forecast considering the present port activities and the conditions of existing berth facilities.

The determination is made taking Oil Berth No. 10 into consideration.

A consideration is made for not only oil-tankers but also for vessels calling at Djibouti Port and berthing at Berth Nos. 10, 11 and 12 for bunkering, water supply, repair, spare parts supply, food supply, etc., hereafter referred as "the Non-Commercial" vessels.

As a result, the ships allocation and size of the berths are concluded as summarized below;

Berth No. 10	:	For oil tankers of 35,000 DWT or above or equivalent "Non-Commercial" vessels with a maximum draft less than 12.0 m.
Berth No. 11 and 12	:	For oil tankers of 3,000 to 35,000 DWT or equivalent "Non-Commercial" vessels with maximum draft less than 11.0 m.

As for the layout of the berths, the center of each berth will be at the same location as the existing berth but the face line will be shifted seaward to align with new berth No. 10.

5 As a result of the succeeding preparatory design, the proposed reconstruction project of the Oil-Berths No. 11 and 12 includes the demolition of the existing berths, the construction of steel sheet pile cellular cofferdam type quaywall with a length of 90 m for each berth and access ways. For the recommended components of the Project, see Table I.

6 The required construction period will be 24 months for two berths and it is recommendable to start the reconstruction of Berth No. 11 followed by No. 12 in this order to minimize influence of construction works on the port activities.

7 Required project cost including engineering services is estimated to be 2,487 million in Japanese Yen.

8 An environmental study was made on the two stages, i.e., during the construction period and after the commencement of the oil berths operation. It is revealed that adverse environmental effects to be caused by the implementation of the project will be minimal, since the majority of the scope of the project is rehabilitation of existing berthing facilities.

To minimize oil spill to the sea, however, oil spill wall and oil sump are recommended to be provided on the individual Oil-Berths No. 11 and 12.

Promotion of environmental consciousness to all concerned is also recommended.

Effective utilization of existing pollution control devices and materials such as oil fence and oil absorbing solvent, which are kept in storage, is also recommended.

9 Based on the aforementioned proposed berthing facilities and the estimated cost concerned, project appraisal is made.

Economic benefits of the project are identified as follows:

a) Accommodation of tankers otherwise diverted to other ports, because of the difficulties of berthing at the Port of Djibouti.

b) Revenue of railway fares to transport cargo to Ethiopia that would be lost when the cargo would be diverted to Assab for transportation to Ethiopia by road.

c) Avoidance of demurrage of "Non-Commercial" vessels other than tankers.

d) Ease of operation of tankers and other "Non-Commercial" vessels by utilising three oil berths instead of one.

e) Reduced risk of pollution and accidents resulting from the congestion of the operation with one oil berth at the port.

f) Strengthening of the competitiveness of the Port of Djibouti against other ports, and good publicity effects for clients from the operation with three oil berths rather than only one.

g) Profit of local oil companies, maritime agencies and companies engaged in the port operation accrued from the operation with three oil berths.

Taking the quantifiable items a), b) and c) above into consideration, the economic internal rate of return (EIRR) and Benefit Cost Ratio at discount rate of 10 % are 13.21 % and 1.55 respectively.

The project as defined by the reconstruction of the structure of Oil Berth Nos. 11 and 12 and relevant miscellaneous facilities is deemed as feasible.

10 Finally, the Study Team recommends that the Oil-Berth Nos. 11 and 12 be newly re-constructed as early as possible to secure and encourage the economy and social activities in Djibouti and to avoid any disaster and marine pollution which may be caused by the unstable physical conditions of the existing berths.

Table I Recommended Components of the Project

Name of Facilities/Works	Dimensions, Specifications	Quantities		Remarks
		Berth No. 11	Berth No. 12	
1) Demolition of Existing Berth Structure	Demolition of existing concrete superstructures, part of foundation piles, access bridge and cat-walk.	L.S.	L.S.	
2) Quaywall	Steel sheet pile Cellular cofferdam type structure. Total length: 89.9 m Design Water depth: -12 m	1 set	1 set	
3) Accessories for Quaywall	3-1) Rubber fender 3-2) Mooring Bitt 3-3) Others	4 sets 8 sets L.S.	4 sets 8 sets L.S.	Ladders Oil pit corner protection concrete curb
4) Reinforcement of Existing Bitts	Additional armour stone for existing bitt foundations	L.S.	L.S.	
5) Access Road	Causeway type with armour rock	Ea	Ea	
6) Concrete Pavement	For apron and access road	L.S.	L.S.	Pre-cast block type
7) Lighting Facilities	Lighting poles for Quaywall and for existing mooring bitts.	L.S.	L.S.	
8) Water Supply System	Water supply pit and water supply branch pipes from main pipe line to water supply pit.	L.S.	L.S.	
9) Fire Alarm System	Fire alarm device connecting between Oil-Berth and the Harbor Masters Office.	L.S.	L.S.	
10) Ladders for Existing Mooring Bitt	For access to the existing bitts.	3 sets	2 sets	

THE STUDY ON THE OIL-BERTHS RECONSTRUCTION OF PORT OF DJIBOUTI IN THE REPUBLIC OF DJIBOUTI

FINAL REPORT

Table of Contents

Location Maps
Photographs
Summary

Chapter 1 Background of the Study

1.1 Purpose of the Study---------- 1 - 1

1.2 General Description of the Republic of Djibouti---------- 1 - 2

1.3 General Description of the Port of Djibouti ---------- 1 - 5

1.3.1 General ---------- 1 - 5
1.3.2 Present Port Facilities---------- 1 - 7
1.3.3 Port Activities---------- 1 - 9

1.4 Outline of the Related Development Plans---------- 1-13

1.4.1 National Socio-economic Development Plan ---------- 1-13
1.4.2 Port Related Development Projects ---------- 1-14

Chapter 2 Present Situation of the Oil-Berths in Port of Djibouti

2.1 General ---------- 2 - 1

2.2 Natural Conditions ---------- 2 - 2

2.2.1 Meteorological Conditions ---------- 2 - 2
2.2.2 Oceanographic Conditions ---------- 2 - 5
2.2.3 Topography and Hydrography ---------- 2 - 8
2.2.4 Geological and Soil Conditions ---------- 2-10

2.3 Present Condition of the Oil-Berth Facilities ---------- 2-27

2.3.1 Structure of Berths ---------- 2-27
2.3.2 Ancillary Facilities ---------- 2-40
2.3.3 Present Conditions of Revetments ---------- 2-42
2.3.4 Evaluation of Existing Oil-Berth Facilities ---------- 2-44

2.4 Oil Distribution/Storage Facilities ---------- 2-46

2.4.1 Oil Distribution Pipelines ---------- 2-46
2.4.2 Oil Storage Facilities ---------- 2-48

2.5 Railways ---------- 2-52

Chapter 3 Demand Forecast

3.1 Socio-Economic Background ---------- 3 - 1

3.1.1 Economic Indicators ---------- 3 - 1
3.1.2 Finance ---------- 3 - 1
3.1.3 Foreign Trade ---------- 3 - 4
3.1.4 Domestic Energy Consumption ---------- 3 - 4

3.2 Trends in Ocean Traffic ---------- 3 - 8

3.3 Trends in Oil Traffic ---------- 3 - 8

3.4 Trends in Oil Demand ---------- 3 - 9

3.4.1 Domestic Consumption ---------- 3-10
3.4.2 Transshipment ---------- 3-10
3.4.3 Bunker Supply ---------- 3-11

3.5 Demand Forecast ---------- 3-13

3.5.1 Basic Assumptions ---------- 3-13
3.5.2 Oil Demand Forecast ---------- 3-14
3.5.3 Comparison of Forecasts ---------- 3-17

Chapter 4 Reconstruction Plan of the Oil-Berths

4.1 Present Trends in Oil-Berths Utilization ---- 4 - 1

4.1.1 Oil Tankers ---- 4 - 1

4.1.2 Bunkering and "Non-Commercial" Operation Ships at Berth Nos. 10, 11 and 12 ---- 4 - 5

4.1.3 Activities of Oil Companies ---- 4 - 6

4.2 Allocation of Oil -Berths ---- 4 - 9

4.2.1 Present Situation of Oil Berths Utilization ---- 4 - 9

4.2.2 Allocation of Oil Berths ---- 4 - 9

4.3 Determination of Number and Size of Proposed Oil Berths ---- 4-10

4.3.1 Required Number of Proposed Oil Berths ---- 4-10

4.3.2 Size of Oil Berths ---- 4-14

4.4 Alternative Layout Plans of Proposed Oil Berths ---- 4-16

4.4.1 Problem of Existing Oil Berths Structures: ---- 4-16

4.4.2 Layout Plan of Proposed Oil-Berths ---- 4-17

4.5 Location and Back-up Facilities of Oil-Berths ---- 4-21

Chapter 5 Preliminary Design

5.1 Preliminary Design Conditions ---- 5 - 1

5.1.1 Design Policy ---- 5 - 1

5.1.2 Design Conditions ---- 5 - 2

5.2 Preliminary Design ---- 5 - 5

5.2.1 Determination of Structural Type ---- 5 - 5

5.2.2 Preliminary Design Drawings ---- 5 - 5

5.3 Construction Method ---- 5-11

5.3.1 Construction Activities in Djibouti ---- 5-11

5.3.2 Construction Method of Proposed Berths ---- 5-11

5.4 Cost Estimates ---- 5-12

5.5 Implementation Program ---- 5-13

Chapter 6 Environmental Impact Study

6.1 General ---------- 6 - 1

6.2 Sources of Environmental Impact ---------- 6 - 1

6.2.1 During Construction Works ---------- 6 - 1
6.2.2 After Completion ---------- 6 - 2
6.2.3 Identification of Environmental Impact ---------- 6 - 2

6.3 Forecast and Evaluation of Environmental Impact of Proposed Plan ---------- 6 - 2

6.4 Conclusion ---------- 6 - 2

Chapter 7 Organization and Management

7.1 Organization and Management ---------- 7 - 1

7.1.1 Outline of Port Autonome International de Djibouti ---------- 7 - 1
7.1.2 Organization of PAID ---------- 7 - 2
7.1.3 Present Situation of Management and Operation ---------- 7 - 8
7.1.4 Present Operation and Management Problems ---------- 7-12
7.1.5 Improvement Measures for the Present Operation and Management ---------- 7-15
7.1.6 Financing of PAID ---------- 7-16
7.1.7 Overview of PAID's Financial Conditions ---------- 7-20

7.2 Anti-Disaster and Safety Management ---------- 7-21

7.2.1 Present Port Activities ---------- 7-21
7.2.2 Present Condition of Anti-Disaster and Safety Management ---------- 7-29
7.2.3 Others ---------- 7-35
7.2.4 Recommendations on the Anti-disaster and Safety Management ---------- 7-35

Chapter 8 Project Appraisal

8.1 General ---------- 8 - 1

8.2 Cost and Benefit Aspects for the Project ---------- 8 - 1

8.2.1 Economic Analysis ---------- 8 - 1
8.2.2 Financial Aspects ---------- 8-10

Chapter 9 Conclusions and Recommendations

9.1 Conclusions ---------- 9 - 1

9.2 Recommendations ---------- 9 - 6

Appendixes

List of Tables

Summary

Table I Recommended Components of the Project ---------- V

Chapter 1

Table 1-1 Berthing Facilities of the Port of Djibouti ---------- 1 - 8
Table 1-2 Ship Calls at Port of Djibouti ---------- 1-11
Table 1-3 Cargo Handling Volume at Port of Djibouti ---------- 1-12
Table 1-4 Incoming Cargo Volume by Commodity (1992) ---------- 1-12
Table 1-5 Container Traffic at Container Terminal ---------- 1-13

Chapter 2

Table 2-1 Hindcast Wave Height ---------- 2 - 5
Table 2-2 Tide Level ---------- 2 - 6
Table 2-3 List of Earthquakes Recorded in Djibouti ---------- 2-14
Table 2-4 Scope and Location of Field Investigation ---------- 2-29
Table 2-5 Condition of Structural Corrosion ---------- 2-30
Table 2-6 Criteria for Evaluation of Fenders ---------- 2-31
Table 2-7 Corrosion of Steel Members ---------- 2-32
Table 2-8 Degrees of Concrete Deterioration ---------- 2-33
Table 2-9 Concrete Compressive Strengths ---------- 2-34
Table 2-10 Present Conditions of Fenders ---------- 2-35
Table 2-11 Visual Inspection of Structures (No. 11) ---------- 2-37
Table 2-12 Visual Inspection of Structures (No. 12) ---------- 2-38
Table 2-13 Ancillary Facilities of Berth Nos. 11 and 12 ---------- 2-40
Table 2-14 Planned Railway Cargo Volume ---------- 2-52
Table 2-15 Rolling Stocks owned by CDE ---------- 2-54
Table 2-16 Railway Passenger Fares ---------- 2-55
Table 2-17 Railway Freight Charges ---------- 2-55

Chapter 3

Table 3-1 Economic Indicators in Djibouti ---------- 3 - 2
Table 3-2 Government Budget ---------- 3 - 3
Table 3-3 Gross Official Development Assistance and External Debt ---------- 3 - 3
Table 3-4 Foreign Trade ---------- 3 - 5

Table 3-5 Bunkering at Major Ports around the Red Sea ---------- 3 - 6
Table 3-6 Oil Consumption and Electricity Generation ---------- 3 - 7
Table 3-7 Evolution of Number of Vessels calling at Port of Djibouti ---------- 3 - 8
Table 3-8 Main Tanker Size (1991) ---------- 3 - 9
Table 3-9 Evolution of Oil Demand ---------- 3-12
Table 3-10 Marine Bunkering at Port of Djibouti ---------- 3-12
Table 3-11 Forecast of Economic Indicators---------- 3-13
Table 3-12 Oil Demand Forecast (2010) ---------- 3-14
Table 3-13 Number of Vehicles & Motor Fuel Consumption ---------- 3-15
Table 3-14 Electricity Generation Forecast (forecast by EDD) ---------- 3-15
Table 3-15 Economic Indicators of Neighboring Countries ---------- 3-16
Table 3-16 Comparison of Oil Demand Forecasts ---------- 3-17

Chapter 4

Table 4-1 Number of Calls of Oil Tanker, Total Tonnage & Average Tonnage --- 4 - 1
Table 4-2 Size of Oil Tanker and Number of Calls at Berth Nos. 10, 11 & 12---- 4 - 2
Table 4-3 Average Handling Volume and Berthing Time per Call---------- 4 - 3
Table 4-4 Particulars of Oil Tankers Called at Port of Djibouti (1992)---------- 4 - 4
Table 4-5 Activities of Bunkering at Port of Djibouti by Oil Companies ---------- 4 - 5
Table 4-6 Bunkering and "Non - Commercial" Operation
at Berth Nos. 10, 11 & 12---------- 4 - 5
Table 4-7 Share of Oil Products Handled by Oil Companies---------- 4 - 6
Table 4-8 Oil Storage Facilities at Port of Djibouti ---------- 4 - 7
Table 4-9 Record of Port Closing/Operation Stoppage ---------- 4-13
Table 4-10 Forecasted Berth Occupancy Time in Year 2010 ---------- 4-14
Table 4-11 Trends of Oil Tankers Size Built in 1980 - 1989 ---------- 4-15
Table 4-12 Comparison of General Layout of Berth Nos. 11 and 12---------- 4-18

Chapter 5

Table 5-1 Objective Vessels : 3,000/35,000 DWT Oil Tanker ---------- 5 - 3
Table 5-2 Structure Comparative Study---------- 5 - 7
Table 5-3 Cost Estimate---------- 5 - 15

Chapter 6

Table 6-1 Environmental Impact Matrix for the Proposed Oil - Berths Project--- 6 - 3
Table 6-2 Environmental Impact Elements and Countermeasures
(during construction works)---------- 6 - 4

Table 6-3 Environmental Impact Elements and Countermeasures (after completion) ---------- 6 - 5

Chapter 7

Table 7-1 Members of Board of Council ---------- 7 - 3
Table 7-2 Personnel Numbers by Divisions of PAID ---------- 7 - 7
Table 7-3 PAID Budgets (1989 ~ 1992: Actual, 1993: Provisional) ---------- 7-18
Table 7-4 Balance Sheet (1989 - 1992) ---------- 7-19
Table 7-5 Profits of PAID 1989 - 1991 ---------- 7-19
Table 7-6 Properties Acquired and Repayments ---------- 7-20
Table 7-7 Service Craft in Port of Djibouti ---------- 7-24

Chapter 8

Table 8.1 Overflow of Oil Tankers and "Non-Commercial" Vessels in the Reference Solution ---------- 8 - 3
Table 8.2 Port Charges for Tankers ---------- 8 - 4
Table 8.3 Revenues from Tariffs on Oil Cargoes in 2010 ---------- 8 - 5
Table 8.4 Revenues of Port from Diverted Transshipment and Import ---------- 8 - 5
Table 8.5 Revenues of CDF from Diverted Transshipment (1,000 FD) ---------- 8 - 6
Table 8.6 Demurrages on "Non-Commercial" Vessels ---------- 8 - 7
Table 8-7 Project Cash Flow ---------- 8 - 8
Table 8.8 Sensitivity Analysis of EIRR ---------- 8 - 9
Table 8.9 Revenues from Tariffs on Oil Products ---------- 8-11
Table 8.10 Expenses of PAID ---------- 8-11
Table 8.11 Forecast of Expenses of PAID in 2010 ---------- 8-13
Table 8.12 Main Premises for the Forecast of Expenses ---------- 8-13
Table 8.13 BCEOM's Forecast of Cargoes ---------- 8-14
Table 8.14 Forecast of Revenues and Expenses Related to Tankers in 2010 ---------- 8-14

List of Figures

Chapter 1

Figure 1-1 Economic Structure in Djibouti ---------- 1 - 3
Figure 1-2 General Plan of the Port of Djibouti ---------- 1 - 6
Figure 1-3 Cargo Traffic Trend in Port of Djibouti ---------- 1-10
Figure 1-4 Mid-Term Master Plan of the Port of Djibouti (1993) ---------- 1-17
Figure 1-5 Long Term Master Plan of the Port of Djibouti (1993) ---------- 1-18

