various consultants and private companies.

80. Many of these plans focus only on container handling, without paying much attention to other functions of the port such as small crafts, a sand pier and so on. Compared to the following alternatives, more dredging is required in front of the second berth (north berth).

2) Alternative Plan - D2 (see Figure 3-10-2)

81. This alternative is one of the comprehensive plans to comply with all the functions required in 2015 that were analyzed in the previous section. It includes a third container berth for future expansion. New facilities to be constructed are as follows:

- Two (2) consecutive container berths with one (1) for future expansion
- Six (6) berths for tuna boats which mainly use Pier 18 at present
- Two (2) berths for sand barges which use Pier 20 with concession
- Increasing the depth north of Pier 18 for passenger cruiser ships
  (At least one length of ship is assured as the width of slip between Pier 18 and the new container terminal. This new space will be available for future expansion of the activities of small crafts)

82. In this case, all the facilities of PCC, including the pier at Diablo, around the port are assumed to move to the north Corozal for the new port construction. In addition, new marinas such as a ARI marina at Amador will be used for relocated pleasure boats.

83. However, this alternative will be more expensive than the next one, since the dredging volume is larger than the alternative plan - D3.

3) Alternative Plan - D3 (see Figure 3-10-3)

84. This is basically the same as the alternative mentioned above. It allows for the possibility of future expansion of the container terminal at site - Farfan. Therefore this alternative is slightly more economical.

4) Alternative Plan - D4 (see Figure 3-10-4)

85. The components of this plan represent the base minimum in terms of meeting the demand. It allows the width of the slip in front of the north of Pier 18

to be reduced, based on the past performance of ship maneuvering. As a result, it is not always necessary to relocate the PCC pier at Diablo. Only the sand pier 20 should be moved to another place. The space between the PCC pier and the existing public boat club at Diablo could be available. The Diablo Spinning Club with concession by APN is also to be removed.

86. In addition, it is possible to limit the dredging to the ship berthing place just in front of the container terminal in order to start operation as soon as possible and reduce the construction cost. In this case, the berth structure is designed as one with a depth of 14 meters; dredging is carried out to the depth of 13 meters for the time being, and the container vessels call at the terminal with the help of high tide as aforementioned.

87. Concerning tuna boats, only two (2) berths are secured at the south side of the new container terminal in front of Pier No.19. In follows that the port of Vacamonte (or other vacant existing berths) should play an important role in supporting them.

88. This plan is the most economical among those of D2, D3 and D4. According to the latest information of subsoil investigation, however, it is necessary to dredge various types of rock around the quay face line. This will influence the construction cost.

5) Alternative Plan - D5 (see Figure 3-10-5)

89. In this final plan, the quay face line of the container terminal in the plan D5 is rotated southwestward to the line where rock dredging isn't necessary. A turning basin of a diameter of 2L(= 600m) can be secured in this area.

90. New facilities to be constructed are as follows:

- Two (2) consecutive container berths
- Two (2) berths for tuna boats which mainly use Pier 18 at present
  (The port of Vacamonte (or other vacant existing berths) should play an important role in supporting them)
- Two (2) berths for sand barges which use Pier 20 with concession
- Deepening the depth of the north of Pier 18 for passenger cruiser ships

91. Regarding the new container terminal, the space for the future expansion of the yard can be assured behind it without affecting the housing area at Diablo.

Finally, the total area will become 700 meters by 500 meters.

(Note)

92. It is not recommended to fill up two water slips with earth (one surrounded by Pier No. 15, 16, 17 and the south of 18, and the other by the north of 18 and 19) in order to form the new container terminal around there easily. The reasons are as follows:

① Decrease of the pier extension of the port

(a) In case that any of Pier No. 16, 17, 18 and 19 are not available, the port will not be able to serve all the cargoes and/or passengers at the target year. As evaluated in section 3.4 and elsewhere, the future wharf utilization will be rather high. In particular, small crafts (ferries and launches) might not have any place to moor in the absence of Pier 17 and 19.

(b) The launches could be accepted around the pier for PCC launches protected by a breakwater at Naos island of Amador. It also seems to be the most appropriate and the most economical way. However, it requires some investment for a new pier after all. In addition, it would be very difficult to obtain the consent from ARI, which is now developing the whole of Amador as a strategic center of tourism.

(c) As one desirable alternative, the ferries might be integrated at the passenger pier of ARI at Amador. Especially the north part of its joint seems to be appropriate for them. It is protected from waves caused by vessels and/ or the direct wind from the Pacific Ocean. However, it requires some investment and the consent from ARI as well as the aforementioned launches. ARI intends to plan this area for high-class tourists with sophisticated hotels etc., but not for ordinary users.

(d) The amplification of the port of Panama (Mulle Fiscal) could be considered as another alternative for the ferries. Investment in a new quay and a new long permanent channel in the Panama bay is required, which may be seriously affected by siltation.

② Increase of construction cost of the new container terminal

(a) The construction of the new container terminal at existing Pier No. 18 seems

economical at first because the existing berths can be utilized for filling in the slips. In fact, however, the demolishing cost of the shed of Pier 18, etc., will be more expensive than the other alternative proposed in this Study (see Appendix).

(b) In addition, in order to handle conventional cargoes, construction work would have to be performed very carefully, which could result in delays and further expense. In contrast, the construction of the new container terminal at Diablo could be carried out more smoothly because the site is separated from the existing facilities.

(2) Site - Farfan

93. This site has a sufficient potential for port development in the future, and will be developed after Site- Diablo. Therefore, the container terminal will be designed as one with a depth of 15 meters, and the berthing area just in front of the piers will be tentatively dredged to a depth of 14 meters in the same manner adopted in Alternative Plan - 5 of Site - Diablo. It is noted that the existing seaside road is to be shifted to run around the following plan.

94. The representative future plans of this site will be as follows:

1) Alternative Plan - F1 (see Figure 3-10-6)

95. This is the alternative in which the land is reclaimed in the front of the seashore of the site. The dredged earth and sand can be utilized for construction materials. As seen in the figure, however, the maximum number of container berths, including those for future expansion, is 5 - 6 berths. Compared with the next alternative, the potential for future expansion is very limited.

2) Alternative Plan - F2 (see Figure 3-10-7)

96. Different from the above plan, this plan consists of digging into the land. The maximum number of container berths is estimated as more than 9. In addition, the large area around these berths can be utilized for various port-related uses such as an industrial complex.

97. This plan is more desirable than Alternative Plan - F1 from the viewpoint of future expansion. According to the latest information of subsoil investigation, however, it is necessary to dredge rock around the Farfan Beach, which will

influence the construction cost. This applies to F1 as well.

3) Alternative Plan - F3 (see Figure 3-10-8)

98. Different from the aforementioned plans, the container terminal is located a little to the south of the area where rock dredging is required. The quay head line is parallel to the alignment of the Canal. Concerning the future expansion of the yard, the space for it can be assured as with D5 at Diablo.

(3) Site - Amador (see Figure 3-10-9)

99. A new oil terminal will be located in front of the existing Balboa Tank farm at Amador. It consists of one (1) tanker pier and two (2) oil barge piers as aforementioned in the previous section 3.6.

100. The turning basin of 2 L (370m) for the tanker is shifted slightly to the south around the existing Balboa Yacht Club, since the turning basin is not secured between the Canal and the pier. The function of the yacht club should be relocated.

101. In this figure, a cruise ship pier and a recreational marina planned by ARI are also shown. (A jetty type pier for cruise ships is modified as a T-type pier parallel to the Canal here.)

(4) Site - Corozal

102. As aforementioned, PCC plans to gather their functions, which are scattered around the port of Balboa, in the north part of Corozal. The relocation of the function of Pier No.19 will be included.

(5) Rodman (see Figure 3-11-2)

103. The existing facilities of Rodman shall be compensated for in the process of the construction of the new Canal. Alternative facilities will be constructed to the south of the existing facilities. The plan is carried out by digging into the land as shown in the figure. It is also necessary to change the alignment of the Pan-American Highway.