Chapter 2

Figure 2-1 Temperature in Djibouti (1941 - 1970) ---------- 2 - 3
Figure 2-2 Precipitation in Djibouti (1961 - 1980) ---------- 2 - 3
Figure 2-3 Windrose in Djibouti (1984) ---------- 2 - 4
Figure 2-4 Windrose in Djibouti (1971 - 1990) ---------- 2 - 4
Figure 2-5 Result of Current Observation ---------- 2 - 7
Figure 2-6 Survey Datum ---------- 2 - 8
Figure 2-7 Hydrographic Survey Map ---------- 2 - 9
Figure 2-8 Simplified Geological Map of Djibouti ---------- 2-11
Figure 2-9 Cross Area of Three Rifts ---------- 2-12
Figure 2-10 Distribution Map of Epicenters (1974 - 1980) ---------- 2-13
Figure 2-11 Distribution Map of Epicenter (1990 - 1992) ---------- 2-13
Figure 2-12 Location Map of Previous Boring Points ---------- 2-16
Figure 2-13 Soil Profile at Berth No. 10 ---------- 2-17
Figure 2-14 Results of SPT at Berth No. 9 (1974) ---------- 2-18
Figure 2-15 Location Map of Cone Penetration Test ---------- 2-21
Figure 2-16 Soil Profile at Berth No. 11 (I - I) ---------- 2-22
Figure 2-17 Soil Profile at Berth No. 11 (II - II & III - III) ---------- 2-23
Figure 2-18 Soil Profile at Berth No. 12 (IV - IV) ---------- 2-24
Figure 2-19 Soil Profile at Berth No. 12 (V - V) ---------- 2-25
Figure 2-20 Soil Profile at Berth No. 12 (VI - VI & VII - VII) ---------- 2-26
Figure 2-21 Location of Investigation at Berth No. 11 ---------- 2-28
Figure 2-22 Location of Investigation at Berth No. 12 ---------- 2-28
Figure 2-23 Measured Points of Steel Structures for Corrosion ---------- 2-29
Figure 2-24 Visual Inspection Spots at Berth No. 11 ---------- 2-37
Figure 2-25 Detail of Deformed Spots at Berth No. 11 ---------- 2-37
Figure 2-26 Visual Inspection Spots at Berth No. 12 ---------- 2-38
Figure 2-27 Detail of Deformed Spots at Berth No. 12 ---------- 2-38

Figure 2-28 Armor Stone at Berth No. 11 ---------- 2-39
Figure 2-29 Armor Stone at Berth No. 12 ---------- 2-39
Figure 2-30 Ancillary Facilities at Berth No. 11---------- 2-41
Figure 2-31 Ancillary Facilities at Berth No. 12---------- 2-41
Figure 2-32 Location of Typical Cross Sections of Revetment---------- 2-43
Figure 2-33 Cross Section of Revetment (1) - (1) ---------- 2-43
Figure 2-34 Cross Section of Revetment (2) - (2) ---------- 2-43
Figure 2-35 Plan of Oil Distribution Pipelines---------- 2-47
Figure 2-36 Oil Storage Terminal Plan (Shell)---------- 2-49
Figure 2-37 Oil Storage Terminal Plan (Mobil)---------- 2-50
Figure 2-38 Oil Storage Terminal Plan (Total)---------- 2-51
Figure 2-39 Working Route of CDE---------- 2-53

Chapter 4

Figure 4-1 Ship Size, Oil Cargo Volume and Number of Calls---------- 4-11
Figure 4-2 General Layout of Proposed Berth Nos. 11 and 12 (Alternative "1")--- 4-19
Figure 4-3 General Layout of Proposed Berth Nos. 11 and 12 (Alternative "2")--- 4-19
Figure 4-4 Various Ship Sizes and Arrangement of Berth Facilities---------- 4-20

Chapter 5

Figure 5-1 Tide Level ---------- 5 - 2
Figure 5-2 Structure Comparative Study---------- 5 - 6
Figure 5-3 Plan and Section of Berth No. 11 ---------- 5 - 8
Figure 5-4 Plan and Section of Berth No. 12 ---------- 5 - 9
Figure 5-5 Access Road---------- 5-10
Figure 5-6 Construction Method of Steel Sheet Pile Cellular Cofferdam ---------- 5-14
Figure 5-7 Implementation Schedule ---------- 5-16

Chapter 7

Figure 7-1 Organization Chart of Ministry of Port and Maritime Affairs ---------- 7 - 5
Figure 7-2 Organization Chart of Port Autonome International de Djibouti (PAID) ---------- 7 - 6
Figure 7-3 Flow of Cargo Handling and Operation ---------- 7-10
Figure 7-4 Expanded Harbor Limit---------- 7-22
Figure 7-5 Flow Chart of Ship's Documents---------- 7-27
Figure 7-6 Cargo Oil Flow Chart ---------- 7-28
Figure 7-7 Organization Chart of Harbor Master's Office (Captainerie) ---------- 7-30
Figure 7-8 Emergency Operation System---------- 7-31

List of Appendixes

A-1	Wave Hindcasting ----------	A - 1
A-2	Tide Observation ----------	A-10
A-3	Existing Hydrographic Survey Maps ----------	A-12
A-4	Results of Cone Penetration Test ----------	A-15
A-5	Sketches of Damaged Concrete Members ----------	A-16
A-6	Water Quality Analysis ----------	A-20
A-7	Ship/Shore Safety Check List ----------	A-23
A-8	Ship/Shore Safety Check List Guidelines ----------	A-26
A-9	Guidelines for Completing the Ship/Shore Safety Check List ----------	A-28
A-10	Typical Insulating Flange Joint ----------	A-33

ABBREVIATIONS

AfDB	:	African Development Bank
BD	:	Barrel per day
BM	:	Bench Mark
CDE	:	Djibouti–Ethiopian Railways
CFS	:	Container Freight Station
CPI	:	Consumer Price Index
cu. m.	:	cubic meter
D.L.	:	Datum Line
DINAS	:	Direction Nationale de la Statistique
DWT	:	Dead Weight Tonnage
EU	:	European Union
ECU	:	European Currency Unit
EDD	:	Djibouti Electric Company
ETA	:	Estimated Time of Arrival
FD	:	Djibouti Franc
FY	:	Fiscal Year
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
GRT	:	Gross Registered Tonnage
GT	:	Gross Tonnage
GWh	:	Gigawatt hour = 1,000MWh = 1,000,000KWh
ha.	:	hectare
HP	:	Horse Power
IDA	:	International Development Association
IGN	:	Institut Geographique National
IMF	:	International Monetary Fund
ISERST	:	Institut Superieur d'Etudes et des Recherches Scientifiques et Technique
JMA	:	Japan Meteorological Agency
KFAED	:	Kuwait Fund for Arab Economic Development
KWh	:	Kilowatt hour
LBTP	:	Laboratory of Building and Public Works
Ma	:	Million years
MT	:	Metric ton
MWh	:	Megawatt hour = 1,000KWh
NT	:	Net Tonnage
PAID	:	Port Autonome International de Djibouti: Port Authority of Djibouti
SFD	:	Saudi Fund for Development
SOLAS	:	International Convention for the Safety of Life at Sea
SPT	:	Standard Penetration Test
sq. m.	:	square meter
UN	:	United Nations
UNDP	:	United Nations Development Program
USAID	:	United States, Agency for International Development
WFP	:	World Food Program

Chapter 1 Background of the Study

CHAPTER 1 BACKGROUND OF THE STUDY

The Port of Djibouti is situated at the mouth of the Red Sea and occupies an important position as a maritime servicing base on the route to the Mediterranean Sea through the Suez Canal. For these reasons, the development of the port facilities has been going on since the French colonial days, and after its independence, it has been the supply center, gateway to the neighboring countries, and has served as a transshipment center. In recent years, in competition with Aden (Yemen) and Jedda (Saudi Arabia) across from the Gulf, some of this uniqueness has decreased, but its function as a transshipment center for Ethiopia and Somalia, and the neighboring countries has not been lost, and the port has become more important in the politics and economy for the Gulf states, the middle east and east African countries.

The characteristics of the Port of Djibouti as an important transshipment center will contribute to the socio-economic value of Djibouti, and will provide for the politics and socio-economy by the stable supply of oil products.

At the present time, there are three berths used for handling bulk oil products, namely Berth Nos. 10 to 12, but they were all reported to have been constructed in the middle of '60s, and deterioration of the facilities is evident and they are no longer safe structurally even though there are restrictions imposed on the oil tankers when mooring at the berths, and traffic of vehicles on the platforms have weight limits when traveling on them.

Berth No. 9 (Môle de Fontainebleau) is planned to be rehabilitated as a berth for France, and Berth No. 10 is actually under reconstruction with funds from Saudi Arabia and Kuwait Fund for Arab Economic Development. As for Berth Nos. 11 and 12, the French firm BCEOM diagnosed their structures in 1989, after which there were some urgent repairs made from time to time and nothing more has been done since.

1.1 Purpose of the Study

The purpose of the Study is to formulate a plan for the Reconstruction of the Oil-Berths No. 11 and No. 12 for the demand of the oil-berths in the target year i.e. 2010. The Study proposes the following three main points:

(1) Confirmation of the necessity for the reconstruction of the oil-berths at the Port of Djibouti;
(2) Formulation of a reconstruction plan of oil-berths at the Port of Djibouti; and
(3) Technology transfer to counterparts on the Djibouti side.

1.2 General Description of the Republic of Djibouti

The Republic of Djibouti is situated on the Horn of Africa on the east coast, south of the Red Sea, and the country overlooks the vast plains of Ethiopia to the west, and the topography has rolling plains. The land to the north has the Mountains of Goda ranging from 1,750 to 2,010 m consisting of volcanic hills, and to the south are the plateaus where the nomads live.

The land area covers 23,200 sq. km, and has one of the least farm lands in all of Africa. It produces only 3 % of the national food requirements.

The east side of country faces the Gulf of Aden, and shares its border with Eritrea, Ethiopia, and Somalia on the west, north and south sides respectively. Total border length is 520 km and Djibouti has a coastline of 372 km.

Djibouti is geographically located at the crossroads between three continents, halfway between Europe and Asia, Africa and the Gulf countries with the Red Sea and the Indian Ocean conducting trade between these countries prior to the opening of the Suez Canal. After the Suez Canal opened, it developed as a supply point for the vessels passing through this area.

Acknowledging the importance of Djibouti after the opening of the Suez Canal in 1856, France landed its military force to Djibouti 1892, and colonized Djibouti. The Djibouti-Addis Ababa Railway construction was performed from 1898 to 1917 (called the Franco-Ethiopian Railway at the time, and presently called the Djibouti-Ethiopian Railway: CDE), and the Port of Djibouti became established as a center of trade. The railway is important as a means of transportation to the outer world for neighboring Ethiopia. The de-colonization process, initiated by France, led to its independence from France on 27 June 1977.

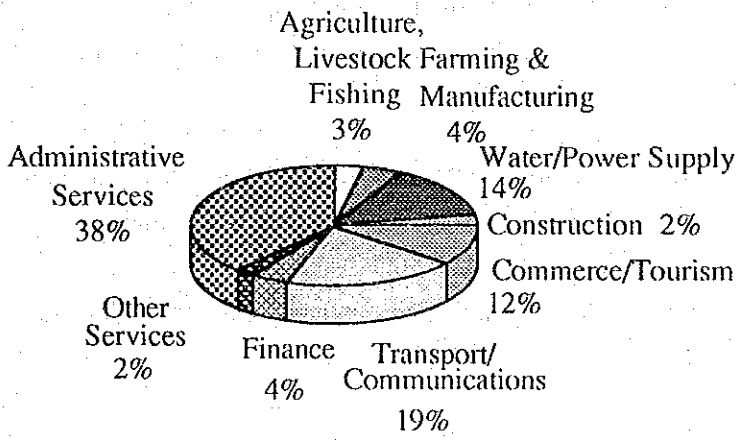
The population of Djibouti is 519,900 (March 1991 census), of which approximately 110,000 are refugees from Ethiopia and Somalia. The population of Djibouti City, its capital, is 329,337 and the largest city. The other principal cities are Ali-Sabieh, Dikhil, Obock and Tadjourah and all together with Djibouti City are where the population is concentrated. The population in urban areas is 75% of the total. Moreover, there are some 90,000 nomads living in the southern plateaus. The annual growth rate of population is estimated 6.15 % for last 8 years.

The average temperature rises to 35 °C from May to September, and there are strong, dry northwest/west winds (so-called "Khamsin") blowing, but the winds reverse from

October to April when the average temperature is 25 °C and reminds one of the mild summers in the Mediterranean Regions.

Economy

Djibouti's economy is dominated by the service sector, accounting for 77 % of the Gross Domestic Product (GDP). 47 % of the labor force are employed in the public or quasi-public sector. GNP per capita is 89,166 FD or 502 US$ in 1988. The composition of National Economy is schematized in Fig. 1-1.



Source: DI.NA.S (1988)

Figure 1-1 Economic Structure in Djibouti

As described hereinbefore, there is very little land available for farming, and the arable land is less than 0.3 % of the whole nation (6,000 ha), and with the lack of irrigation water, it is very difficult to raise food for its own needs. The annual agricultural production amounts to 1,572 tons in 1988/89 year. Since fish is not traditionally on the national diet, only 359 tons of fish sold in 1990. Industries are not developed, with only some light industries.

Under these natural conditions, the country is supported by the following economic activities:

1) Djibouti-Ethiopia Railway;
2) Transshipment services for the countries on the Gulf coast;
3) Port services at the Port of Djibouti;

4) Economy of the foreign residents including the French Armed Forces residing in Djibouti; and
5) Financial and economic aid from foreign aid organizations.

From Items 1), 2) and 3) in the above, the importance of the Port of Djibouti is clearly indicated. In addition to the above, there is the tourist attractions of the 372 km coastline, and the geo-thermal electric generation provided by the volcanic area can be considered as future source of revenue.

Transport-related Infrastructures

The transport systems at Djibouti consist of its terminus as the transportation system networks to the neighboring countries (refer to the "Location Map" in the front of this Report).

The total road network at Djibouti is 3,067 km, and approximately one-third of the network of 1,130 km are national roads. Of the national roads, 412 km is paved while the rest is not. As for the urban areas, the Cities of Djibouti, Ali-Sabieh, Tadjourah and Obock have road lengths of 98 km, 5 km, 10 km and 4 km respectively.

The number of vehicles registered as of December 31, 1991 was 38,442 vehicles, of which 32,597 vehicles were privately owned.

The former French-Ethiopia Railways built in the colonial days, and newly reorganized as the Djibouti-Ethiopia Railways built is operated by both Djibouti and Ethiopia countries under the Railways Agreement entered on March 1981. The system is a public enterprise operated on an autonomy basis, with its main office in Addis Ababa, and 6 directors each appointed by both countries.

The number of passengers using the railways is 1.2 million per annum, and the average traveled distance is 260 km which is the distance from Djibouti to Dire Dawa (Ethiopia) and indicates that most of the passengers travel to Ethiopia.

The cargo that is moving between both countries, and the movement from Djibouti to Ethiopia is 200,000 tons annually, and the movement in the opposite direction is 100,000 tons. The railway line is the life-line for Ethiopia, but is superannuated and is badly in need of repairs. The rehabilitation is considered to be financed by the European Union.

There is an international airport at Djibouti (Ambouli), and domestic airports at Obock and Tadjourah. The annual number of passengers making use of air travel is on the order of 300,000 of which 60 % are foreign and domestic passengers transiting into Djibouti.

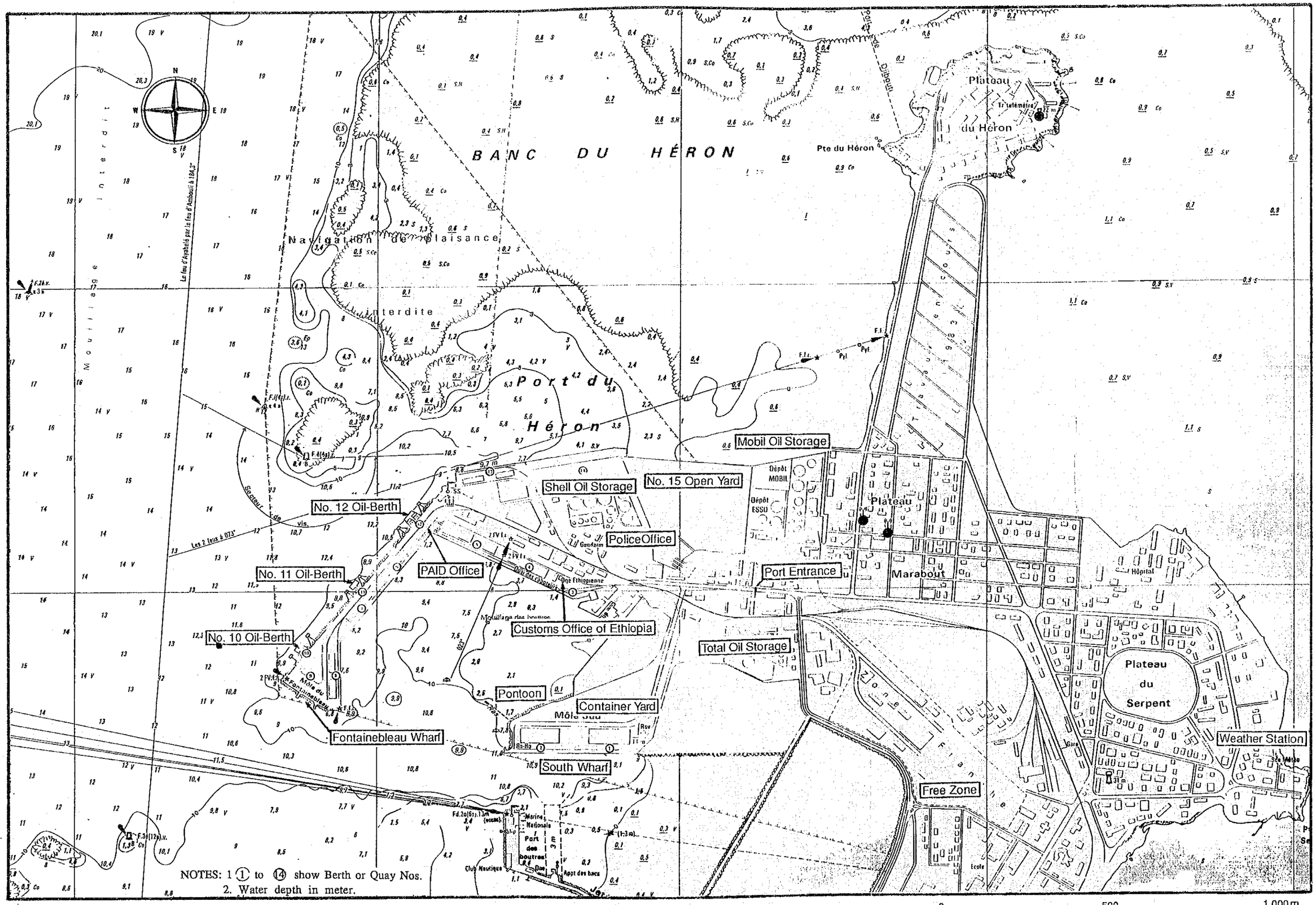
1.3 General Description of the Port of Djibouti

1.3.1 General

The port activities in the Port is an important industry for Djibouti. The Port of Djibouti services the vessels using Suez Canal with fuel and water supply, and performs the commercial services for trade conducted with Ethiopia, Somalia, and other neighboring countries. Trade is conducted with the ports in Berbera (Somalia), Aden (Yemen), Jedda, Hodeidah (both Saudi Arabia), Assab, Massawa (both Eritrea), Port Sudan (Sudan).

The Port of Djibouti is administered by the Port Autonome International de Djibouti (PAID) which is a public corporation operating on a self-accounting system, and is under the jurisdiction of the Ministry of Port and Maritime Affairs of the Government as a basic industry.

As shown in Fig. 1-2, the Port has good natural conditions for a port, during most of the year winds are easterly or northeasterly, and the waters in the basins are calm throughout the year. In the summer months from June to August, the "Khamsin" wind brings northwesterly winds with strong gusts of 40 °C, rarely reach 20 m/sec, but the swells that enter the harbor are less than 1.5 meters. The tidal range is 2.84 m, tidal currents are less than 1 knot.



NOTES: 1 ① to ⑭ show Berth or Quay Nos.
2. Water depth in meter.

Figure 1-2 General Plan of the Port of Djibouti

1.3.2 Present Port Facilities

The Port of Djibouti performs three functions as follows:

General Cargo (Traditional Port)

General cargo are handled at 6 quays (Quay Nos. 5, 6, 7, 8, 13 and 14). The vessels that enter the Port have drafts of 8 to 11 meters and due to the water depth limitations, 75 % of the vessels utilize the facilities of Quay Nos. 8, 13 and 14.

Due to the superannuation of oil berth No. 10, 11 and 12, Berth No. 13 is used as a substitute oil berth and the functions for handling general cargo is not affected. Berth No. 14 was opened up in 1992, and is used as for bulk cargo for vessels with drafts of 12 meters.

There is a total shed/warehouse floor area of 35,000 sq. m, but with the recent inflow of foodstuffs for aid to Ethiopia, the berths are not capable of handling the cargo unloaded there. There is very little space available for open storage, and it is necessary to make repairs to the paved surface which is in a state of disrepair.

Oil Handling Facilities (Oil Berths)

There are three berths used for commercial oil handling, Berth Nos. 11 and 12 which are the subject of investigation under this Study, and Berth No. 10 which is already under rehabilitation. There are three major oil companies operating in Djibouti: Mobil, Total and Shell, and together they have a storage capacity of over 200,000 tons. The facilities of Berth Nos. 11 and 12 cannot be used in their full capacity.

There are three oil pipelines (10"/12" dia.) leading from the oil-berths to the storage tanks owned by the oil companies which restrict the port activities because many parts of pipeline network are exposed on the ground.

Container Handling Facilities (South Container Terminal)

With the increase of intermediate handling of cargo, the two quays Nos. 1 and 2 in South Wharf are being utilized as a container terminal since 1985. There are two 35 ton gantry cranes, four 40 ton forklift trucks, two 2 ton forklift trucks, 8 tractors and 12 trailers equipped in connection with the container processing.

Quay Nos. 1 and 2 will need to be modified to accept the larger container vessels in the middle term. For the long-term needs, there will be one new berth planned to receive the larger container vessels.

The container yard is presently 5.6 ha, and there are plans to expand the yard to 22 ha in the future.

Table 1-1 Berthing Facilities of the Port of Djibouti

Quay/Berth No.	Water Depth (m)	Berth Length (m)	Cargo Type
No. 1	-9.5	180	Container
No. 2	-12.0	220	Container
Ro Ro	-11.0	180 (50)	Ro Ro
No. 3	-3.5	260	Cargo (dhow ships)
No. 4	-3.5	(Nos. 3 & 4 total)	ditto
No. 5	-9.0	210	General Cargo
No. 6	-9.0	180	ditto
No. 7	-10.0	180	ditto
No. 8	-10.0	250	ditto
No. 9	-9.0	200	French Navy
No. 10	-12.5	220	Oil (under rehabilitation)
No. 11	-12.0	180	Oil
No. 12	-12.0	250	Oil
No. 13	-10.8	210	Bulk
No. 14	-12.0	288	Bulk

- Container Cargo Handling Equipment at Container Terminal
  - 35 ton Gantry Crane 2 each
  - 40 ton Forklift Truck 4 each
  - 12 ton Forklift Truck 2 each
  - Tractor 8 each
  - Trailer 12 each
- Cargo Handling Equipment
  - 25 ton Mobile Crane 1 each
  - 40 ton Mobile Crane 1 each
  - 80 ton Crane Pontoon 1 each

- Cargo Handling/Storage Facilities

- Shed/Warehouse (60,000 sq. m)	19 units
- Open Handling/Storage Yard	8 ha.
- -25 °C Cold Storage (2,300 cu. m)	1 unit

- Free Zone

The Free Trade Zone (tax free) of 14 ha. is situated next to the port area. Plots are available for lease or other industrial purposes. Plots have road and rail access with electricity and water supplies.

1.3.3 Port Activities

1) Ship Calls

The vessels calling at the Port of Djibouti are given in Table 1-2. Table indicates that the number of conventional vessels, container vessels, Ro-Ro vessels is increasing, but there is not much change noticed of the total tonnage per vessel. All the bulk handling vessels, oil tankers, and butane gas carriers are increasing in size, and this trend will increase with the improvement of the port facilities.

2) Cargo Traffic

The total cargo volume being handled has ranged from a total of 1.10 million tons to 1.30 million tons since the independence as shown in Fig. 1-3 and Table 1- 3, and in the political situation, there has been a marked increase, and for 1991 there was an excess of 2.0 million tons handled.

Of the general cargo handled, imports are destined for Djibouti, Ethiopia and transit elsewhere, and 80 % of the export are in transit, and indicates that transshipment is the main service provided by the Port of Djibouti.

The amount of fuel oils handled increased to 710,000 tons during the Gulf crisis in 1990, but this has fallen off to 420,000 ton in 1991. The import of fuel oils for Ethiopia is 20,000 to 30,000 tons annually and this is on the rise as their economy stabilizes. Bunkering is decreasing every year, and competition with other ports for bunkering service is becoming keener by the year.

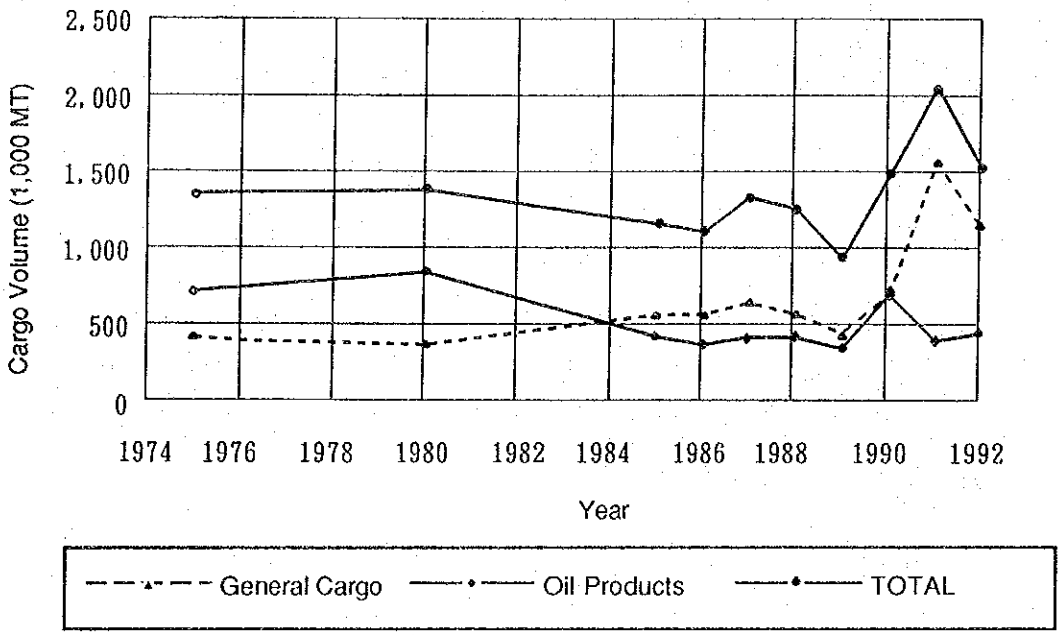


Figure 1-3 Cargo Traffic Trend in Port of Djibouti

Table 1-2 Ship Calls at Port of Djibouti

Type of Vessel	1984	1985	1986	1987	1988	1989	1990	1991	1992
	7,210	8,368	9,589	9,650	8,352	8,600	10,115	8,335	7,960
	267	253	263	226	244	195	270	325	333
Conventional	1,925	2,117	2,522	2,181	2,038	1,677	2,731	2,709	2,651
					16,385	17,333	17,000	15,077	13,394
					26	30	12	13	5
Multipurpose					426	520	204	196	67
	14,570	11,836	11,596	14,657	11,550	12,656	12,323	10,883	11,753
	100	128	136	108	131	122	133	171	248
Container	1,457	1,515	1,577	1,583	1,513	1,544	1,639	1,861	2,915
	8,714	8,750	8,383	10,544	10,300	9,000	11,544	14,092	13,139
	63	72	81	68	70	86	79	130	76
Ro-Ro	549	630	679	717	721	774	912	1,832	999
	16,500	14,214	14,900	21,923	16,000	23,000	22,125	30,000	0
	16	14	10	13	1	1	8	1	0
Bulk Carrier	264	199	149	285	16	23	177	30	0
	8,605	13,469	10,377	11,654	19,944	19,791	23,944	22,306	16,686
	124	81	69	78	89	86	108	98	78
Oil Tanker	1,067	1,091	716	909	1,775	1,702	2,586	2,186	1,302
	5,500	3,200	8,250	6,357	6,486	7,364	3,000	8,762	8,591
	6	5	8	14	37	11	18	42	38
Butane Carrier	33	16	66	89	240	81	54	368	326
	15,364	18,500	7,250	19,500	16,250	13,400	9,091	7,625	7,981
	11	10	8	6	4	5	11	8	10
Passenger Boat	169	185	58	117	65	67	100	61	80
					1,222	786	735	794	1,021
					45	42	34	68	68
Fishing Boat					55	33	25	54	69
	4,797	5,385	5,888	4,554	4,336	3,886	4,509	3,129	4,369
	118	104	125	287	378	175	214	224	136
Warship	566	560	736	1,307	1,639	680	965	701	594
	19,769	24,857	8,769	29,143	24,714	28,667	29,250	26,235	25,987
	13	14	13	7	7	3	8	17	11
LASH	257	348	114	204	173	86	234	446	286
	405	386	1,017	595	455	485	500	455	464
	37	44	58	121	88	103	100	44	30
Coastal Ship	15	17	59	72	40	50	50	20	14
	1,143	1,247	1,050	669	2,699	1,868	1,403	1,701	2,291
	133	97	121	133	93	91	72	67	90
Others	152	121	127	89	251	170	101	114	206
	17,531	12,842	24,127	11,391					
	49	76	63	69					
Anchorage	859	976	1,520	786					
	7,805	8,658	8,715	7,380	7,380	7,797	9,164	8,757	8,467
	937	898	955	1,130	1,213	950	1,067	1,208	1,123
Total	7,313	7,775	8,323	8,339	8,952	7,407	9,778	10,578	9,508

Note: Upper : Average GT
Middle : Number of Ship Calls
Lower : Total Gross Tonnage * 1,000 per year
Source: Annual Statistics of PAID

Table 1-3 Cargo Handling Volume at Port of Djibouti

(Unit: 1,000 metric tons)

Cargo Type	1975	1980	1985	1986	1987	1988	1989	1990	1991	1992
General Cargo	449.2	396.3	609.9	622.1	723.8	618.9	463.1	714.8	1,624.2	1,164.2
(Incoming Total)	247.5	281.8	471.5	463.2	469.8	445.6	323.5	458.4	951.7	767.7
to Djibouti	89.1	170.2	232.7	230.1	208.1	258.6	192.8	210.9	378.6	338.8
to Ethiopia	125.1	68.3	174.2	136.3	86.0	109.2	51.5	69.7	238.5	128.1
to Somalia	0.7	17.1	14.4	11.8	46.3	17.8	8.0	5.5	10.6	53.4
Transshipment	32.6	24.8	48.7	83.9	128.8	58.7	70.1	171.7	322.6	245.4
Dhow	-	1.4	1.5	1.1	0.6	1.3	1.1	0.6	1.4	2.0
(Outgoing Total)	201.7	114.5	138.4	158.9	254.0	173.3	139.6	256.4	672.5	396.5
Djibouti export	8.6	5.8	12.1	22.0	22.4	22.5	27.2	34.4	47.9	1.4
Ethiopia export	155.0	34.8	37.2	29.0	49.6	41.9	20.8	26.4	30.3	11.5
Somalia export	0.3	0.1	-	-	0.2	0.3	0.5	0.4	0.7	0.2
Transshipment	37.8	40.3	50.3	69.8	132.0	55.7	51.5	154.7	538.4	326.7
Dhow	-	33.5	38.8	38.1	49.8	52.9	39.6	40.5	55.2	56.6
Oil Products	716.9	855.6	448.9	372.4	473.0	460.1	378.1	716.0	438.4	494.9
Import	460.8	514.2	308.1	285.7	332.7	324.0	291.5	439.6	324.3	368.7
Re-export	-	20.5	39.6	1.9	9.9	7.2	21.5	194.7	54.5	51.2
Bunkering	256.1	320.9	101.2	84.8	130.4	128.9	65.1	81.7	59.6	75.0
Water Supply	170.8	130.8	84.1	86.6	115.6	151.6	72.2	85.4	90.1	82.7
TOTAL	1,336.9	1,382.7	1,142.9	1,081.1	1,312.4	1,230.6	913.4	1,516.2	2,152.7	1,517.2

Source: Annual Statistics of PAID

Table 1-4 Incoming Cargo Volume by Commodity (1992)

(Unit: 1,000 metric tons)

Commodity	to Djibouti	to Somalia	to Ethiopia	Transship't	Total
Agricultural Products	96.8	10.1	71.0	132.6	310.5
Foodstuff/Beverage	113.0	41.2	24.8	33.2	212.3
Oil Products	5.8	0.0	0.3	8.2	14.4
Mineral Products	46.4	0.2	0.8	4.2	51.4
Timber/Hides/Paper/Textile	26.0	0.9	9.1	13.7	49.7
Metallic Products	8.3	0.2	3.1	5.6	17.3
Electrical/Machinery Equipment	7.7	0.1	3.2	11.3	22.3
Transport Equipment	4.0	0.0	0.5	2.3	6.8
Chemical Products	19.5	0.6	12.7	15.5	48.3
Others	11.4	0.1	2.5	18.8	32.8
Total	338.8	53.4	128.1	245.4	765.7

Source: Annual Statistics of PAID

Table 1-5 Container Traffic at Container Terminal

(Unit: TEU)

Traffic \ Year	1985	1986	1987	1988	1989	1990	1991	1992
Incoming	6,980	10,737	11,654	13,096	11,202	19,356	43,667	28,134
Import	5,516	6,205	7,473	9,249	8,397	9,111	14,474	16,080
Transshipment	1,349	4,124	3,341	2,906	2,025	7,887	22,031	8,841
Empty Container	115	408	840	941	780	2,358	7,162	3,213
Outgoing	6,300	6,500	7,257	10,281	11,512	16,751	41,143	30,077
Export	1,072	508	622	593	826	812	1,337	1,192
Transshipment	n/a	n/a	n/a	n/a	2,103	6,760	22,162	10,223
Empty Container	5,228	5,992	6,635	9,688	8,583	9,179	17,644	18,662
Total	13,280	17,237	18,911	23,377	22,714	36,107	84,810	58,221

Source: Annual Statistics of PAID

1.4 Outline of the Related Development Plans

1.4.1 National Socio-economic Development Plan

The Laws for Socio-Economic Development (guidance law for socio-economy) were established in 1982. The following 5 items are established for development:

1) Development of the country as an international maritime related city
2) Against poverty in the country
3) Improvements to become self-sufficient in foods
4) Industrialization
5) Reduction of the dependency on the energy

Based on the above policy, the 1984/89 National Socio-Economic Plan was established, and the Second Socio-Economic Guidance Law for 1990/2000 was established in February 1991. In May 1992, the Planning Department of the Prime Minister's Office set up the Second Socio-Economic Development Plan for the 1991/1995. In this Plan, the Reform Plan for Port and Maritime Affairs for 1991/1995 is described with the following objectives:

1) Utilization of human resources
2) Promotion of private sector for port and maritime sector
3) Environmental protection
4) Economic improvement par port and maritime activities

1.4.2 Port Related Development Projects

In the port sector, several projects were carried out with technical and economic assistance from foreign countries. Major donor countries are France, Italy, Kuwait and Saudi Arabia.

The cooperation style of these countries are characterized as follows:

France: Until March, 1993, there was always a French engineer in PAID dispatched by the French Government, as a part of technical assistance program. But since the date above, this program has been suspended. The Master Planning of the Port was also prepared with French assistance.

Italy: Actually, Italy assists the development of the Port such as an extension project of Quay No. 14 and Open Yard No. 15 on credit basis.

Kuwait: Kuwait associated with Saudi Arabia has financed a two phase development project. First one was the development of container terminal which started operations in 1985. The Second Port Development consists of six packages: 1) rehabilitation of sheds/workshop; 2) procurement of cargo handling and maintenance equipment; 3) construction of workshop and CFS; 4) lighting system of the container yard and extension of Free Trade Zone; 5) Extension of container yard; and 6) rehabilitation of Berth No. 10.