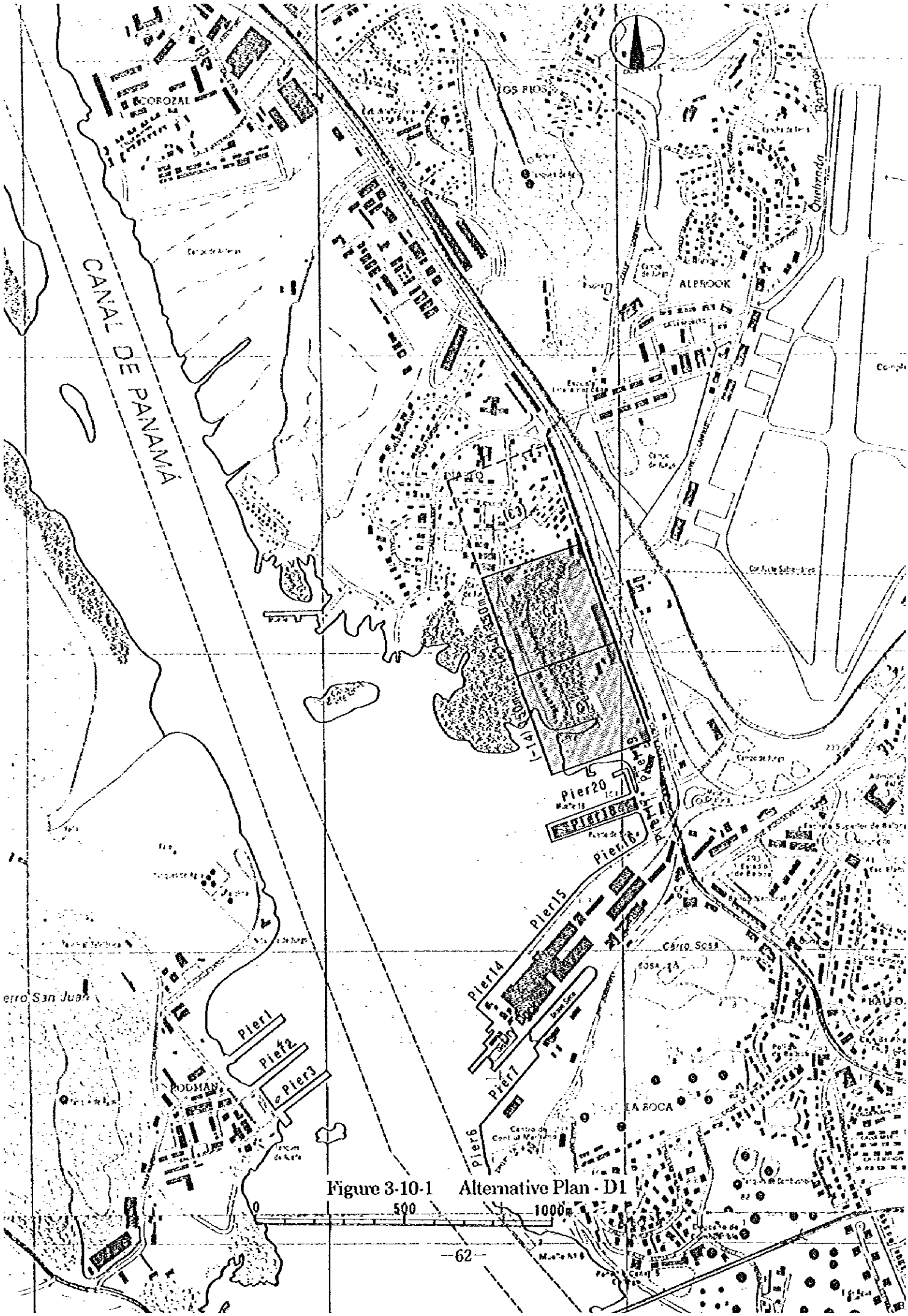


Figure 3-10-1 Alternative Plan - D1

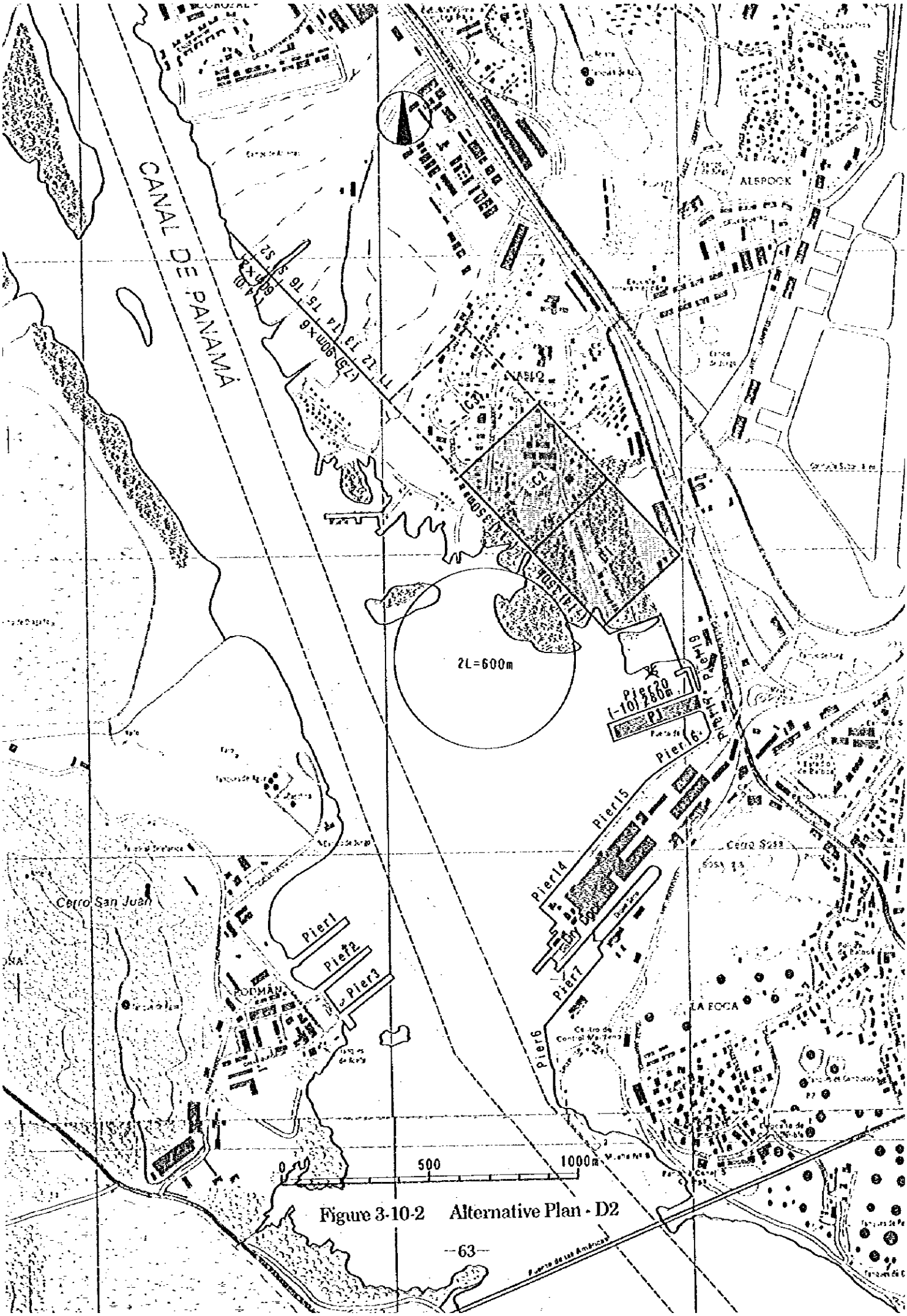


Figure 3-10-2 Alternative Plan - D2

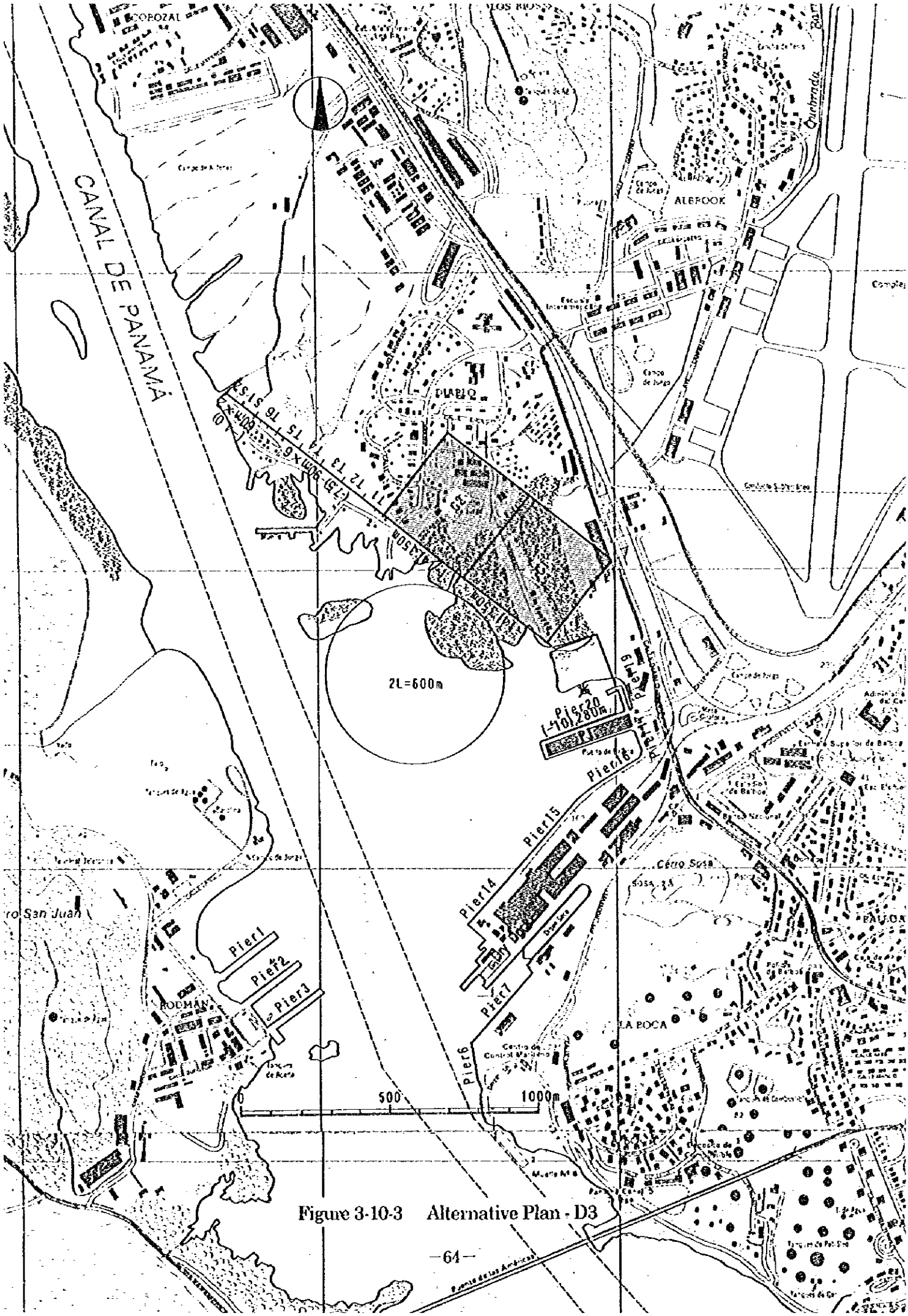


Figure 3-10-3 Alternative Plan - D3

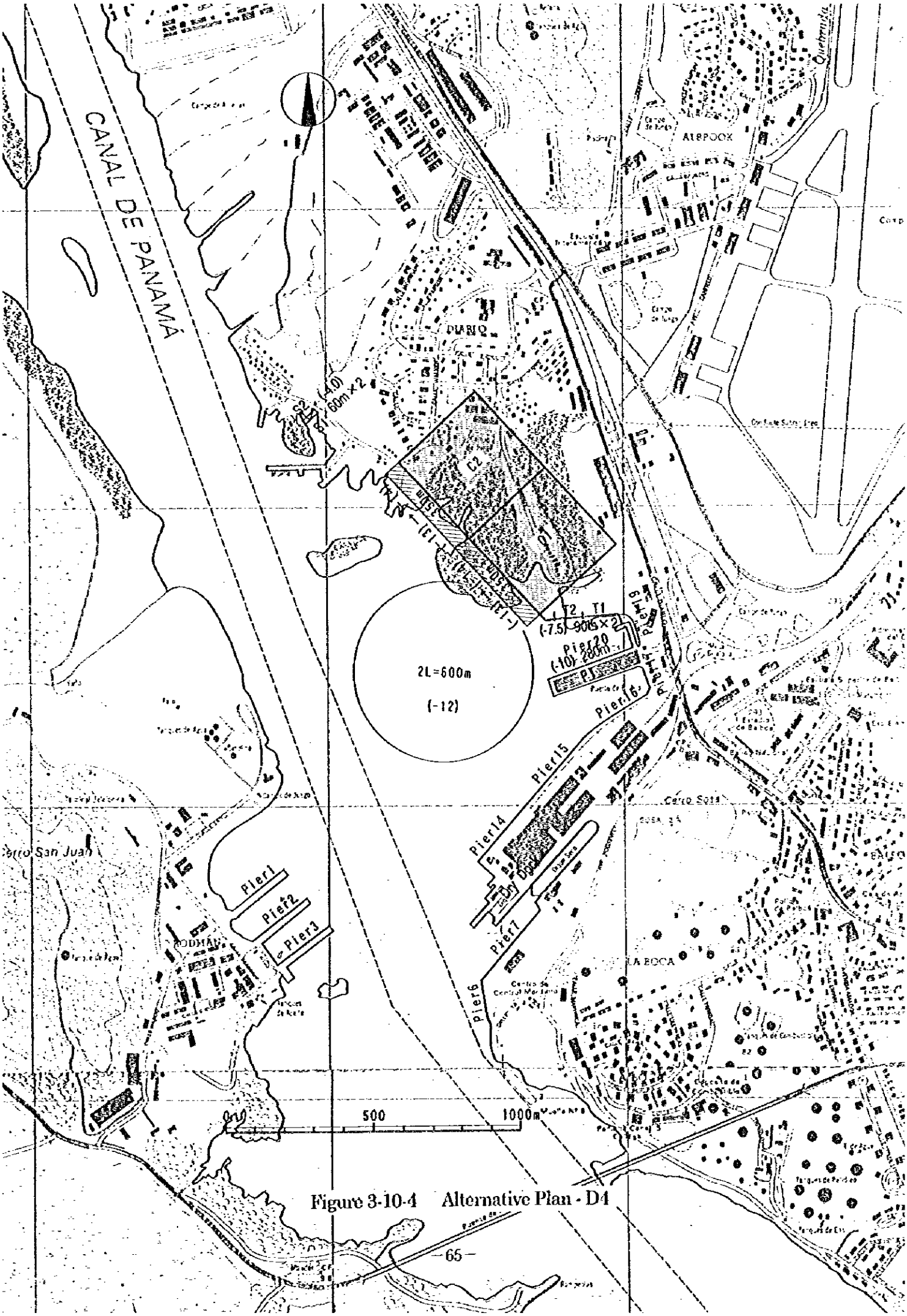


Figure 3-10-4 Alternative Plan - D1

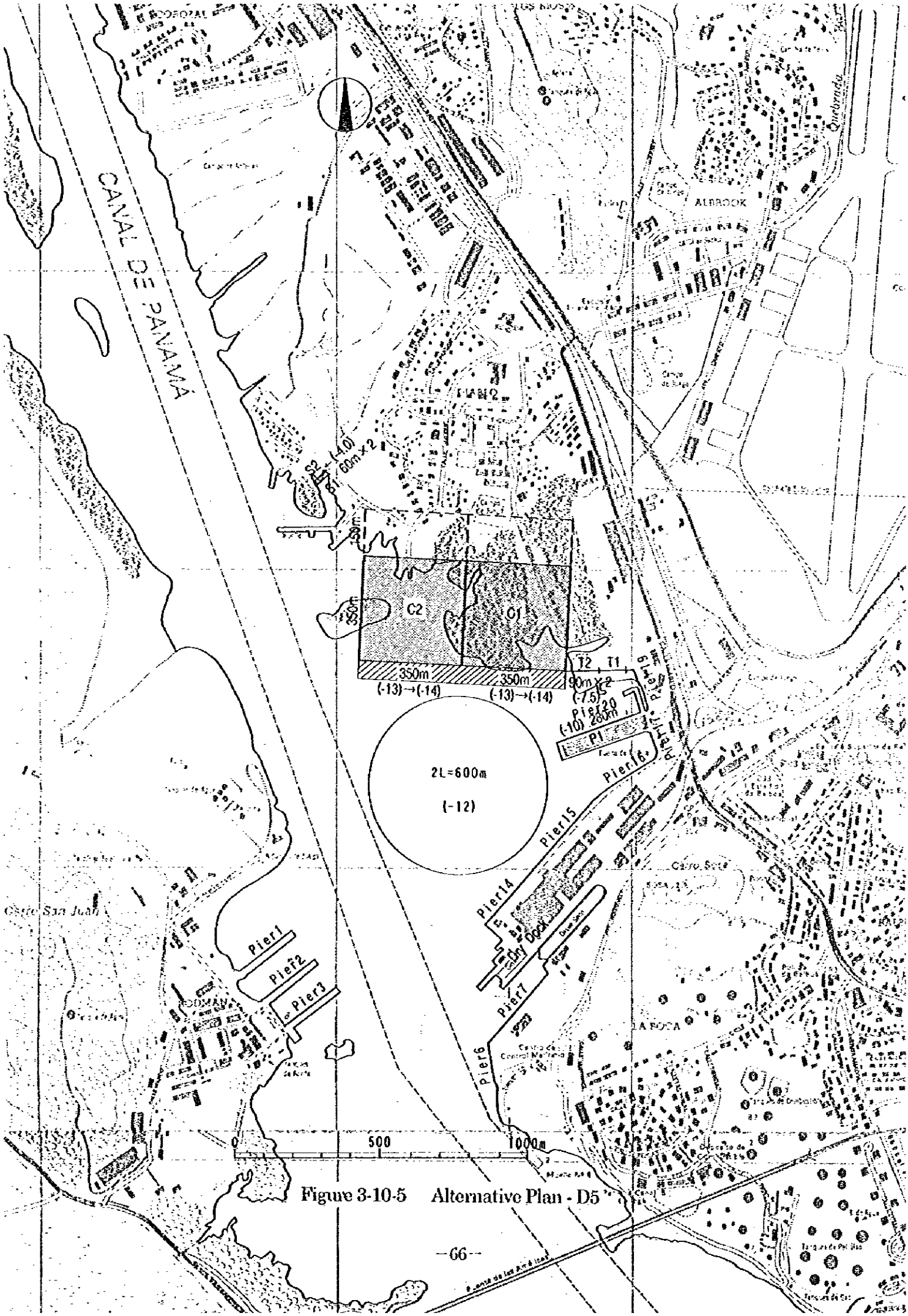


Figure 3-10-5 Alternative Plan - D5

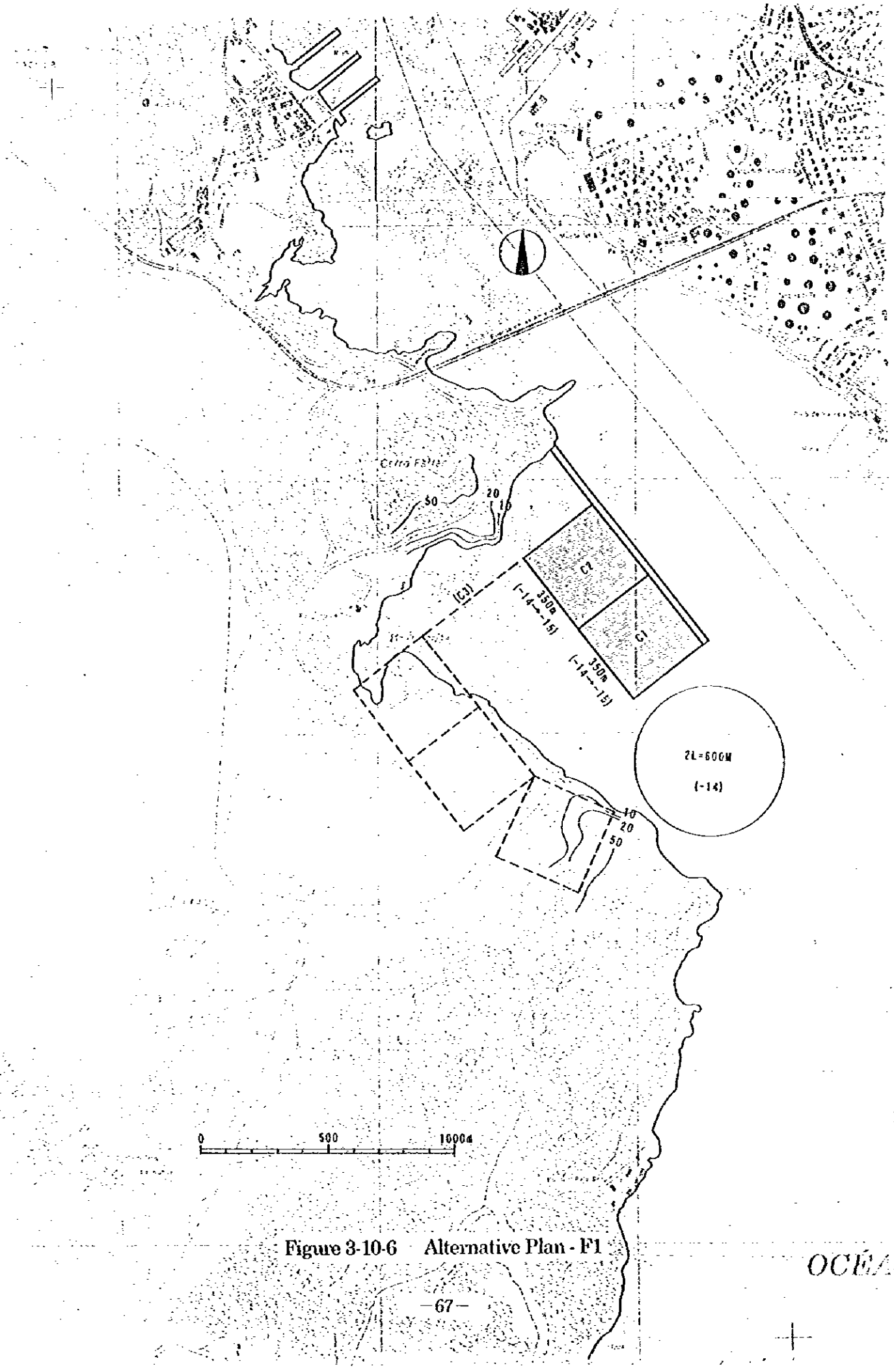


Figure 3-10-6 Alternative Plan - F1

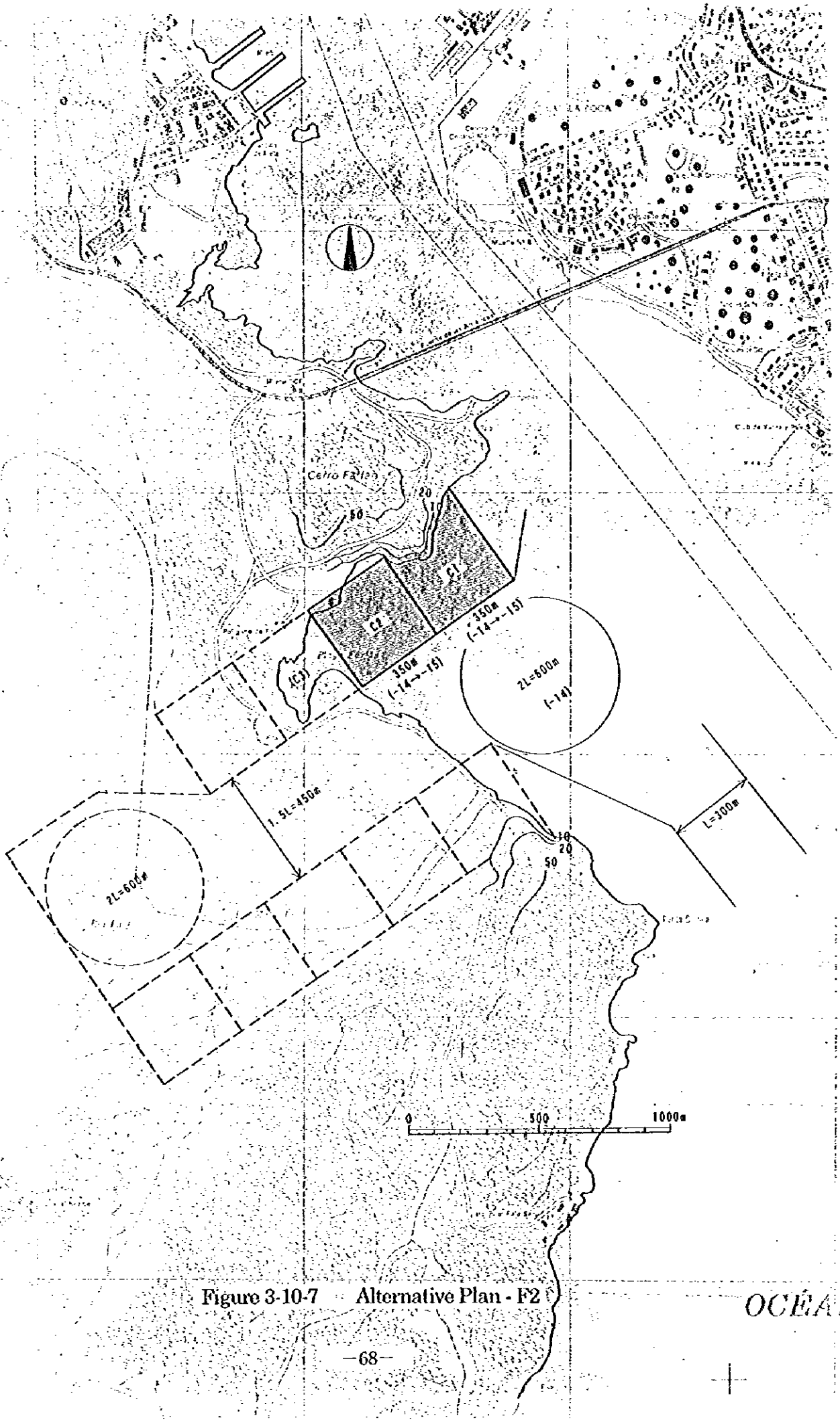


Figure 3-10-7 Alternative Plan - F2

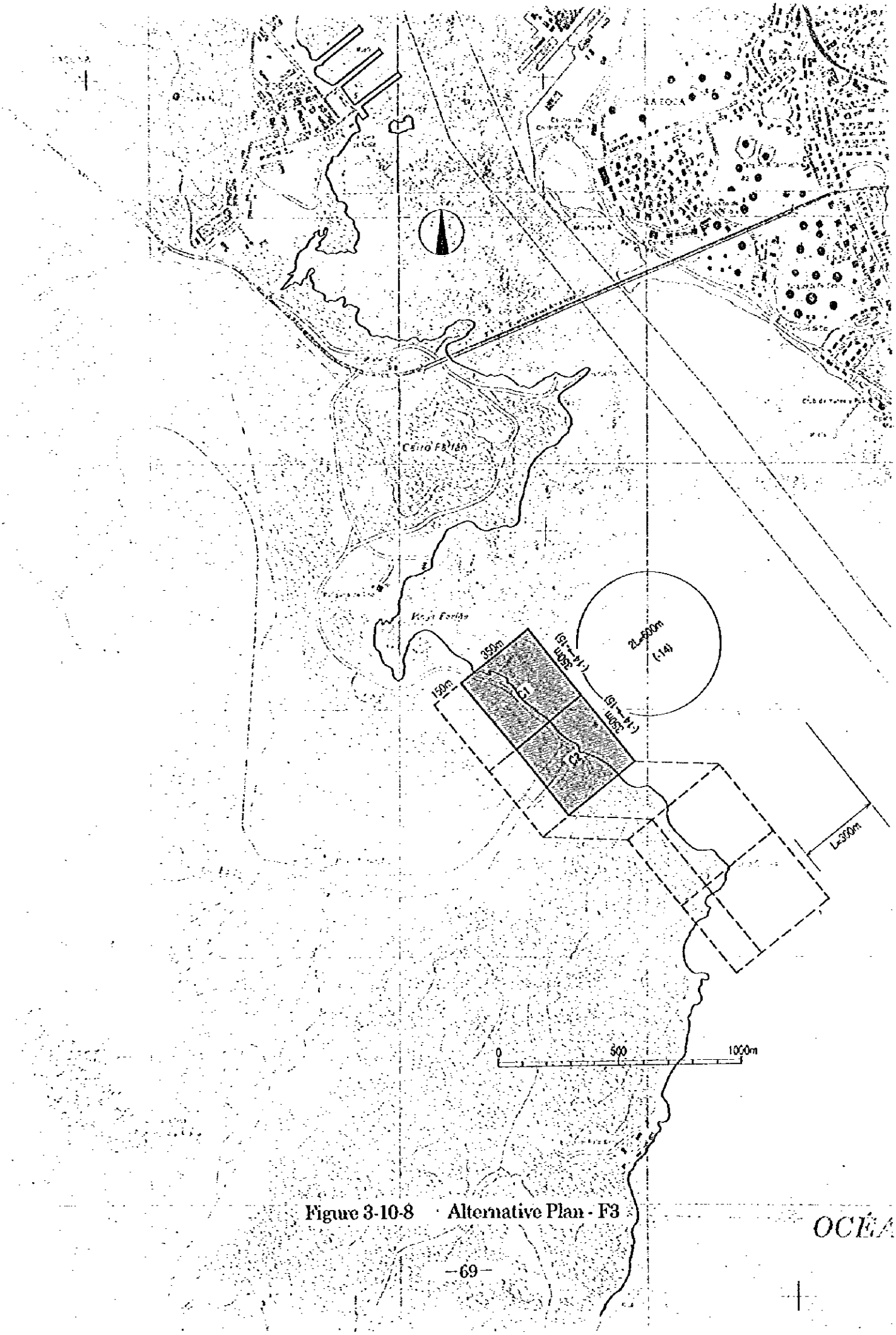


Figure 3-10-8 Alternative Plan - F3

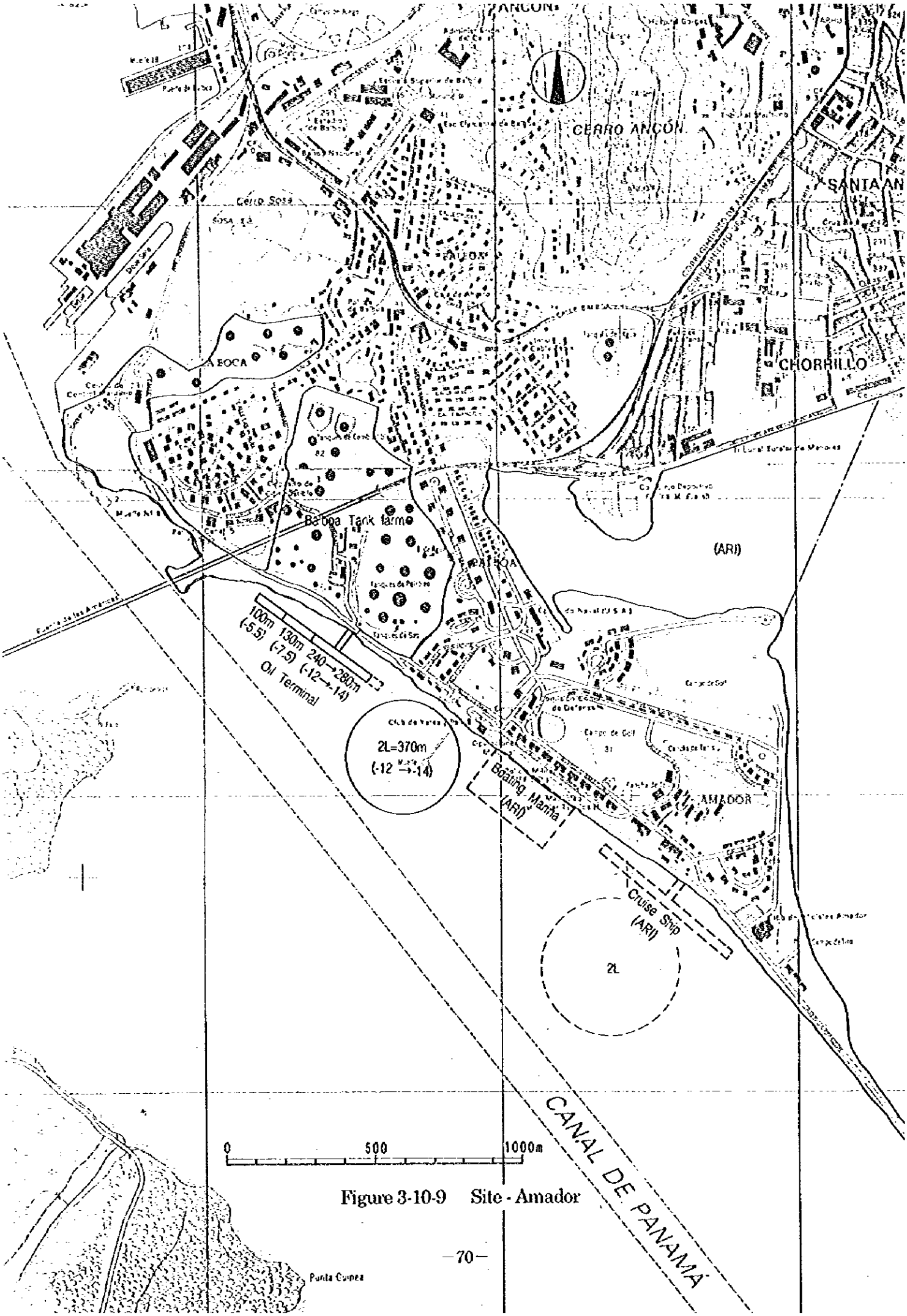


Figure 3-10-9 Site - Amador

3.11 Development of Road Network and Land Use Plan of Surrounding Area

3.11.1 Development of Road Network

104. In order to check the capacity of the road network, port oriented land transportation demand is forecasted. Container cargo transportation demand and other cargo transportation demand are forecasted separately.

(1) Container Cargo Transportation Demand

1) Transportation Demand between Container Terminals and Destination Areas

105. Major container transportation takes place between two container terminals: (1) Balboa and Diablo for 2005 and 2015 and (2) Farfan for 2015, and two major destination areas: (1) Free Zone in Colon and (2) Panama City and its surrounding area.

106. The origin and destination of container cargo through the port of Balboa (medium case) is forecasted as follows;

Table 3-11-1 Origin and Destination of Container Cargo

(thousand TEUs/ year)

Year	1995	2005	2015
Panama Domestic*	23	60	137
Free Zone*	15	26	34
Transshipment	6	352	754
Total	44	437	925

(*) The ratio between Panama Domestic and Free Zone is assumed approximately 6:4 in 1995, 7:3 in 2005, and 8:2 in 2015 based on Table 2-2-11.

107. Cargo flow in unit base is shown as follows based on the assumption that the number of 20 ft containers and 40 ft containers are almost the same.

Table 3-11-2 Container Cargo Flow in Unit Base

(thousand units / year)

Year	2005	2015
Panama Domestic	40	91
Free Zone	17	23
Transshipment	235	503
Total	291	617

2) Transportation Demand of Transshipment Container between Container Terminals

108. Transportation between Diablo and Farfan may take place for transshipment cargo in 2015. In that year, 503,000 units of transshipment containers are handled. (Such transportation is preferable to be reduced as much as possible by adjusting the operation of the terminals and/ or shipping lines.)