Following the second port development project which is nearly completed, the third port development project is to be implemented based on the Master Plan formulated in early 1993. The loan agreement has been made with the KFAED and the SFD and the details of the project are as follows (See also Fig. 1-4):

	Work Item	Allocated Amount KD
1	Civil works for new pavement and rehabilitation of existing pavement for container yards including electrical, lighting, water and drainage	1,020,000
2	Reclamation work of additional land to container yard	180,000
3	Roads from new port entrance to container terminal	440,000
4	Rail network inside container terminal with connection to port network and main line	545,000
5	Container terminal administration building and building No. 1 of port administration building	385,000
6	Technical assistance for training	135,000
7	Engineering services for final design, tender documents, evaluation of tenders and supervision of works	295,000
8	Contingency	300,000
	Total	3,300,000

In January 1993, a new Master Plan Study for the Port of Djibouti was completed as shown in Fig. 1-5, and based on this Master Plan, some particular development projects are under implementation and to be implemented. The major under-going projects of port related infrastructures are described as follows:

1) New Open Yard 15: This project consists of Pavement of Open Yard (surface area: approx. 73,000 sq. m), Drainage System and Lighting System. The cost of the project is approximately 1.2 billion Djibouti francs and financed by the Italian Government as a loan. The works are scheduled to be completed by November 1994.

2) New Quay No. 15: This project consists of the construction of a quay with a length of 106 m as an extension of Quay No. 14. The project cost amounts to approximately 1.5 billion Djibouti francs donated by the Italian Government. The Construction work is scheduled to be completed by May 1994.

3) Rehabilitation of Berth No. 10: This project is a part of the Second Port Development Project which consists of six (6)

packages jointly financed by the Kuwait Fund for Arab Economic Development (KFAED) and the Saudi Fund for Development (SFD).

This rehabilitation project is the last package having two phases of which the first includes demolition of the existing breasting dolphins and reconstruction of two steel sheet pile cellular cofferdam (so-called "gabion") type breasting dolphins with rubber fenders and bollards.

The structural type of dolphins was initially designed as steel pile supported type, but the gabion type was finally adopted for breasting dolphins. The reasons for change of the structural type were: 1) convertibility of the oil-berth to a multi-purpose quay by means of a continuous quaywall based on the future development strategy of PAID; 2) reinforcement of revetment stability of the Jetée du Large damaged by earthquakes; and 3) lower construction cost.

The rehabilitated berth will allow oil tankers of 55,000 DWT class to berth. This project (Phase 1) amounts to 357 million Djibouti francs. It is anticipated to be completed on April 1994.

As for the second phase, the construction of continuous steel sheet pile quaywall between the breasting dolphins reconstructed in the first phase including deepening of water depth in front of quay will be implemented. However, the implementation schedule for the second phase is not fixed yet due to the lack of funds.

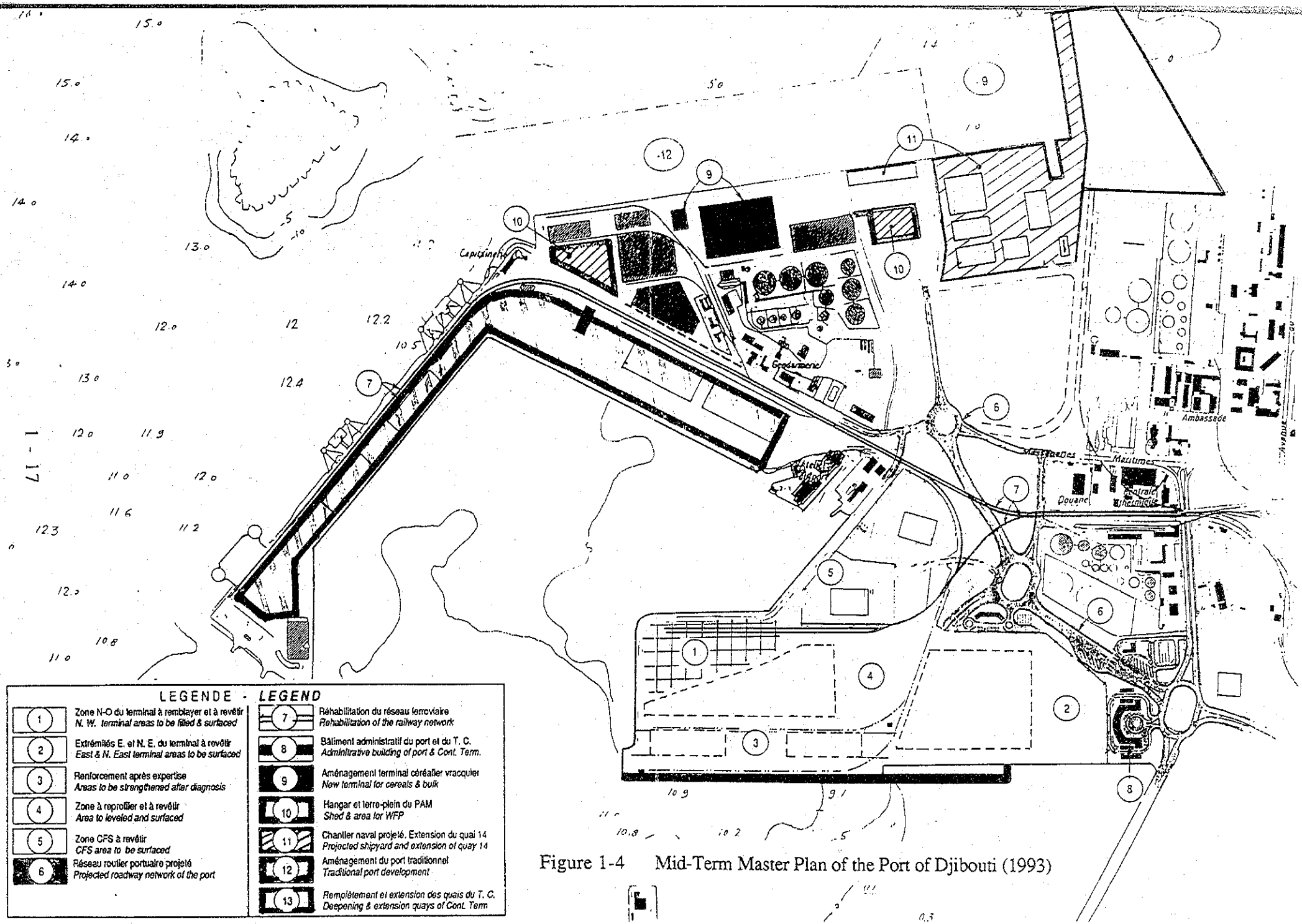


Figure 1-4 Mid-Term Master Plan of the Port of Djibouti (1993)

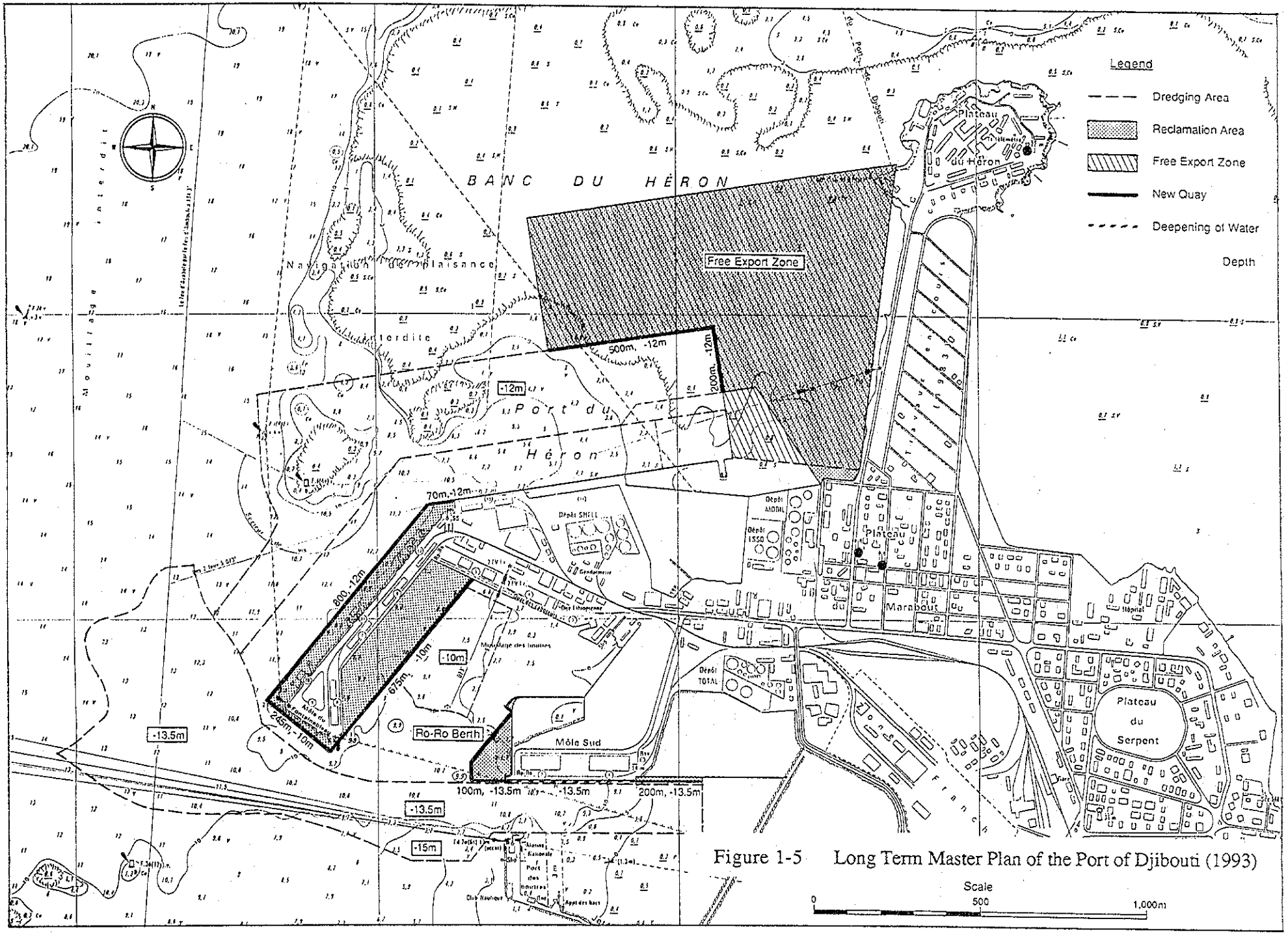


Figure 1-5 Long Term Master Plan of the Port of Djibouti (1993)

Chapter 2 Present Situation of the Oil-Berths in Port of Djibouti

CHAPTER 2 PRESENT SITUATION OF THE OIL-BERTHS IN PORT OF DJIBOUTI

2.1 General

In order to collect data and information on socio-economic and natural conditions as well as structural status of the existing facilities of Oil-Berth Nos. 11 and 12 of the Port of Djibouti, the Study Team conducted a series of site investigations in Djibouti from August 24 to October 17, 1993 and from January 15 to 25, 1994.

As for the site investigations on natural conditions, the soil investigation and the hydrographic survey were conducted.

The hydrographic survey was conducted in front of the Oil-Berth Nos. 10, 11 and 12 covering an area of 16 ha (200 m by 800 m) from September 18 to 27, 1993.

The soil investigation was started on October 6, 1993 by using a cone penetrometer to clarify soil characteristics at the Site and ten (10) points were tested completely on October 30, 1993.

Regarding the survey on the existing facilities, a series of inspections were conducted on not only the superstructures but the sub-structures by using diving experts from September 18 to 21, 1993. Structural diagnosis is described in this Chapter based on the results of the site inspections.

2.2 Natural Conditions

2.2.1 Meteorological Conditions

A continuous climate observation has been kept by the Meteorologie Nationale, the Government of Djibouti at one inland location, Serpent, 1 km away from the Port of Djibouti.

In Djibouti, the average temperature is approximately 30 degrees centigrade throughout the year, and annual precipitation is approximately 150 mm. Consequently, the climate is generally warm and dry. The prevailing wind blows from the Red Sea side, but the NW wind, the so-called Khamsin, prevails in June to August when the monthly highest temperature climbs up to 40 degrees centigrade. In these months, there is no precipitation and it is unbearably hot.

Annual precipitation varies very widely by the year, such as 692 mm in 1989 or 556 mm in 1967 as the maximum, while 9 mm in 1980 or 22 mm in 1965 is the minimum.

The statistics show in Djibouti, it rains in the months of October and November, and February to April, but the monthly precipitation varies widely by year as there was no precipitation at all in these months, while there was heavy rains of over 500 mm in another year.

The monthly maximum wind velocity is generally 10 to 15 m/sec which is not so strong except for the period of Khamsin season. Even in the period of Khamsin season, it is 10 to 20 m/sec except for abnormal years.

General meteorological information, obtained from "RED SEA AND GULF OF ADEN PILOT, 1980 (REVISED 1987)", Meteo and ISERST are shown in Fig. 2-1 to 2-4.

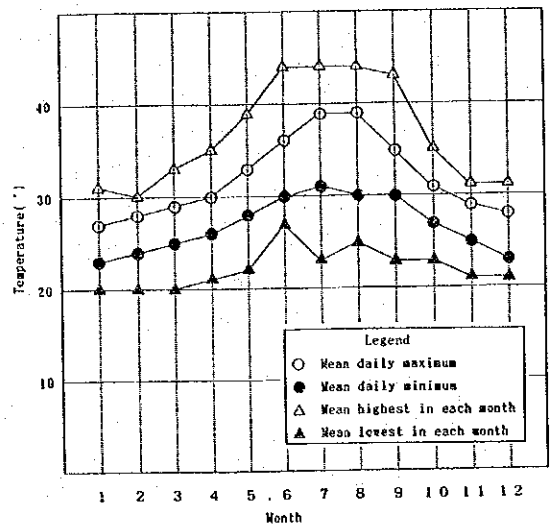


Fig. 2-1 Temperature in Djibouti (1941 ~ 1970)

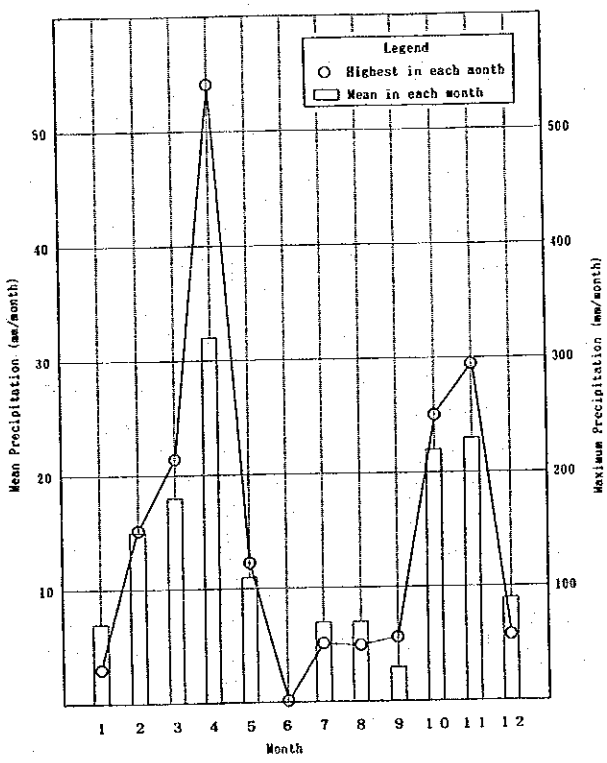


Fig. 2-2 Precipitation in Djibouti (1961 ~ 1980)

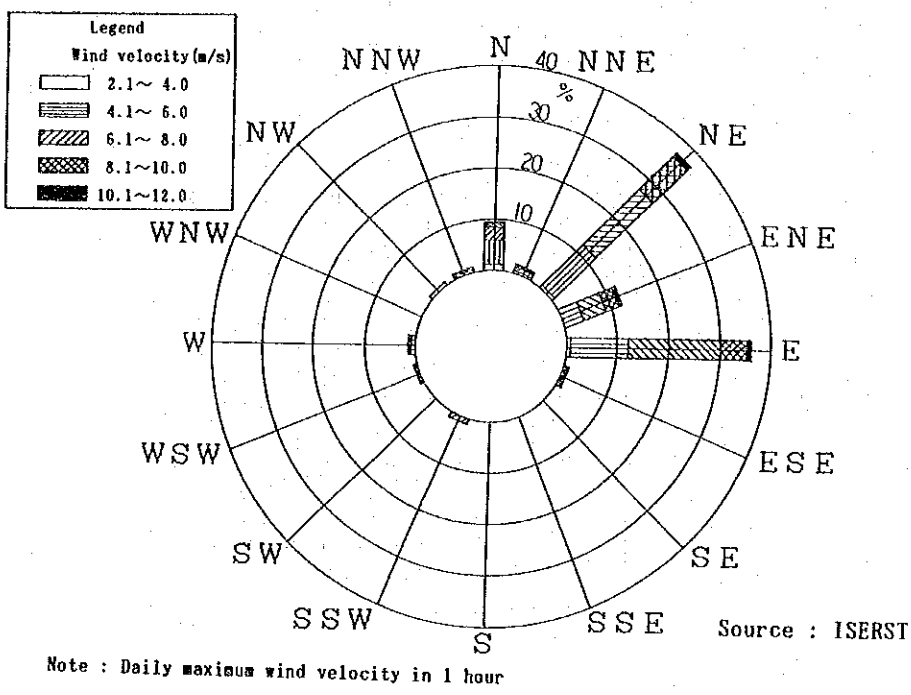


Fig. 2-3 Windrose in Djibouti (1984)

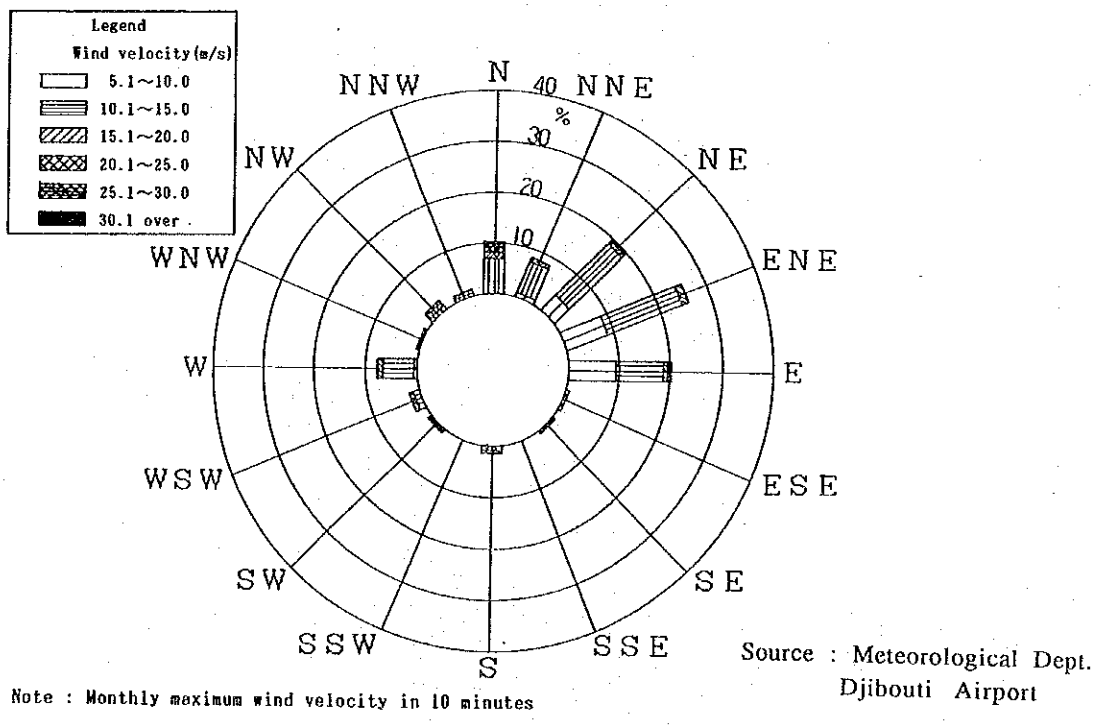


Fig. 2-4 Windrose in Djibouti (1971 ~ 1990)

2.2.2 Oceanographic Conditions

(1) Waves

Wave observation data are not available from PAID, and consequently, the Study Team has conducted the wave hindcasting, based on the wind information observed in Djibouti.