109. If berths of embarkation and disembarkation are selected randomly, 1/4 of the transshipment at Diablo or Farfan will be handled at a different berth of embarkation or of disembarkation. On this assumption, 126 (503 × 1/4) 000 units of transshipment containers are transported between these two terminal areas.

(2) General Cargo and Bulk Cargo Transportation

110. The number of laden vehicles which carry port oriented bulk cargo is estimated as shown below. Based on the result of a field survey by JICA (The Feasibility Study on the Improvement of the Panama-Colon Highway, 1993), unit weight carried by one vehicle is assumed as 4.0 for break bulk cargo and 5.0 for solid and liquid bulk cargo. This traffic mainly takes place between Panama City and the port of Balboa (existing Balboa).

Table 3-11-3 Traffic Number of Laden Vehicle

Cargo Type	Break Bulk		Other Bulk	
Target Year	2005	2015	2005	2015
Total Cargo Volume (thousand ton/year)	95	185	839	1492
Unit Weight (ton/vehicle)	4.0	4.0	5.0	5.0
Number of Laden Vehicle (thousand/year)	24	46	168	298

(3) Port Oriented Traffic Volume and Development of Road Network

111. Road traffic volume related to the container transportation is estimated here. All containers are assumed to be transported by one unit on chassis pulled by a tractor. In order to convert the number of containers to the traffic volume, the ratio of laden trailer and the ratio of related vehicle induced by container transportation are assumed as 0.5. Consequently, the ratio between traffic volume and the number of containers transported is;

$$(1+0.5)/0.5=3$$

112. Annual traffic volume is shown below;

Table 3-11-4 Annual Traffic Volume

(thousand vehicles / year)

Year	2005	2015
Panama Domestic	119	274
Free Zone	51	68
Total	170	342

113. The above traffic caused by container transportation will be allotted to Diablo terminal and Farfan terminal.

114. Traffic volume of transshipment containers between two terminal areas is calculated as 378 (126× 3) 000 for the Long Term Plan.

115. Traffic volume for bulk cargo to and from Panama City Area is 576 (192 × 3) thousand vehicles/year in 2005 and 1032 (344 × 3) thousand vehicles in 2015.

116. In order to check the capacity of each road section, annual traffic volumes shown above are converted to design hourly traffic volume. Parameters are assumed as follows;

Annual traffic days	350	days/year
Traffic hours	8	hours/day
Daily peak ratio	1.3	
Hourly peak ratio	1.4	

117. Design traffic volume related to the port activities for each segment of the road network around the port is as follows:

Table 3-11-5 Design Traffic Volume for Each Segment of the Road Network

(Vehicles/ hour)

Short term (2005)	484
Diablo - Panama Domestic	77
Diablo - Free Zone	33
Existing Balboa - Panama City Area	374
Long Term (2015)	1139
Diablo/ Farfan - Panama Domestic	178
Diablo/ Farfan - Free Zone	44
Transship (Diablo - Farfan)	246
Existing Balboa - Panama City Area	671

118. The maximum traffic volume around the port is approximately 500 vehicles/hour in 2005 and 1150 vehicles/hour in 2015. This traffic volume will affect the traffic condition, which is under congestion even now, and expansion of the capacity is urgently needed. In addition, major trunk lines around the port area should have at least four lanes and crossings, corner curves and road alignments need to be improved. New road area for widening should be reserved including expansion space.

119. The traffic volume between Diablo and Farfan terminals is around 250 vehicles/hour in the Long Term Stage. On the current road network, this traffic and part of the traffic from/ to Panama domestic and Free Zone flow into the American Bridge mix with the general traffic. Since this traffic may cause congestion on the bridge, it is necessary to strengthen the bridge or to secure a by-pass route.

120. (It is also desirable to strengthen the road network to/ from the international airport of Tocumen from the viewpoint of development of inter-modal transportation in the future.)

121. Transship cargo transportation between the port of Balboa and the ports of Cristobal by road or railroad is expected. In this regard, much higher priority should be put on the early completion of the Panama-Colon Superhighway and North Corridor and the arrangement of direct access to them. The railroad station

and related facilities should be appropriately separated from the road network around the port to prevent traffic jams at railroad crossings.

3.11.2. Land Use Plan of Surrounding Area

122. The function of port is fulfilled in combination with the road network system and surrounding area. Port development must be in good coordination with the land use of the surrounding area. In order to promote land use of surrounding area in line with the port development policy, the port management body shall have basic policy of land use and administrate the area closely related to port activity.