In the process of wave hindcasting, the estimated values were computed by means of SMB Method applying the effective fetch for irregular shoreline in six wind directions from NNE to W which might grow higher in wave height at Oil Berth Nos. 11 and 12. Wind blow duration in those six wind directions were judged from the local wind data records.

The waves of 30-year probability and of 50-year probability were computed through a statistical method, applying the Weible & Gumbel's distribution function.

The wind data available in the wave hindcasting are obtained from the 20 year period from 1971 to 1990.

The results of wave hindcasting are shown in Table 2-1.

Table 2-1 Hindcast Wave Height

Directions of Wave	Recurrence Period (year)			
	30		50	
	Significant Wave Height $H_{1/3}$ (m)	Significant Wave Period $T_{1/3}$ (s)	Significant Wave Height $H_{1/3}$ (m)	Significant Wave Period $T_{1/3}$ (s)
NNE	1.5	4.2	1.6	4.3
N	1.6	4.2	1.6	4.2
NNW	1.6	4.1	1.7	4.2
NW	1.8	4.7	1.9	4.9
WNW				
W	1.8	4.7	1.9	4.8

(2) Tide

The tide was observed at thirty minute intervals at Berth No. 12 while hydrographic survey was conducted by the Study Team.

Table 2-2 shows levels to be applied in the planning of the present project, which were determined after comparing the four kinds of tidal data as follows:

1) Tide observed by the Study Team in the present field survey;

2) Data shown in ADMIRALTY TIDE TABLES, volume 2 1993 ATLANTIC AND INDIAN OCEANS INCLUDING TIDAL STREAM TABLE, published by the HYDROGRAPHER OF THE NAVY;

3) The information shown in the marine chart;

4) The tide observation recorded by an automatic tide gauge of ISERST installed at Quay No. 3 (in September 1993).

Table 2-2 Tide Level

Height above datum of soundings					
		Mean High Water		Mean Law Water	
H.W.L.	L.W.L.	Higher	Lower	Lower	Higher
+2.9 m	+0.2 m	+2.4 m	+2.2 m	+1.0 m	+1.8 m

H.W.L.; Mean Springs High Water Level
L.W.L.; Mean Springs Low Water Level

(3) Current

No long-term reliable data are available from the port-related organizations as to the tide currents in the study area. Only information obtained was that obtained by hearing at Harbor Master's Office that the maximum current velocity might be around 1 knot.

Also, "Quay No. 14, Berth No. 10 & Ancillary Facilities Preliminary Design Report by BCEOM, January 1986" describes that the currents in the Gulf of Tadjoura are relatively weak, with a speed of about 1 knot, flowing in the opposite direction from the tide, with a western flood and an eastern ebb current.

In order to obtain the actual tide current patterns in the study area, a current survey was conducted on 2nd October, 1993, just two days after a full moon at the sea in front of Berth No. 10, using a floater.

The results of the current observation are shown in Fig. 2-5.

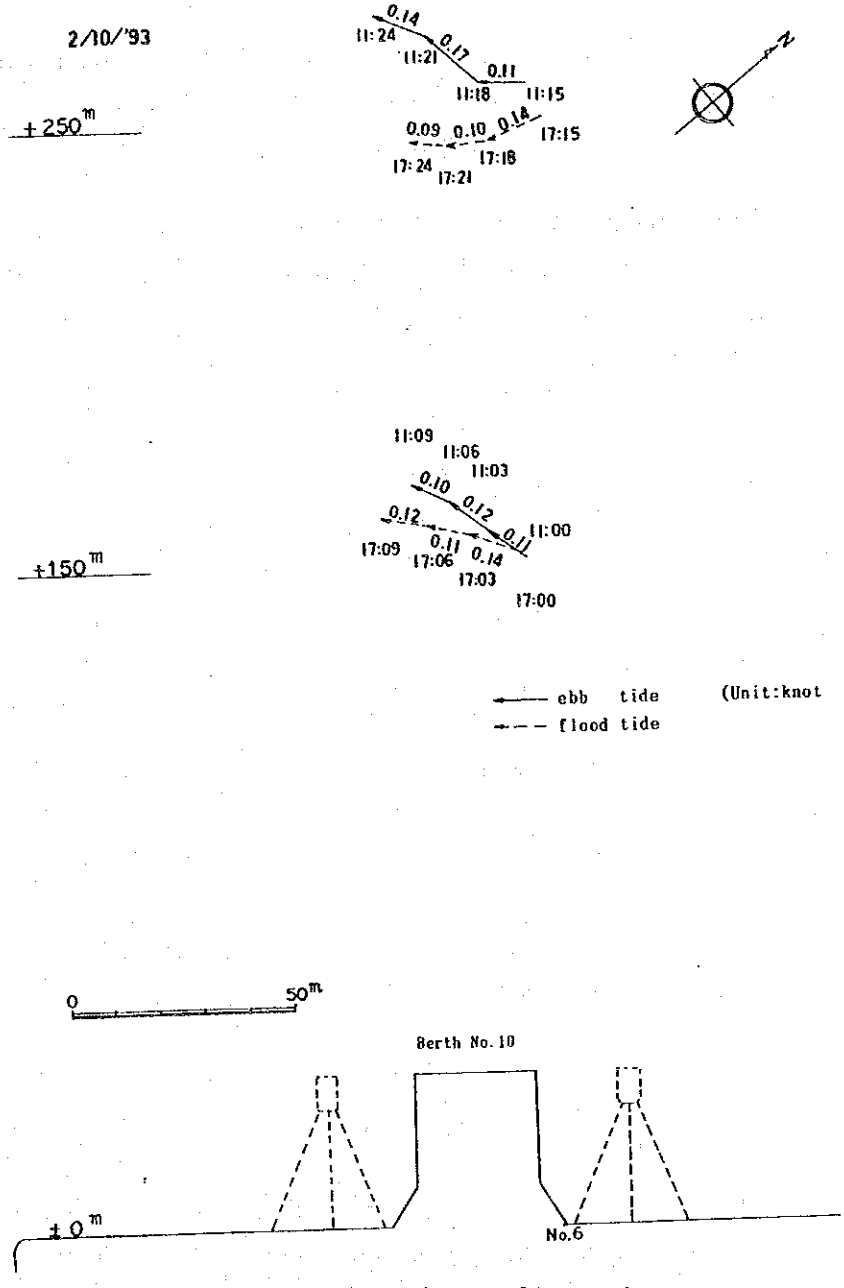


Fig. 2-5 Result of Current Observation

2.2.3 Topography and Hydrography

(1) Existing Topographic/Hydrographic Survey Maps

The port hydrographic survey results are shown in Appendix Figs. A-3-1 to A-3-3 for reference.

(2) Hydrographic Survey conducted by the Study Team

The topographic survey was conducted with a transit and a level. A total of 33 reference points were set with paint marking and pins at 25 m intervals on the existing concrete parapet wall along Berth Nos. 10, 11 and 12.

The bench mark B.M.3B of IGN was used as survey reference point.
The elevation of B.M.3B (D.L. + 3.689) was verified by using the aforementioned tidal observation data. The relation between B.M.3B and relevant tidal data are summarized below:

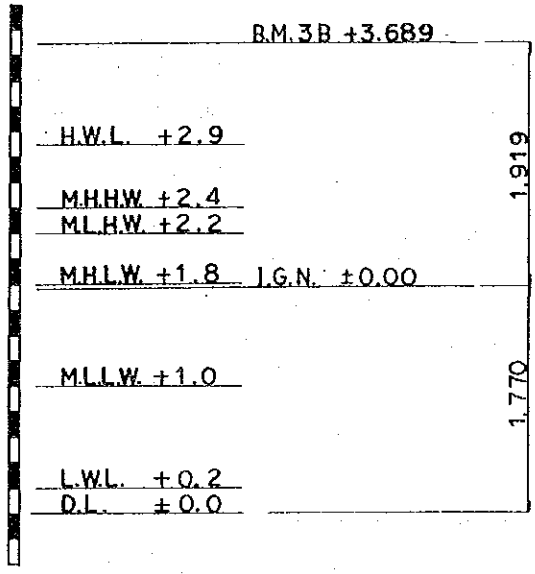


Fig. 2-6 Survey Datum

The hydrographic survey was conducted by using an echo sounder equipped on the survey boat and, being guided by transits and marker buoys, at an interval of 25 m within an area of 800 m by 200 m.

The Hydrographic Survey Map is shown in Fig. 2-7.

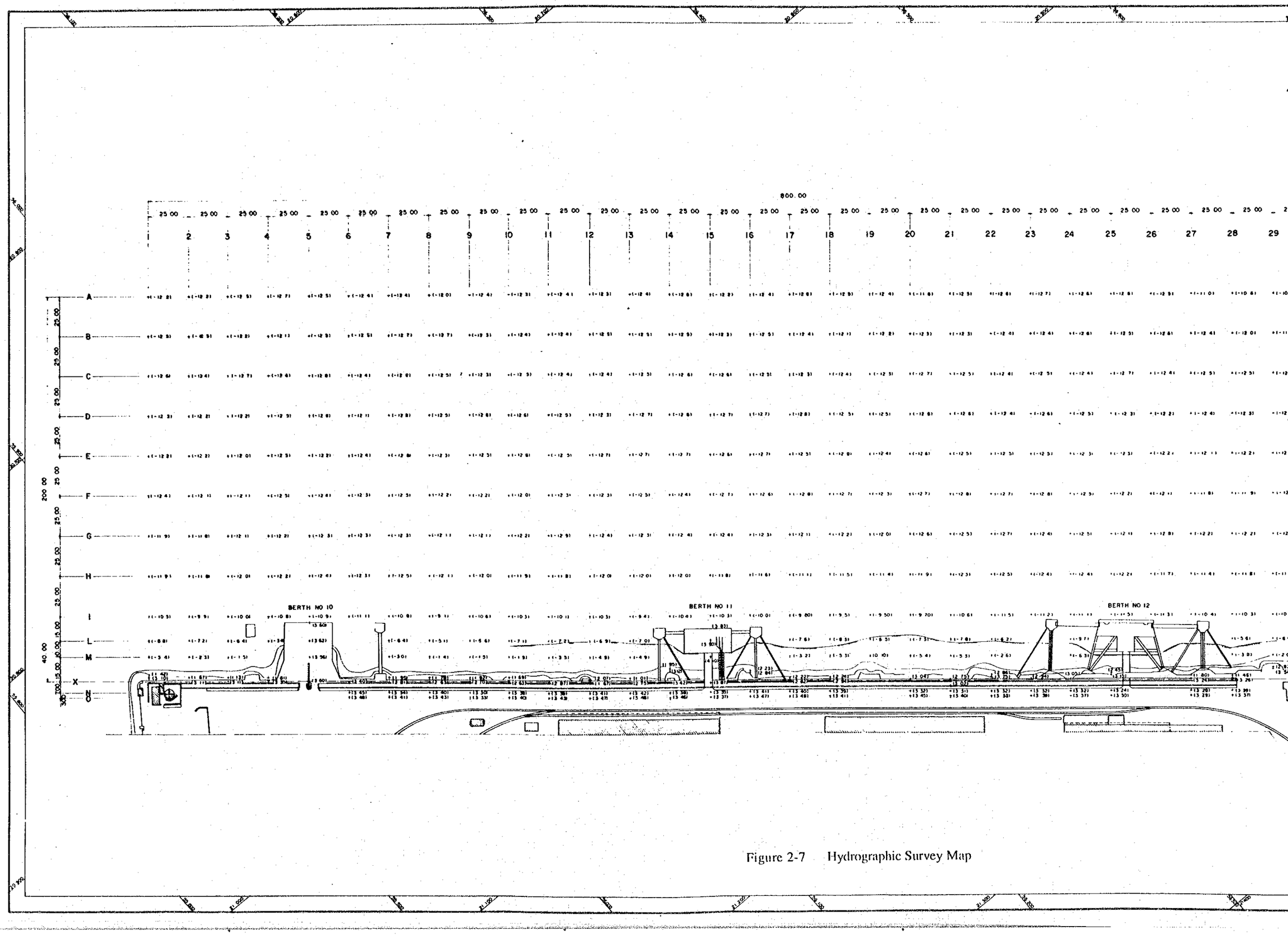


Figure 2-7 Hydrographic Survey Map

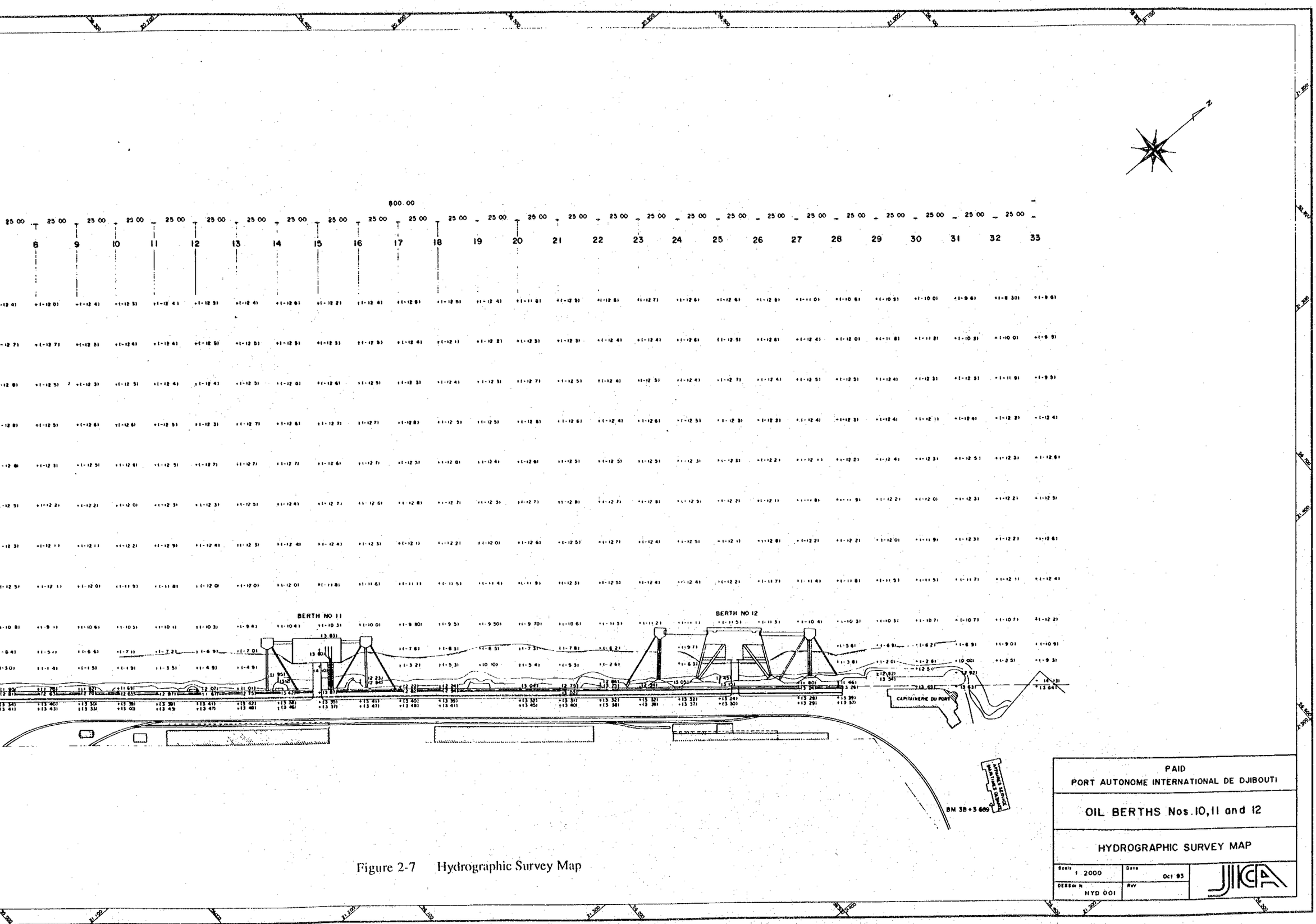


Figure 2-7 Hydrographic Survey Map

PAID PORT AUTONOME INTERNATIONAL DE DJIBOUTI	
OIL BERTHS Nos.10,11 and 12	
HYDROGRAPHIC SURVEY MAP	
Scale 1 2000	Date Oct 93
DESIGN HYD 001	Rev

JICA

2.2.4 Geological and Soil Conditions

(1) Geological and Geophysical Characteristics of Djibouti

Geological history of Djibouti is described as follows (refer to Fig. 2- 8):

1) Cracked basalt (+25 Ma: over 25 million years) is placed on Mesozoic formation, the base rock (Jurassic limestone and Cretaceous Ali Sabieh sandstone);