123. Here, a land use plan of surrounding area of existing port facilities at Balboa and new container terminal at Diablo and Farfan is studied. This plan is not necessarily based on the detailed demand forecast for future land use, if it is basically for the Long Term Plan (or Post Master Plan) Stage. Preliminary recommendation of land use plan of surrounding area is shown in Figure 3-11-1 and 3-11-2. These figures also show the road network studied in the previous section.

124. The major issue on land use is explained as follows.

(1) Surrounding Area of the Existing Port

125. As an urgent program for cargo handling, some container yard space will be necessary. The details will be explained in Chapter IV.

126. Around Pier No. 19, a parking area will be necessary mainly for passenger use. In addition, ticket windows, waiting rooms, and administration offices for passenger should be concentrated and integrated there in order to separate passenger flow from cargo flow.

127. The south part of alignment of the existing Gaillard Highway is planned to be moved slightly to the north by Ministry of Public Works. The existing Paitilla airport will be relocated to the north part of the new Gaillard Highway.

128. To the south area neighboring the existing port will be utilized for port activities. At present, private companies have automobile and container storage yards at a portion of this area. Land use here might be limited by the restricted surfaces of the airport especially around the extension line of the runway.

Therefore, it seems to be appropriate to put automobiles (compact and mobile) in such an area. The other space can be also utilized for various purposes according to need.

(Note)

129. The necessary storage area for automobile is estimated simply as below;

① In 1995, around 20 thousand metric tons of break bulk cargoes was imported by Ro-Ro vessel. Here, all of them are assumed to be automobiles. If unit weight of 1.45 metric ton is employed, the number of vehicles is estimated at around 14,000.

② The area of around 7 ha between the existing Gaillard Highway and the old Albrook Airport is mainly utilized for storage of vehicles. Supposing that average required stocking area for one passenger car is around 20 ㎡, the capacity of the area is estimated at 3,500 vehicles.