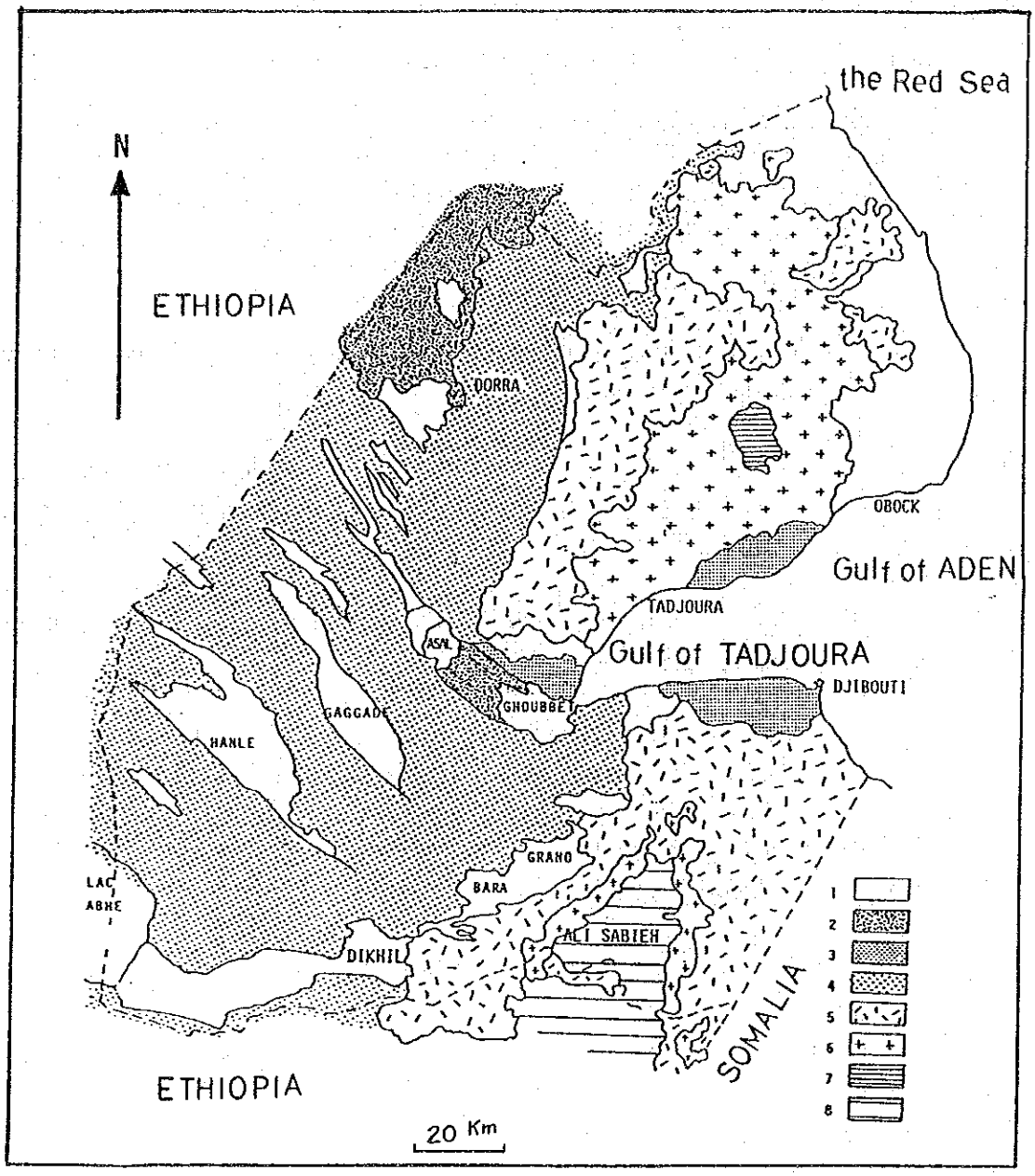
2) Rhyolite is distributed on the eastern edge of Ali Sabieh "horst" (between 19 and 25 Ma);

3) Another rhyolite named Mablas (9.5 to 14 Ma) is distributed on the western edge of Ali Sabieh horst, and along the Gulf of Tadjoura up to Doumera;

4) One thick series of basalt is distributed between 9 and 4 Ma, and covers over Mablas rhyolite partially;

5) Stratoid series between 4 and 1 Ma, mostly composed cracking basalt is placed. This unit occupies two third of Afar depression;

6) The more recent volcanic appearance occupies along the axial valley. It is considered as the incipient ocean crust (-1 Ma).



1. Formation of Recent Deposits
2. Axial Series (- 1 Ma)
3. Initial Basalt Series
4. Stratoid Series
5. Dalha Basalt
6. Mablas Rhyolite
7. Ancient Basalt (+ 25 Ma)
8. Mesozoic Formation

Figure 2-8 Simplified Geological Map of Djibouti

(2) Seismic Requirements of Djibouti

Djibouti is located on the boundary of plate tectonics linking the African and Arabian Peninsulas in the triple junction of three rifts, namely two ocean ridges, the Red Sea and the Gulf of Aden, and the continental east African valley, i.e. Ethiopian rift as shown in Fig. 2-9.

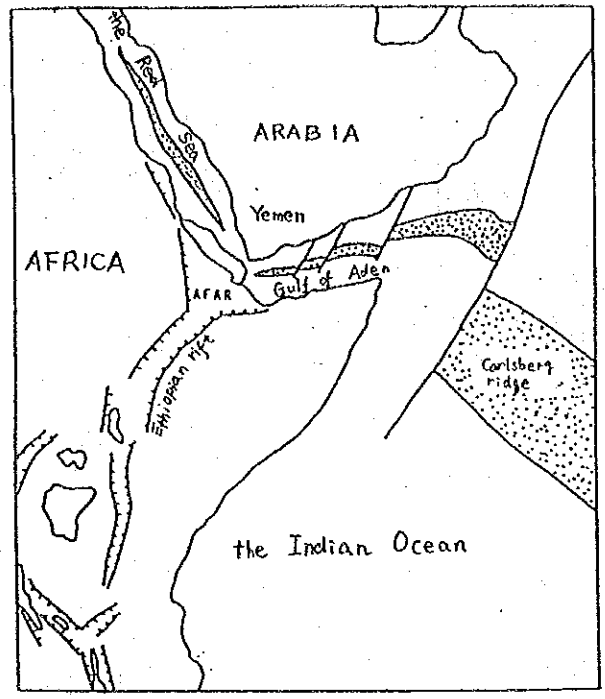


Figure 2-9 Cross Area of Three Rifts

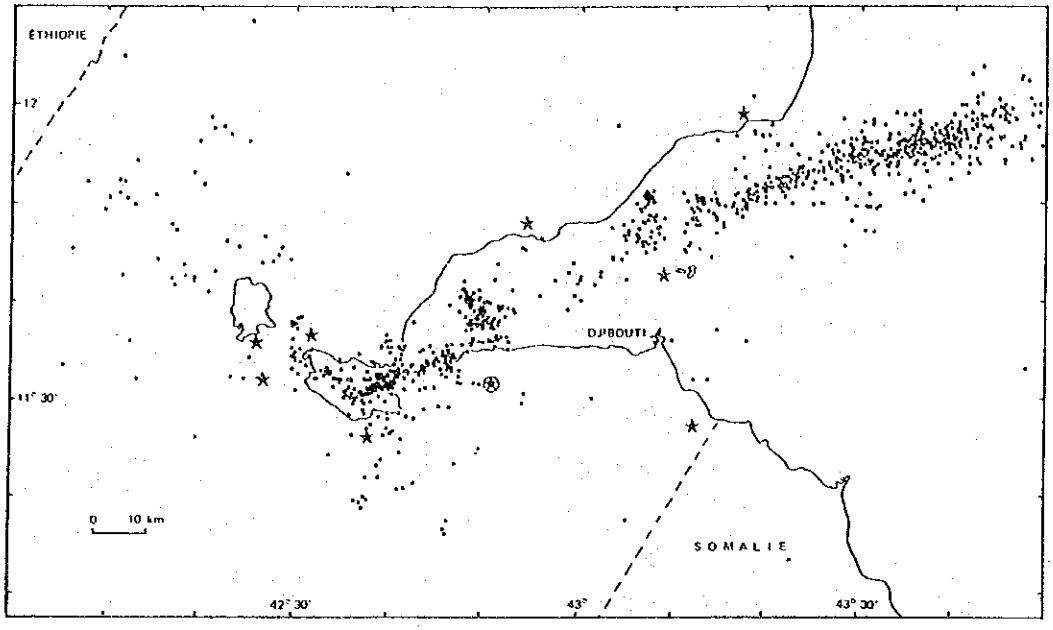
Most earthquakes occur along these boundaries, and Djibouti encountered several earthquakes in the past as shown in Figs. 2-10 and 11.

The earthquake which severely damaged Djibouti city was the one that occurred in April 1973 with a magnitude of 5.5. This earthquake caused several damages to the Port of Djibouti such as cracks in pavement, ruptures on embankments and damages on port office building.

Disastrous earthquakes in Djibouti are of the epicentral type engendering along the axis of the Gulf of Tadjoura at a shallow depth of 3 to 10 km.

As shown in Table 2-3, almost all earthquakes were observed with a magnitude of less than six (6) degrees. However, due to short distances between the Djibouti City and epicenters, relatively high intensities were recorded.

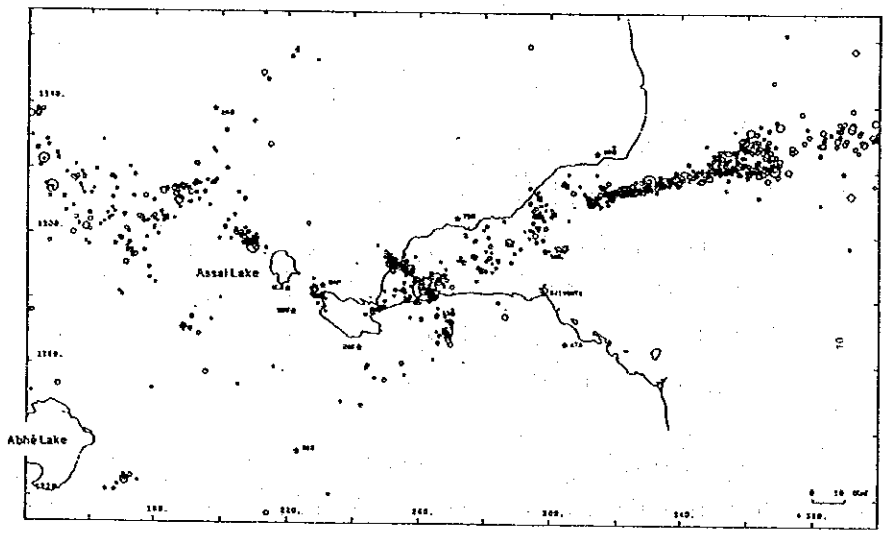
"Tsunami", seismic swell, has never been observed in Djibouti due to the shallow and small water surface area of the Gulf of Tadjoura.



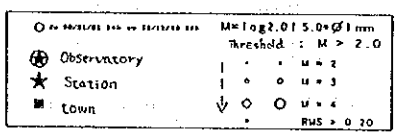
Source : Brief Report on the Seismicity of Djibouti by Ahmed Omar

ISERST, August 22,1993

Figure 2-10 Distribution Map of Epicenters (1974-1980)



Source : Brief Report on the Seismicity of Djibouti by Ahmed Omar



ISERST, August 22,1993

Figure 2-11 Distribution Map of Epicenters (1990-1992)

Table 2-3 List of Earthquakes Recorded in Djibouti

Date	Magnitude	Distance from Djibouti (Km)	Intensity Mercalli in Djibouti	JMA* Intensity equivalent	Max.* Acceleration (m /scc²)	Seismic Coefficient* equivalent	
						K c	Kc.ave.
1899/2	5.6	50	7	4	25 - 80	0.10 - 0.14	0.12
1899/11	3.7	40	4	2	3 - 8	0.05 - 0.07	0.06
1906/1	4.3	40	5	2	3 - 8	0.05 - 0.07	0.06
1907/1	5.0	50	6	3	8 - 25	0.07 - 0.10	0.08
1907/10	3.7	50	4	2	3 - 8	0.05 - 0.07	0.06
1909/2	3.7	50	4	2	3 - 8	0.05 - 0.07	0.06
1910/8	3.7	50	4	2	3 - 8	0.05 - 0.07	0.06
1912/5	5.6	50	7	4	25 - 80	0.10 - 0.14	0.12
1912/8	5.6	40	7	4	25 - 80	0.10 - 0.14	0.12
1926/10	5.5	90	6	3	8 - 25	0.07 - 0.10	0.08
1929/1	6.0	60	7	4	25 - 80	0.10 - 0.14	0.12
1930/10	5.6	70	7	4	25 - 80	0.10 - 0.14	0.12
1932/2	5.0	80	5	2	3 - 8	0.05 - 0.07	0.06
1938/3	4.5	80	4	2	3 - 8	0.05 - 0.07	0.06
1941/3	5.5	130	5	2	3 - 8	0.05 - 0.07	0.06
1945/10	5.6	40	7	4	25 - 80	0.10 - 0.14	0.12
1949/6	5.5	80	6	3	8 - 25	0.07 - 0.10	0.08
1953/11	4.4	70	5	2	3 - 8	0.05 - 0.07	0.06
1957/4	5.0	60	5	2	3 - 8	0.05 - 0.07	0.06
1958/5	5.5	120	5	2	3 - 8	0.05 - 0.07	0.06
1960/1	5.0	80	5	2	3 - 8	0.05 - 0.07	0.06
1961/3	6.0	60	7	4	25 - 80	0.10 - 0.14	0.12
1963/10	5.3	80	6	3	8 - 25	0.07 - 0.10	0.08
1965/7	4.5	130	3	1	1 - 3	0.03 - 0.05	0.04
1969/3	6.4	220	5	2	3 - 8	0.05 - 0.07	0.06
1973/4	5.5	35	7	4	25 - 80	0.10 - 0.14	0.12
1978/11	5.3	80					
1983/9	4.5	20					
1983/9	4.2	20					
1985/4	4.3	40					
1989/8	6.3	175					
1992/3	5.0	35					

Source: Brief Report on the Seismicity of Djibouti by Ahmed Omar, ISERST, August 22, 1993
* : reckoned by the JICA Study Team

(3) Review of Previous Soil Investigations

In the port area, there have been several soil investigations conducted since the French colonial era as shown in Fig. 2-12. Among these, our concerns are those adjacent to Berth Nos. 11 and 12, probably No. 10. Here, the soil characteristics on Berth No. 10 area are reviewed below. As for those on Oil-Berth Nos. 11 and 12, we will discuss these later based on the results of the cone penetration test conducted by the Study Team.

Oil-Berth No. 10 area

The three (3) borings were carried out in 1985 as shown in Fig. 2-13. According to the report prepared by Mécasol, the geological formation of the seabed can be classified into roughly four typical layers: the upper layer has approximately 2 m thick on average consisting of loose fine sand; the second one consists of brownish-red clay; the third one has approximately 3.5 m thick on average consisting of madreporic sand (sand attending the clips of madrepore); and the last one is found at the level deeper than -21 m, consisting of brown clay, greenish clay and yellowish clay.

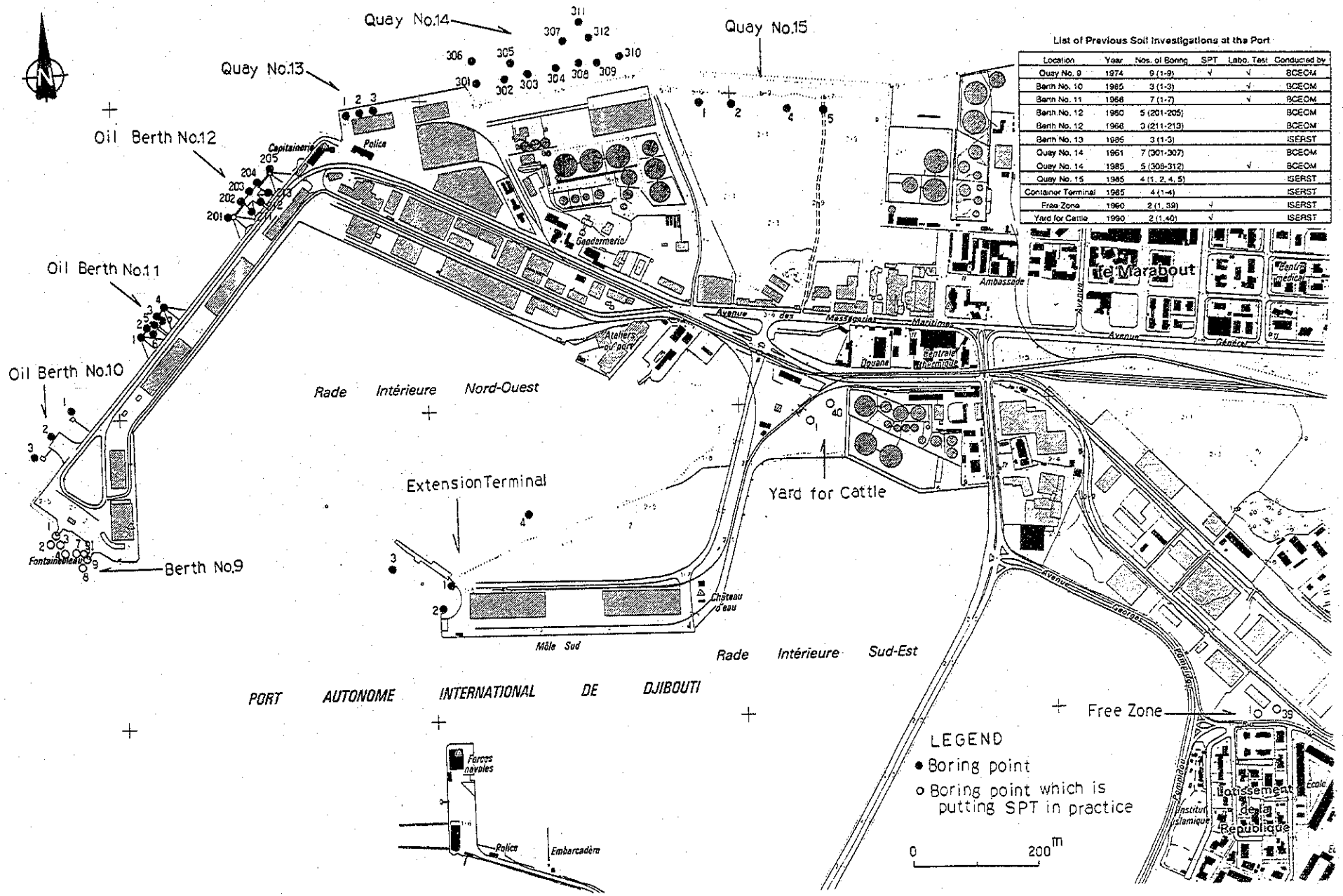
The soil characteristics of each layer are described in the above report as follows:

Loose Sand

Cohesion	: Cd = 0 t/m^2
Angle of Internal Friction	: Ød = 28°

Brownish-red Clay

Sand content	:	less than 10 % smaller than 50 micron	
Clay content	:	about 50 % of elements smaller than 5 micron and 30 % of elements smaller than 1 micron	
Atterberg Limits	:	63.8 % < I_L < 68.8 %	Ave. I_L = 65.9 %
33.7 % < I_P < 40.2 %	:		Ave. I_P = 37.5 %
Cohesion	:		Cd = 3 t/m^2
Angle of Internal Friction	:		Ød = 29 °



List of Previous Soil Investigations at the Port

Location	Year	Nos. of Boring	SPT	Labo. Test	Conducted by
Quay No. 9	1974	9 (1-9)	√	√	BCEOM
Berth No. 10	1985	3 (1-3)		√	BCEOM
Berth No. 11	1988	7 (1-7)		√	BCEOM
Berth No. 12	1980	5 (201-205)			BCEOM
Berth No. 12	1986	3 (211-213)			BCEOM
Berth No. 13	1986	3 (1-3)			ISERST
Quay No. 14	1961	7 (301-307)			BCEOM
Quay No. 14	1985	5 (308-312)		√	BCEOM
Quay No. 15	1985	4 (1, 2, 4, 5)			ISERST
Container Terminal	1985	4 (1-4)			ISERST
Free Zone	1980	2 (1, 39)	√		ISERST
Yard for Cattle	1990	2 (1,40)	√		ISERST

Figure 2-12 Location Map of Previous Boring Points

Madreporic Sand (test results obtained from Fontainebleau Mole)

Unit Weight : $\gamma = 1.6$ tf/m^3

Triaxial test (non-saturated sample):

Cuu = 1.5 tf/m^2, Ød = 32 °

For design, the following values are adopted:

C = 0 tf/m^2, Ø = 32 °

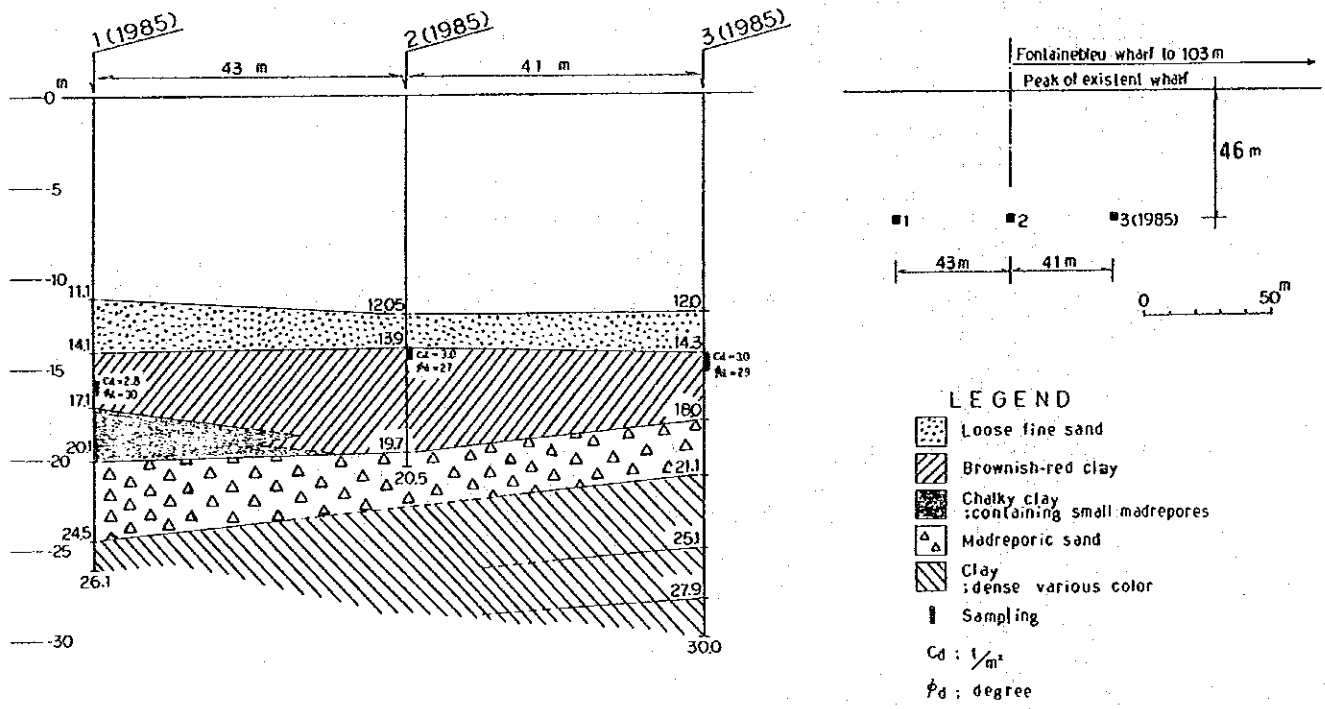


Figure 2-13 Soil Profile at Berth No. 10

Berth No. 9 (Fontainebleau Môle)

On Berth No. 9 located at the edge of the Jetée du Large, the Standard Penetration Test (SPT) was carried out in 1974 as shown in Fig. 2-14. The results of SPT show N-values in each layer are relatively high.

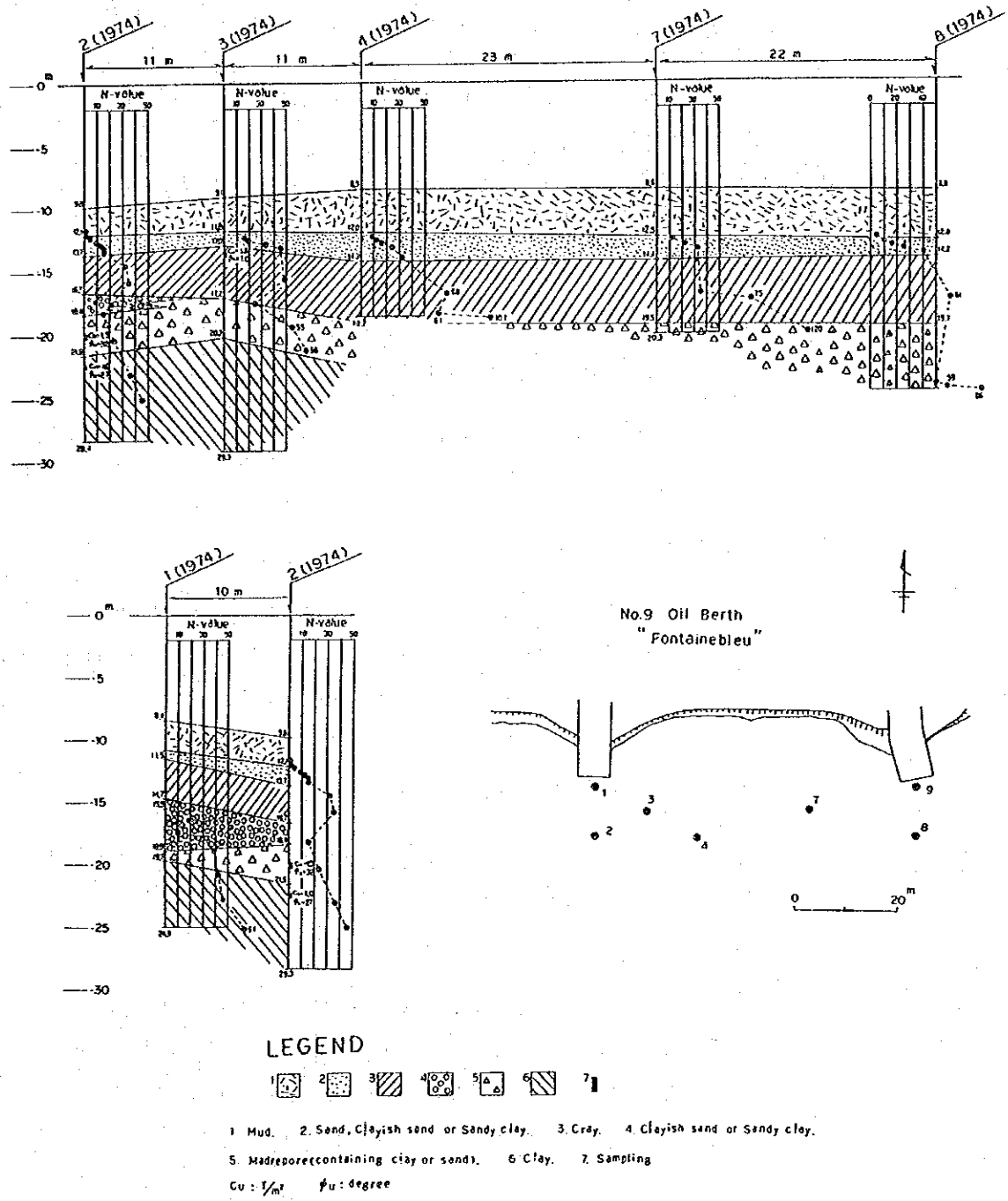


Figure 2-14 Results of SPT at Berth No. 9 (1974)

(4) Results of Cone Penetration Test Conducted by the Study Team

Ten dynamic cone penetration tests were carried out in the locations along Oil-Berth Nos. 11 & 12 as indicated in Fig. 2-15 in order to determine structural type of berths to be rehabilitated or reconstructed. The tests were performed by the LBTP (Laboratoire du Bâtiment et des Travaux Publics) under supervision of the Study Team.

Brief description of the tests are summarized below and the results are attached in Appendix A-4.

1) Location : as shown in Fig. 2-15
2) Test Machine : Automatic Ram Sounding Machine
3) Test Period : October 3 to 30, 1993
4) Test Number : 10 locations
5) Penetration Depth : approx. 20 m from the seabed

Based on the test results combined with the review of the previous studies, it is analyzed that:

Oil-Berth No. 11 Area

The soil profile can be drawn up as shown in Figs. 2-16 and 17. This figure shows that the soil strata are mostly flat. Nevertheless no sampling of soil have been taken at this time, the geological formation of the area are classified into the four typical layers as follows:

1) Alternation of Sand & Clay

   The upper layer has a thickness of 4 m to 6 m and consists of sludge, sand and sandy clay;

2) Sandy & Gravely Madrepore

   This layer is located between -15 to -20 m with a thickness of 2 to 4 m and it consists of madreporic sand and madreporic gravel mixed with chips of shell. It has a Nd-value ranging from 10 to 20;

3) Clay

   The third one has a thickness of 8 m on average consisting of reddish clay and green-grayish clay and this layer appears at the elevation of -18 m deeper. It is mostly compact having an Nd-value of 20 to 50;

4) Sandy Clay & Clayish Sand

The deepest layer found at more than -25 m consists of sandy clay or clayish sand. It contains chips of shell and coral, mostly compact or dense. At some test points, Nd-value has been obtained of more than 50 and this layer could be the foundation for pile foundations.

Oil-Berth No. 12 Area

In the same manner, based on the previous study described in the previous section, the soil profile can be drawn up as shown in Figs. 2-18 to 20. The geological formation of the area is described as follows:

1) Alternation of Sand & Clay

The upper layer is alternation of silty sand and grayish sandy clay with chips of basaltic stone, madrepore and shell. It is assumed that the soil profile shown in Figs. 2-18 to 20 was drawn up based on the soil investigation made in 1960 when the dredging was not performed. So, the upper part of this layer is no longer existing at present time.

2) Madrepore

The second layer appearing at -13 m is approximately 3 m in thick, and consists of madrepore and madreporic conglomerate. It contains chips of shell. This layer has an Nd-value over 10, but some points are more than 50.

3) Madrepore (tender & clayish)

The third layer consists of madrepore tender and clayish having an N-d value of 10. Its thickness is approximately 7 to 8 m and contains chips of shell.

4) Madrepore (mostly tender)

The last layer is found at level -22 m or more, and it is mostly tender except for some places compact where Nd-value reaches at over 20.

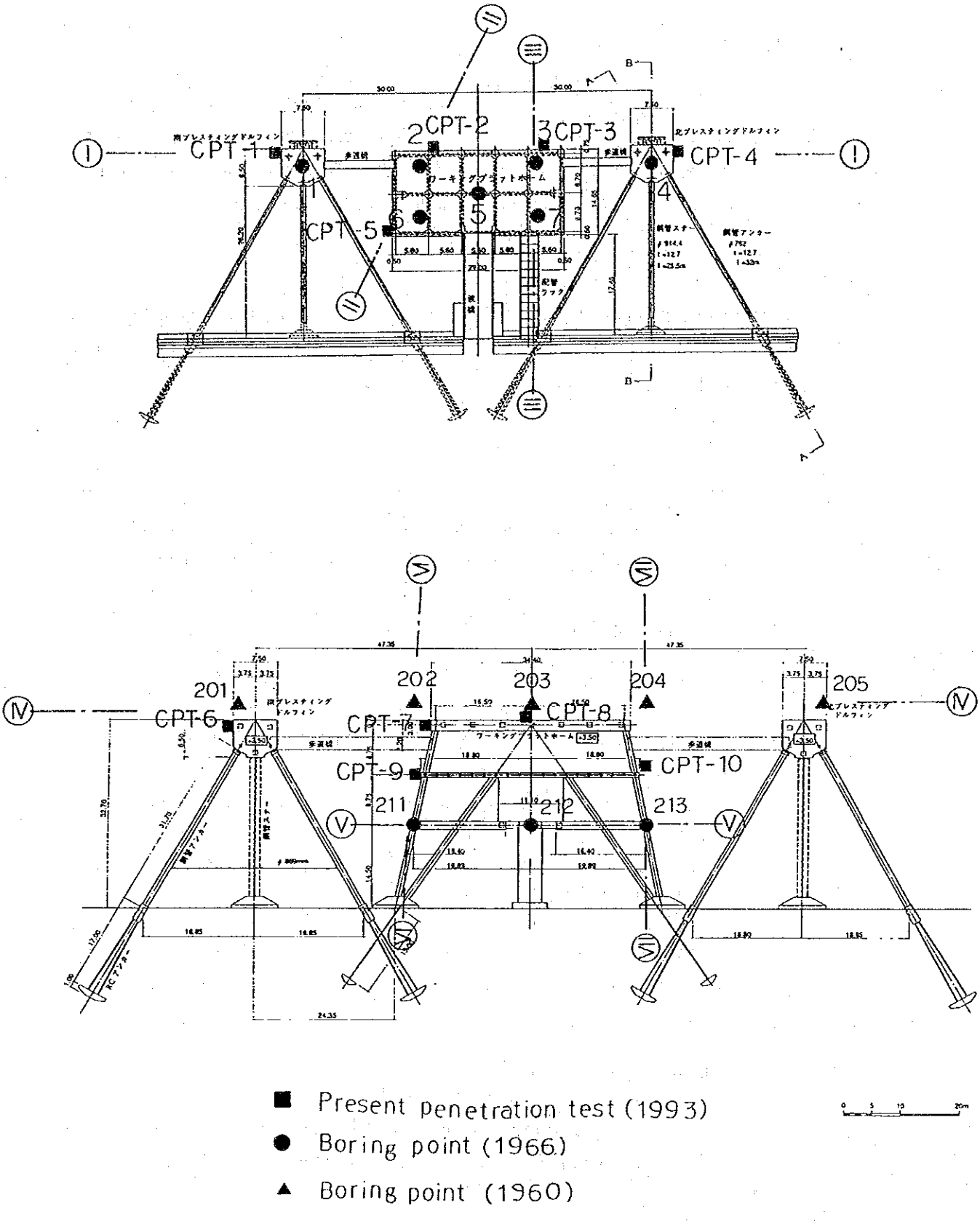


Figure 2-15 Location Map of Cone Penetration Test

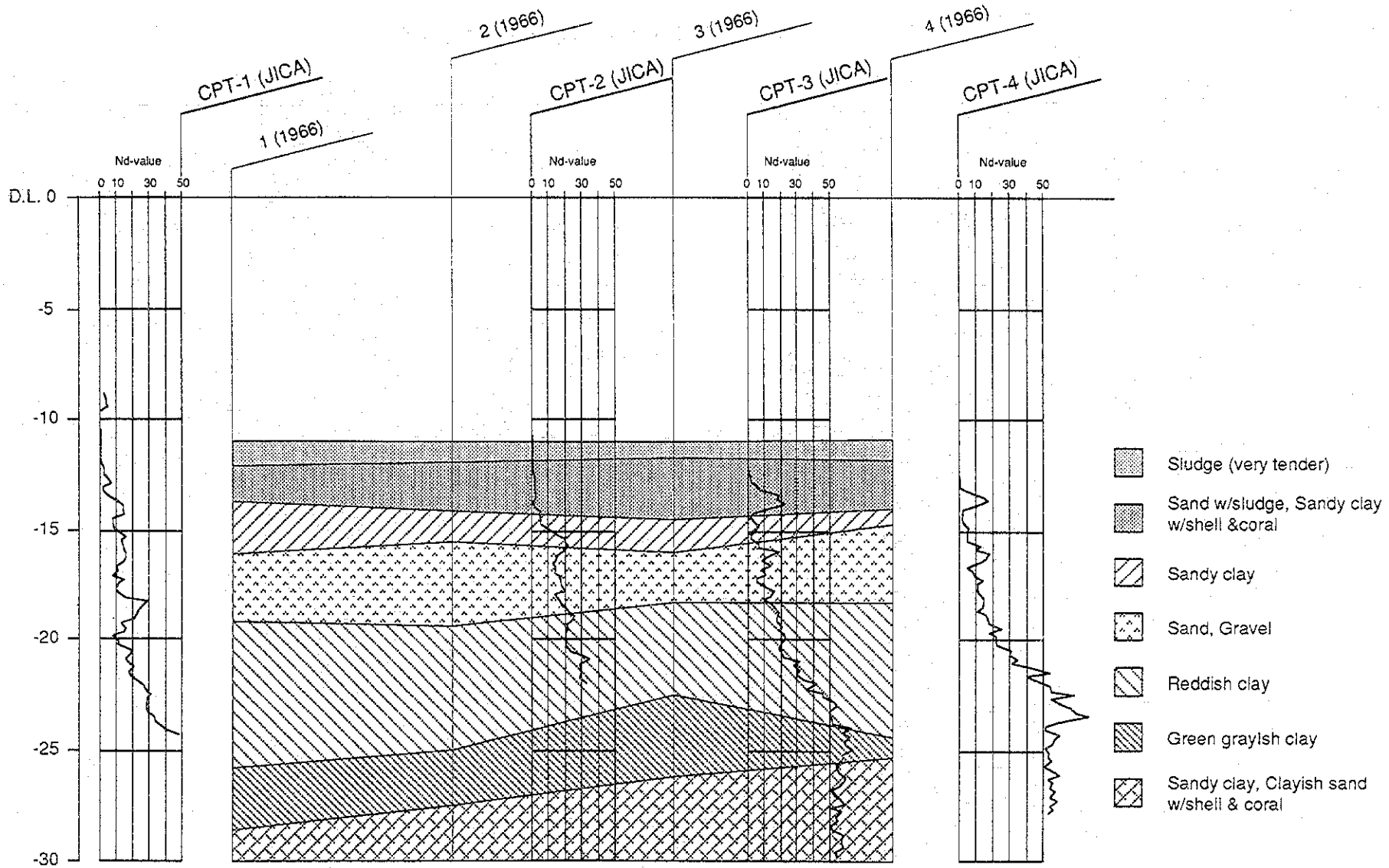


Fig. 2-16 Soil Profile at Berth No. 11 (I-I)