③ Accordingly, 0.35 ha of stock yard is necessary for one thousand metric tons of automobiles handled at the port. That is, 14 - 18 ha for 40 - 51.5 thousand tons is required in 2005, and 23 - 34 ha is for 64.5 - 97 thousand tons. Therefore, a sufficient area must be secured around the existing port.

(2) Surrounding Area of New Container Terminal at Diablo

130. According to the increase of container cargo handling, shipping and trading activity will be concentrated in this area. It is recommended to reserve sufficient space in the back the terminals.

131. Many offices of port related business and industry, including administration offices, are located in the city at present. However, they may move to Diablo through the shift of port function from the existing area. The head quarters of APN has already been moved here. In addition, the scale of these functions increases according to the scale and number of container terminals. The details will be explained in Chapter V.

132. Railway is planned to be introduced as a land bridge between the new container terminal and those on the Caribbean side. It is not recommended to keep the related area inside of the container terminal, since it might affect the terminal operation as aforementioned. The intermodal container transfer facility

of the railroad will be located at the area to the northeast of the terminals. The roads behind the terminal should not be cut off by the railroad activities. Only an access line for passenger terminal is allowed.

133. As to residents at current Diablo housing area, many other residential areas developed by PCC or the US Forces will be available after their reversion to Panama. Therefore, there is no need to secure a new residential area.

(3) Surrounding Area of New Container Terminal at Farfan

134. Since Farfan is almost virgin area, the entire development project should be conducted in a well organized manner. It is recommended to elaborate a total development plan of this area. In order to make future container terminal activities smooth and effective, surrounding area shall be reserved for related activities like cargo handling, land transportation, storage, trade and industrial complex.

135. Construction of a new road network is indispensable for the development of Farfan. New container terminals will be accessed from the Pan-American Highway. Some part of the existing road along the Farfan waterfront should be converted to an access road to the terminal.

136. Besides these areas, northern half of Farfan should be reserved for possible future expansion of port related functions.

137. As is applied to every area, a sufficient green park should be assured for environmental preservation and amusement. It is recommended to allot more than 20 % of the total area as a green park.

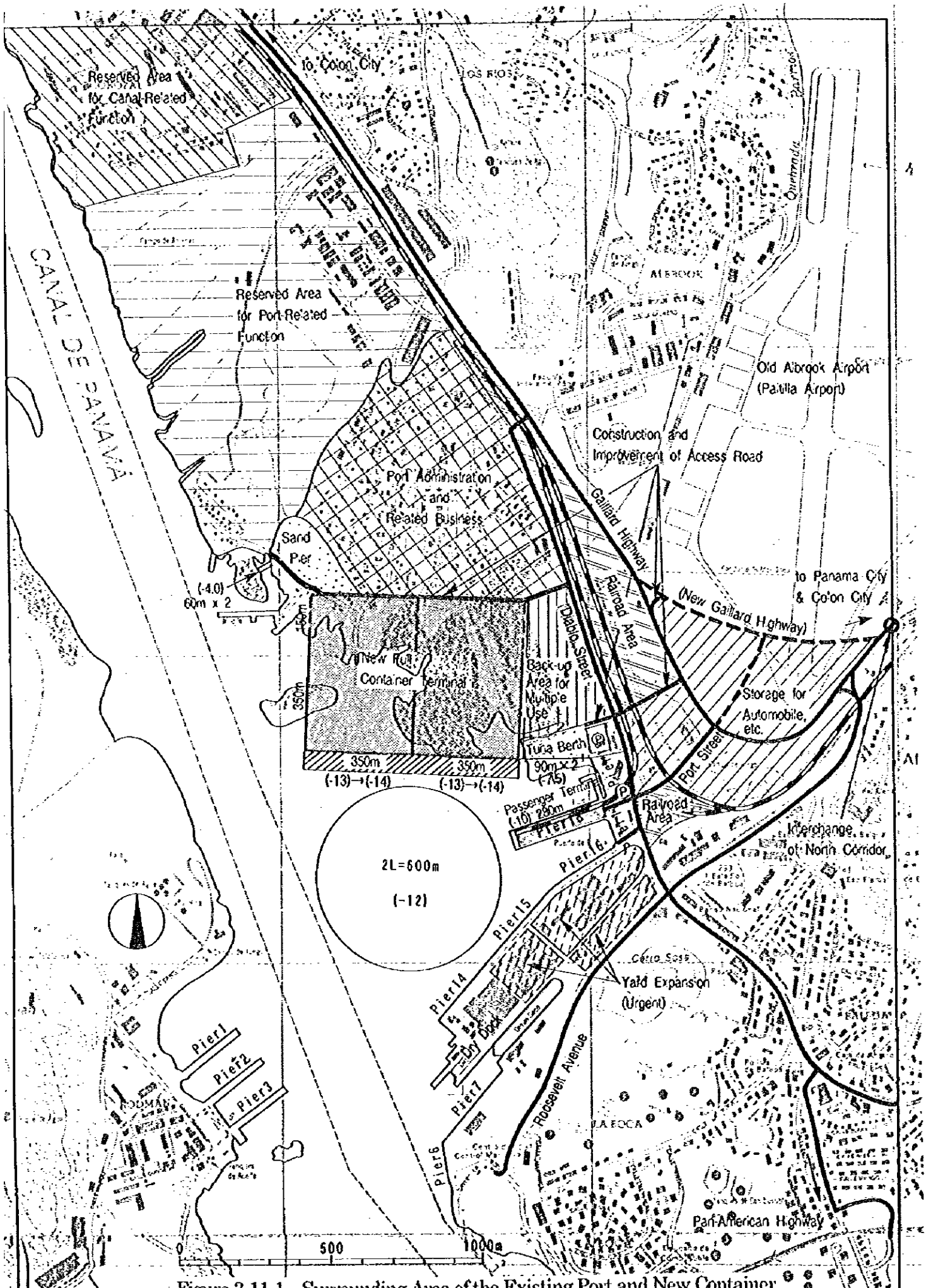


Figure 3-11-1 Surrounding Area of the Existing Port and New Container Terminal at Diablo

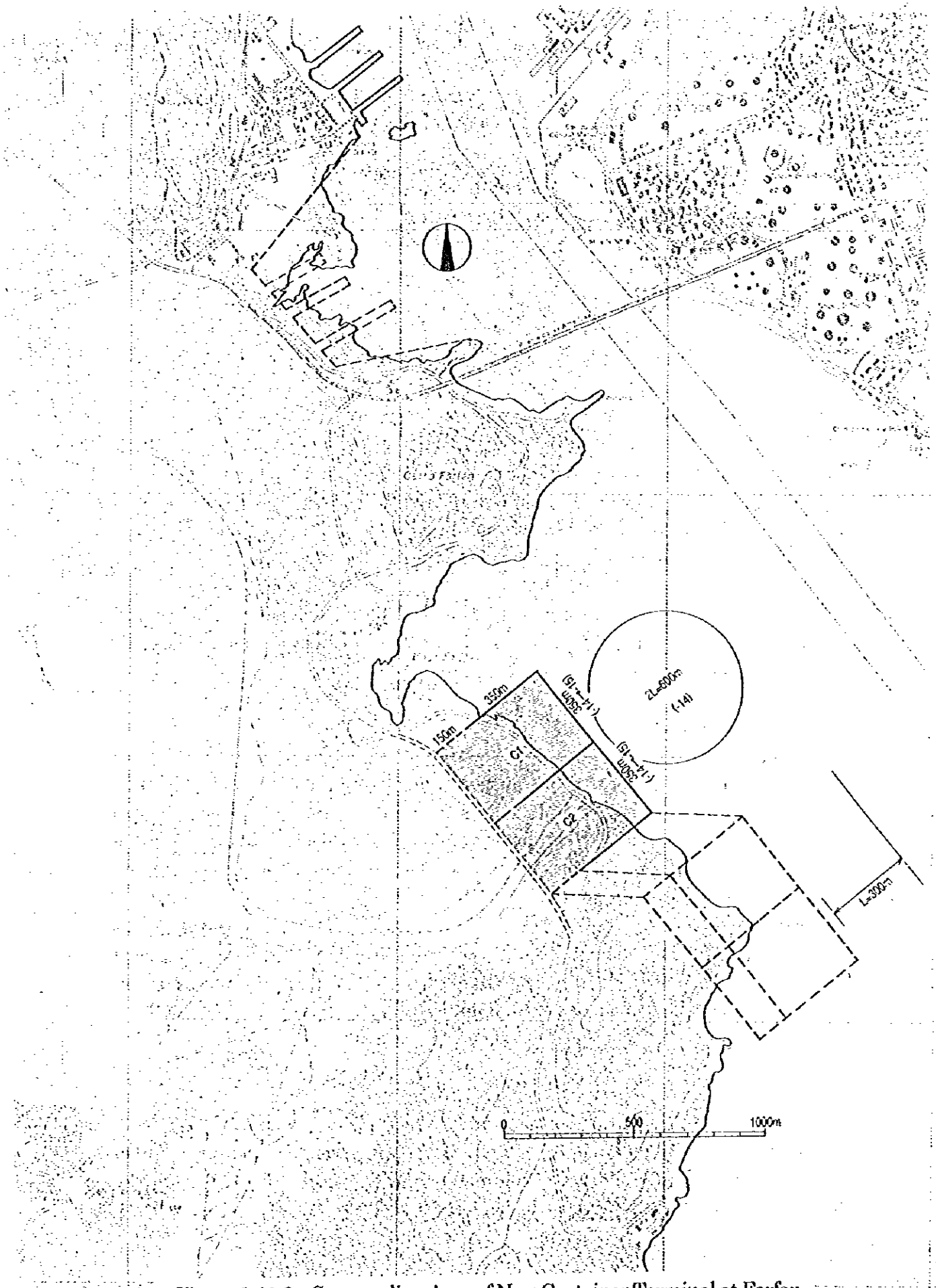


Figure 3-11-2 Surrounding Area of New Container Terminal at Farfan

IV CONTAINER TERMINAL OPERATION SYSTEM

4.1 Ideal Lay-out of Container Terminal

4.1.1 Facilities in the container terminal

(1) Container Yard

1. The container terminal requires extensive space for marshaling the containers. A space for storing empty containers which are to be sent back to shippers for the next shipment is also required.

2. The total container stacking capacity of the container yard depends on not only the space of the yard but is also related to the handling equipment and possible stacking height. Also, annual handling capacity depends not only stacking capacity but also container dwelling time.

3. Container handling equipment moves along fixed routes in the yard in accordance with predetermined procedures. Pavement of container yard can be designed to match the handling system.

(2) Container Freight Station

4. Even though door to door transportation by containers is an ideal method of transportation, with respect to LCL (less than container load), it is necessary to collect it at a specific point, to sort by destination and to stuff in containers in the case of export, or to unstuff consolidated cargo out of containers and to sort and classify it before delivery to consignees in the case of import.

5. Usually, a bay for trucks and a bay for containers are provided on each side of the building with the building sandwiched in between. Both bay are laid out symmetrically for convenience of handling work.

(3) Gate

6. The gate is a facility for performing the works of transfer of documents required when containers move in and out of the terminal, measurement of weight of containers, provision of command from terminal office regarding the locations where the containers are to be placed and check of container bodies.

7. As close communication should be maintained between gate booths and terminal office, the terminal office is normally built near the gate.

(4) Maintenance Shop

8. The maintenance shop is a building where maintenance, inspection and repair works of container handling equipment used in the container terminal, as well as of containers, are carried out. This is because much of the container handling equipment used in the terminal is of a large size and not allowed to travel on public roads. Also, from the standpoint of improving handling efficiency, the maintenance shop is a facility that is indispensable for a container terminal.

(5) Terminal Office

9. Terminal office is the building that accommodates the administration department providing pivot functions such as collection of information for efficiency and centrally managing the container terminal, acceptance and delivery of containers, preparation of stowage plans and yard location plans, commanding of execution of work and control of containers and of container handling equipment.

10. The terminal office is generally located near the entrance of the terminal where a good view of the entire yard can be obtained and close communication with the gate should be maintained.

4.1.2 Improvement of Pier 14, 15 and 16 (Urgent Plan)

11. Pier 14, 15 and 16 are being converted to a container terminal for temporary use until the new container terminal at Diablo becomes available. To this end, the old railway yard and expendable APN buildings behind the Pier 15 and 16 will be removed to provide yard space and two container cranes will be installed.

12. As a large investment will be required for the full scale container terminal at Diablo, the budget for the improvement plan at Pier 14, 15 and 16 should not be excessive. However, it should be sufficient for these piers to serve as a hub port to and from Central and South American feeder ports. This will be done when the Port is able to invite mother container-ships and feeder containers to the Port.

4.1.3 Full Scale Container Terminal at Diablo (Urgent Plan/Short Term Plan)

13. A full scale container terminal will be constructed at Diablo district adjacent to the Pier 18. The Diablo Container Terminal will have 700 meters quay wall with yard space of 350 meters.

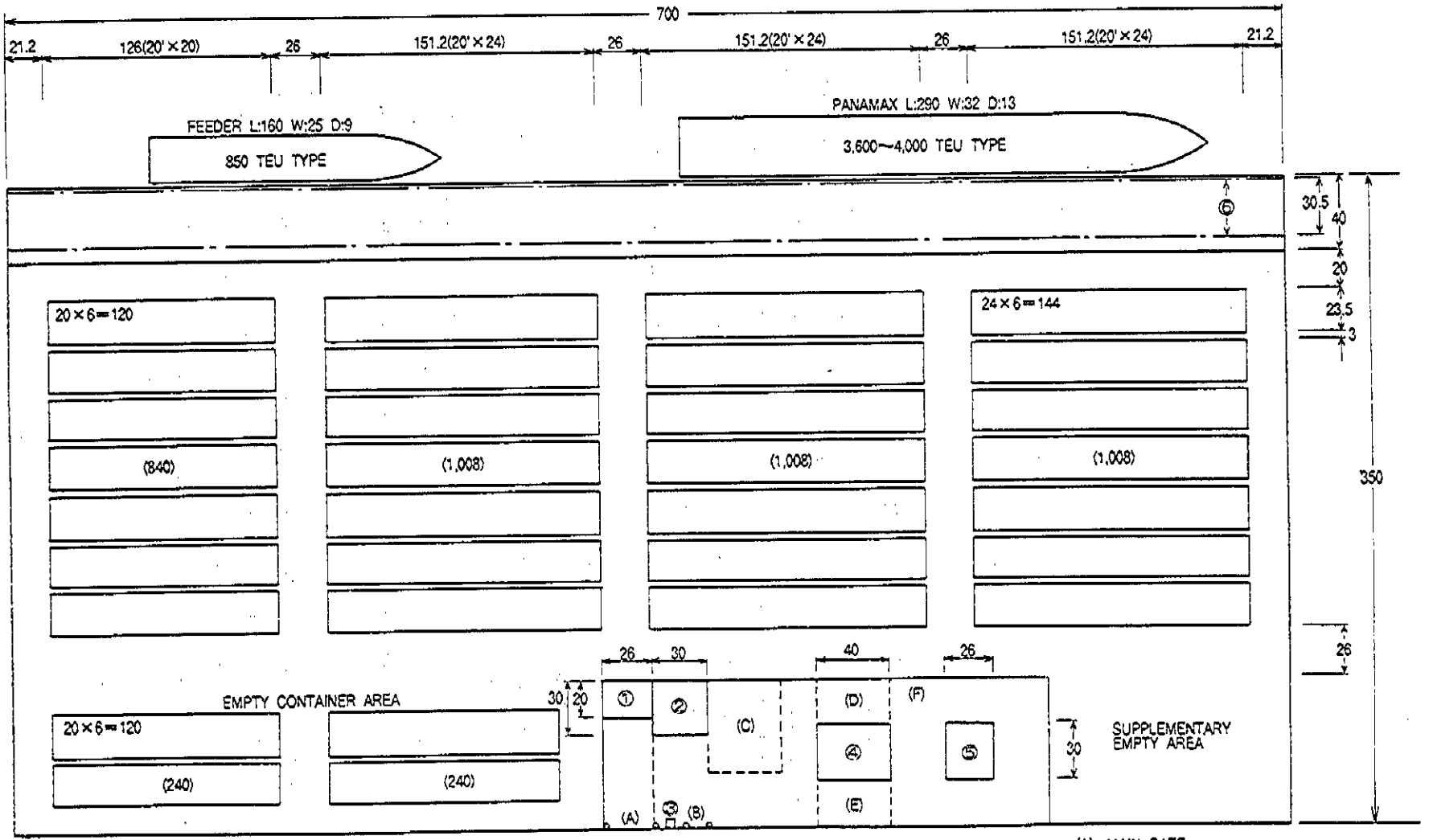
14. A preliminary lay-out of the terminal is shown in Figure 4-1-1. From this lay-out, we note that the maximum stowing capacity will be 4,344 TEU ground slots including empty container area when transfer crane operation will be employed. Though the three layers stack is possible for empty container, export container and transshipment container areas, supposing that an average stacking layers might be 2.5 (Import 2 layers / Export 3 layers), maximum stacking capacity will be 10,860 TEU.

15. Based on the above maximum stacking capacity (except empty container area) and depending on working days per year, average dwelling time (days) in the terminal, ratio of transship container and peak ratio, possible annual throughputs could be 620,000 TEUs based on the following formula :

$$My = Mi \times Dy / (Dt \times p)$$

where ;			(assumed number)
My	:	possible annual throughputs (TEUs)	
Mi	:	storage capacity (TEUs)	10,380
Dy	:	working days per year	350
Dt	:	average dwelling time	4.5
p	:	peak ratio	1.3

$$My = 10,380 \times 350 / (4.5 \times 1.3)$$
$$= 621,026$$



① GATE COMPLEX
② TERMINAL OFFICE
③ GATE BOOTH
④ CFS SHED
⑤ MAINTENANCE SHOP
⑥ CRANE RAIL

(A) MAIN GATE
(B) STAFF AND CFS GATE
(C) STAFF PARKING
(D) CFS (CONTAINER SIDE)
(E) CFS (TRUCK SIDE)
(F) MAINTENANCE AREA

Figure 4-1-1 Preliminary Lay-out of the Diablo Container Terminal (Transfer Crane System)

4.2 Selection of Container Handling Equipment

4.2.1 Container Handling Equipment

16. There are three basic systems in use today ; the Transfer Crane System, the Straddle Carrier System and the Chassis System. Advantages and disadvantages of each system are shown below.

(1) Transfer Crane System

17. In this system, a traveling type transfer crane is used for stacking a multiple layer in the container yard. And trailers are used for moving containers between the container crane and the transfer crane, and for transporting containers within the terminal.

18. The advantages of this system are :

a) Since multiple number of containers can be stacked, the container yard area can be used more efficiently than with other systems. Straddle carrier requires a gap of as much as one meter between the two rows of stored containers to allow for movement of the carrier but there is no need for a gap in the case of the transfer crane system, and consequently there is a high land use efficiency rate.

b) The transfer crane is a technically stabilized machine with low maintenance cost.

19. Disadvantages of this system are :

a) Just as in the case of straddle carrier system, it is troublesome to move a lower layer of multiple stacked containers.

b) The wheel load of the transfer crane is increased excessively and it requires the most heavy duty pavement. However, since the traveling route is limited, heavy duty pavement is needed only for the specified area.

20. Most of the existing transfer cranes have an effective span of 23.4 meters, eight wheels with rubber tires in the traveling device and are powered by a diesel engine generator unit. One lane for truck passage is provided between both legs at the center or on either side, and six files of container can be stored.

(2) Straddle Carrier System

21. In this system, only a straddle carrier is used as container handling equipment. The straddle carrier is used for container handling operations such as loading and unloading containers at the apron, storing and marshaling containers in the container yard and receiving and delivering containers to the truck of the customers, consignee or consignor.

22. The advantages of this system are :

a) It is very flexible in coping with changes in yard allocation and quantity of container. Storage and marshaling can be done freely in conformity with the flow of daily operations in the terminal.

b) Quick dispatching of containers is possible and, therefore, spot receiving or delivery of containers can be performed easily.

c) Since containers can be stacked in multiple layers, the container yard area can be used efficiently.