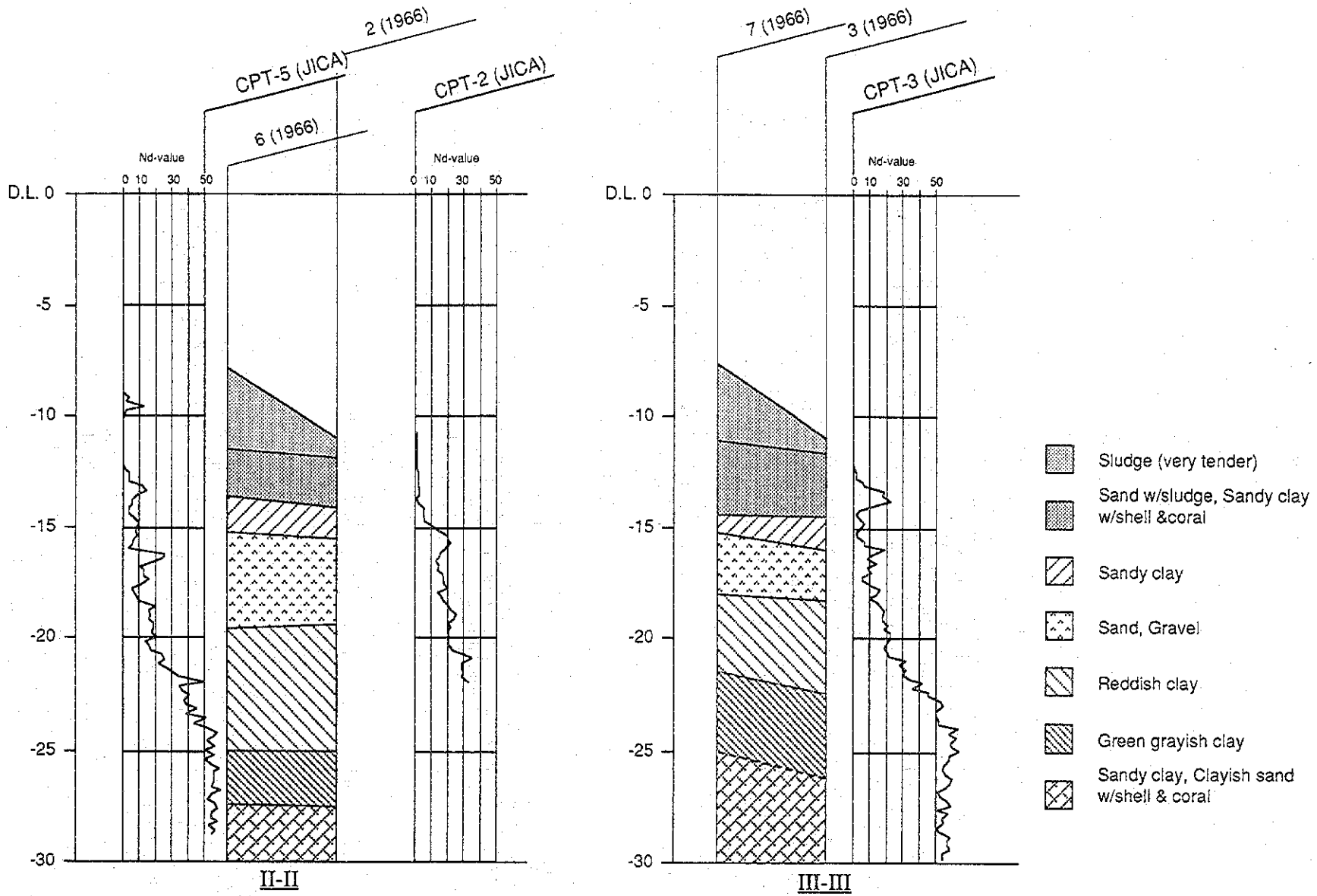


Fig. 2-17 Soil Profile at Berth No. 11 (II-II & III-III)

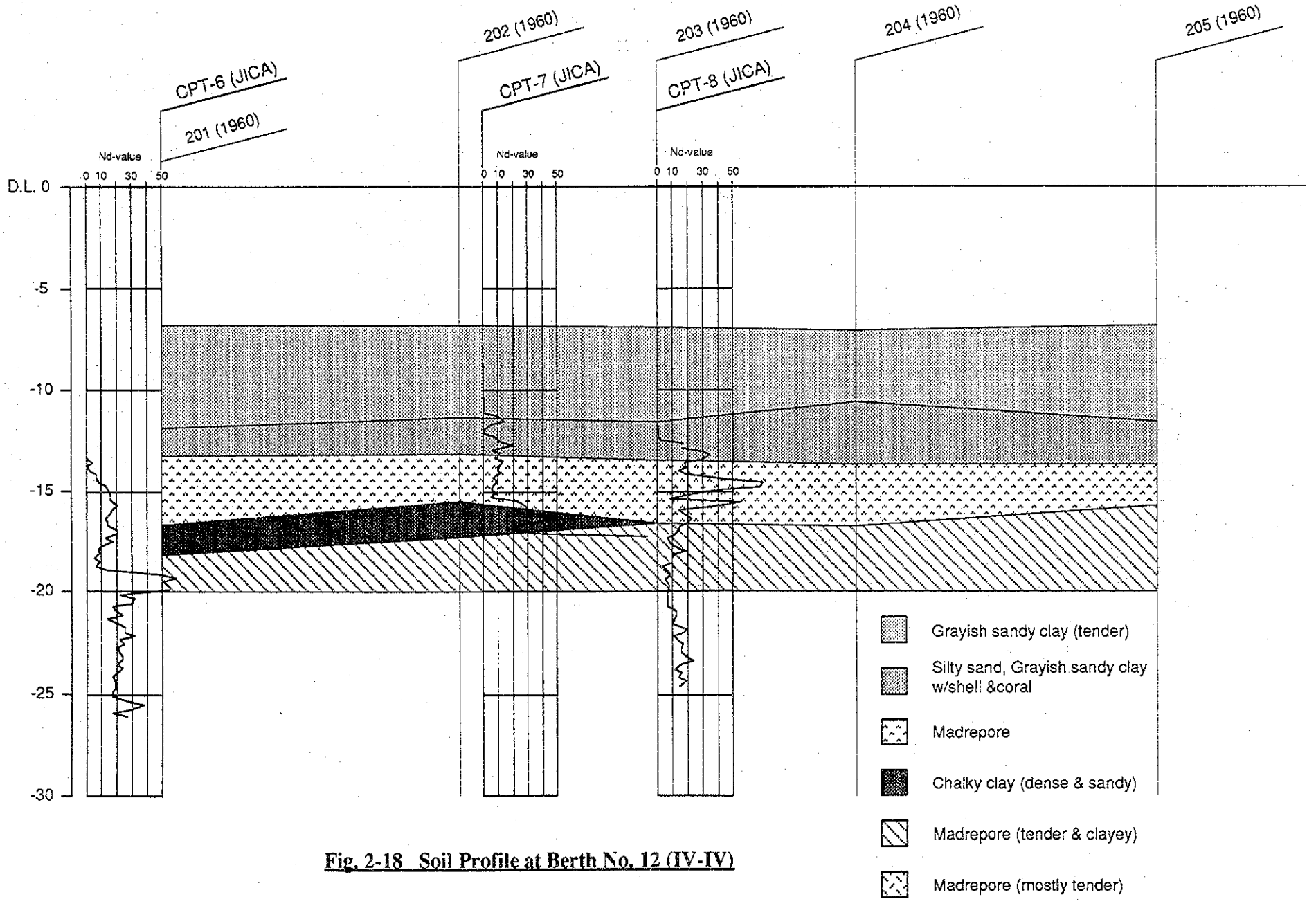


Fig. 2-18 Soil Profile at Berth No. 12 (IV-IV)

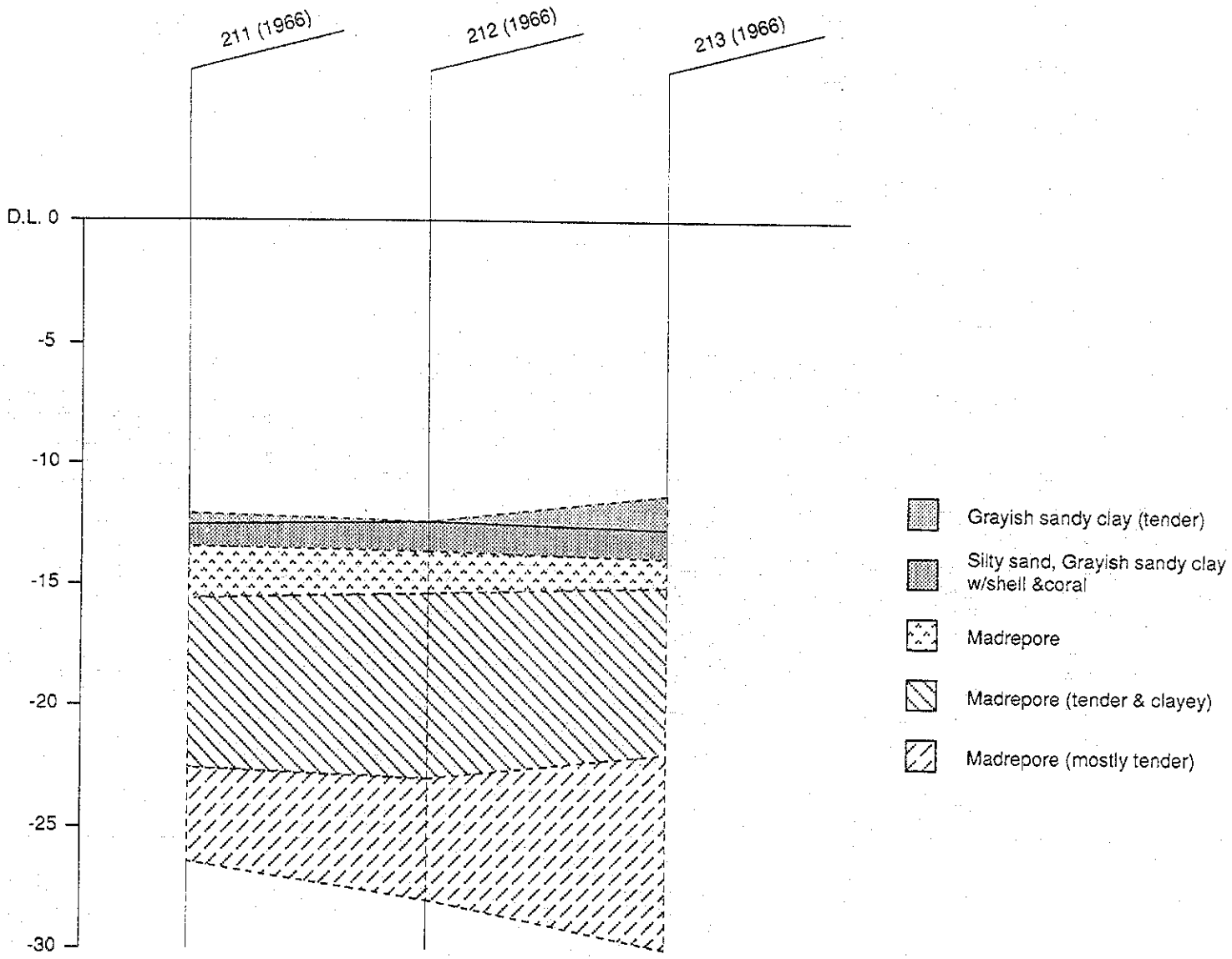


Fig. 2-19 Soil Profile at Berth No. 12 (V-V)

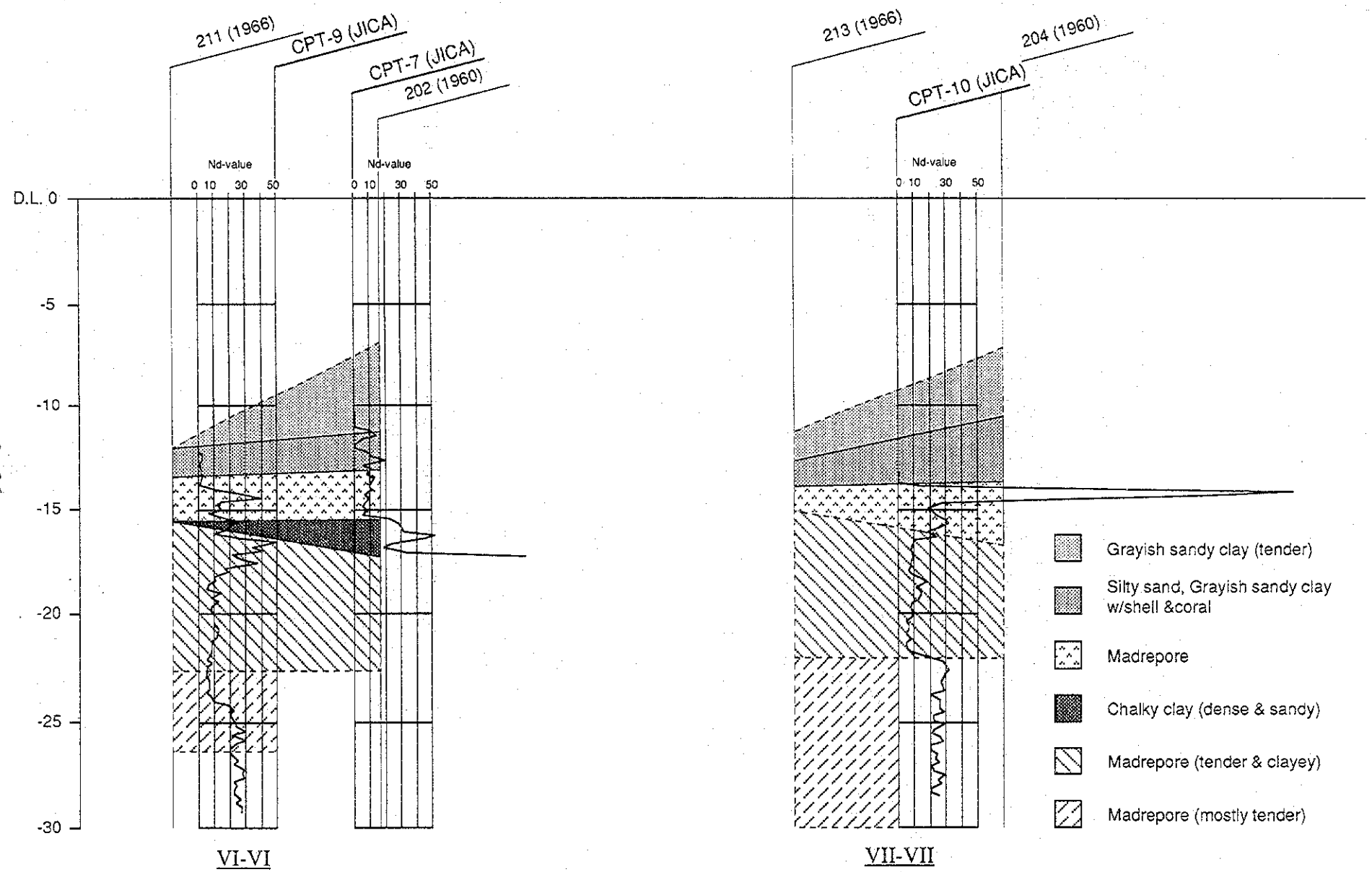


Fig. 2-20 Soil Profile at Berth No. 12 (VI-VI & VII-VII)

2.3 Present Condition of the Oil-Berth Facilities

2.3.1 Structure of Berths

(1) General

Berth Nos. 11 and 12 were constructed approximately 30 years ago at the northwestern end of the Djibouti Port. As shown in Fig. 2-21 and 2-22, each berth has a platform in the center and dolphins at both sides. The structure of the platforms and dolphins are of a pile foundation, each dolphin being supported by a steel stay and two anchors at one end fixed to the onshore to resist mooring forces and berthing impact of ships. Since these platforms and dolphins have been severely damaged by the recurrent earthquakes and bumping accidents with ships, they have severely deteriorated. In view of this situation, it is quite likely that grave accidents due to the deficiencies can not be avoided, if no appropriate action is taken immediately to improve the structures.

(2) Purpose of Investigation

The purpose of the investigation is to inspect the extent of deterioration of the existing platforms and dolphins at Berth Nos. 11 and 12, and to ascertain whether the present system can be economically and reliably used by rehabilitating the obsolete facilities or to be completely replaced by a new system. The scope and methods for the investigation are as follows:

(3) Scope and Methods of Investigation

1) Scope of Work

The scope and the locations of the investigation are shown in Table 2-4 and Fig. 2-21 and 2-22.