23. However, the system also has the following disadvantages :

a) Since the wheel load is very heavy, the container terminal requires a thick pavement.

b) Since the straddle carrier is an industrial vehicle which requires precision operation, special operating skills are necessary and considerable time and cost are required for maintenance.

(3) Chassis System

24. This system is suitable where containers are delivered or received with attachment of carrier's chassis. However, other than North America, since containers are delivered or received with customer's tractor without attachment of carrier's chassis, this system is not suitable.

(4) Other System/Equipment

25. Where the annual container handling volume is comparatively small (30,000~35,000 TEU) and there is enough passage space to allow for movement of container stacker, Stacker Operation using Reach-stacker, Top-lifter, Side-loader or Heavy Duty Forklift is possible with smaller initial investment and cheaper operation cost.

26. Comparison of two systems is shown in Table 4-2-1.

Table 4-2-1 Comparison of Systems

System	Straddle Carrier	Transfer Crane
Storage Capacity	○	◎
Expandability	○	△
Initial Cost	○	△
Maintenance Cost	△	◎
Heavy Pavement	○	○
System Simplicity	○	△
Mobility of Operation	○	△
Flexibility of Operation	○	△
Safe Operation	△	○
Container Damage	△	○

◎ : Excellent ○ : Good △ : Inferior

4.2.2 Selection of Container Handling Equipment at Pier 15 and 16

27. At present, we can not refer to Pier 14, 15 and 16 as a container terminal because of the following reasons.

a) No container crane is equipped.
b) No container yard is allocated immediately behind the apron. Container storage yard is dispersed and far away from the pier.
c) Most of the ships coming to the Port are non-cellular conventional type and very few are self-sustained container-ship.
d) Container loading and unloading is quite similar to the bulky cargo handling with ship's gear, so that, hooking and unhooking of slings on the corner fittings of the container is carried out manually.

Therefore, efficiency of container handling is extremely low.

28. In this port, because of a tremendous differential in the tide levels (six meters in the spring tide), full swing of the conventional type ship's crane is restricted at low tide. The arm of the ship's derrick sometimes hits the edge of the wharf.

29. From this point of view, conventional type ships should be replaced by container vessels earliest possible, however, because there are so many less equipped ports along the West coast of Central and South America, container transportation using conventional type ship will remain in the foreseeable future.

30. Under the above conditions, if the Transfer Crane System is selected by the concessionaire, though it is being widely adopted throughout the world, difficulty in container handling will remain.

31. In the Transfer Crane System, yard tractor/chassis plays the important role of carrying containers between quay-side container crane and transfer crane in the yard. Spotting of the spreader onto the container or of the container onto the yard-chassis is very easy when containers are handled with the proper quay crane or bridge-type ship-crane. However, in this case, so many non-cellular conventional ships are involved and containers on these ships are usually handled with conventional type ship's heavy crane. In this case, because of the sway and twist of containers caused by use of such non-standardized container crane, spotting is very difficult, time consuming and sometimes causes accidents.

32. In contrast to the Transfer Crane System, in the Straddle Carrier System, yard tractor/chassis is not involved and the straddle carrier always picks up containers, which are lain on the ground standing still with whatever type of heavy crane, directly from the ground.

33. If type of ship remains the same for the time being, the Straddle Carrier System would be a better choice for the Port, however, selection of the equipment is not limited to the operation at Pier 14, 15 and 16 but the system might be transferred to a new container terminal at Diablo.

34. However, use of Pier 15 and 16 as a container terminal is merely a short term relief without developing the entire land behind Pier 15 and 16. To minimize investment, existing heavy lifting equipment can be used for temporary container handling, though the container stacking capacity will be extremely limited.

4.2.3 Selection of Container Handling Equipment at Diablo

35. Though some difficulty mentioned above will remain, from the long term view point, the Transfer Crane System will be the best choice.

4.3 Number of Container Handling Equipment Required at Diablo

(1) Container Crane

36. The required number of container crane is calculated using the following formula :

$$Nc = My / (Ec \times O \times H \times Dy \times (1 + rf) \times (1 - rb))$$

where ;

			(assumed number)
Nc	:	number of container crane required	
My	:	annual container throughputs (TEUs)	450,000
Ec	:	handling productivity of crane per hour	25
O	:	berth occupancy rate	0.7
H	:	working hours per day	16
Dy	:	working days per year	350
rf	:	ratio of 40 footer	0.5
rb	:	ratio of breakdown	0.1

$$Nc = 450,000 / (25 \times 0.7 \times 16 \times 350 \times (1 + 0.5) \times (1 - 0.1))$$
$$= 450,000 / 132,300$$
$$= 3.40 = 4 \text{ units}$$

(2) Transfer Crane

37. The same calculation formula as above could be applied for required number of transfer crane (Hv) except for handling productivity (assumed 20 because of often lane change).

$$Hv = 450,000 / (20 \times 0.7 \times 16 \times 350 \times (1 + 0.5) \times (1 - 0.1))$$
$$= 450,000 / 105,840$$
$$= 4.25 = 5 \text{ unit} + 1(*) = 6 \text{ units}$$

(*) minimum of one (1) unit should be added for receiving and delivery of containers.

(3) Yard Tractor and Chassis

38. It depends on the distance between center of the apron and the deepest corner of the stacking yard but, in general, four (4) sets of tractor/chassis are required for one (1) container crane. Breakdown ratio should also be considered. In addition, reasonable number of chassis for CFS parking is required.

(4) Stacker/Lifter

39. For the time being, until the life span of these stacker/lifters now being used at Pier 14 and 15 expires or empty container storage area becomes insufficient, these stacker/lifters can be used to handle empty containers at the new terminal.

V LAND USE PLAN OF SURROUNDING AREAS OF THE PORT

5.1 Export Processing Zone (EPZ)

5.1.1 Effect on Development

1 In order to promote national and regional economy, many developing countries have set up EPZs within their territory. Table 5-1-1 shows the fundamental data of EPZs of Honduras, El Salvador and the Dominican Republic in 1994, and Table 5-1-2 shows the data of Barranquilla EPZ, Colombia.

Table 5-1-1 Fundamental Data of EPZs of Neighboring Countries (1994)

Country	Export (million $)	Foreign Income (million $)	Number of EPZs	Operating companies	Employees	Domestic capital(%)
Honduras	647	97	12	122	42,511	30
El Salvador	431	108	4	35	n.a.	70
Dominican Republic	1,531	450	31	476	176,311	30

Source: Government statistics

Table 5-1-2 Data of Barranquilla EPZ, Colombia (as of August 1996)

Item	Description
Name of EPZ	Zona Franca de Barranquilla
Establishment	1958 (operation in 1961)
Administration	Zona Franca Industrial de Bienes y Servicios de Barranquilla S.A.
Area	180 ha (100 ha in operation next to the port, and 80 ha for construction next to the airport)
No. of companies	65 (industry, commerce and service)
No. of employees	7,270
Cargo Volume and Value (1995) (unit: ton & 1,000US$)	·Volume 452,407 (Import 203,618 Export 248,789) ·Value 1,202,993 (Import 425,651 Export 777,342)

Source: Zona Franca Industrial de Bienes y Servicios de Barranquilla S.A.

2. As shown in the above Table 5-1-1 and Table 5-1-2, the EPZs have contributed especially to foreign currency income and employment. In case of the Dominican Republic, for example, the foreign currency income through the EPZs has compensated a deficit of merchandise trade, together with the tourism income, while the size of labor force thereof has swollen to 176,311. Barranquilla EPZ, Colombia ,as shown in Table 5-1-2 , handled a total cargo volume of 452,407t in 1995, which corresponds to 63.3% of the total cargo volume handled by the Port of Balboa in '95 (714,501t), and the share of the import volume by sea was 85.2% (source: Barranquilla EPZ).

5.1.2 Institutional Scheme of EPZs in Panama and Andean Countries

3. In general, the investors to EPZ will be concerned with the following conditions, especially with tax incentives and labor relations:

a) Political and economic stability of the country
b) Safe situation (neither drugs nor guerrillas)
c) Location of EPZ
d) Adequate infrastructure (especially, water supply and inexpensive, stable and reliable electric supply)
e) Labor relations (flexibility of Labor Law)
f) Tax incentives

4. Table 5-1-3 shows the institutional scheme of EPZs in Panama and the Andean countries (Colombia, Ecuador, and Chile). While the EPZs of Colombia and Chile have a long history of more than 30 years (Barranquilla, Colombia) or 20 years (Iquique, Chile), those of Ecuador and Panama have a short history of less than 10 years (Ecuador) or 5 years (Panama). Generally speaking, the development of EPZs will depend on the incentives, especially tax incentives.

Table 5-1-3 Institutional Scheme of EPZs of Panama and the Andean Countries

Items	Panama	Colombia	Ecuador	Chile
Legislation				
.Law/Decree	1992 (New Law)	1981 (New Law)	1991	1975
.Administration	Public, private or mixed	Privatized in '91	Public, private or mixed	Mixed
.Main objectives	Foreign trade; regional development; jobs	Foreign trade; regional development	Foreign trade; regional development; jobs	Regional development; economic integration with adjacent countries
.Sectors	Industry ;trade; service	Industry; trade; service	Industry; trade; service	Industry; trade; service
Tax incentive				
.Import tax	No tax	No tax	No tax	No tax
.National input	No tax	No tax	No tax	No tax
.Export tax	No tax	No tax	No tax	No tax
.Income tax	Permanent non-tax	Permanent non-tax	No tax for 20 years	No tax-- retained earnings Taxable--distributed profits
.Local taxes	No tax	No tax	No tax for 20 years	Taxable
Other incentives				
.Foreign currency handling	Free	Free	Free	Free
.Customs procedures	More flexible	More flexible	More flexible	More flexible
.Sales to local market	Up to 20 %, paying tax/duty	Yes, paying tax/duty	Under approval of Council	Yes, paying tax/duty
.Requirements	Not specified	Not specified	Not specified	Not specified
Labor Law				
.Special system for EPZ	Special labor provisions	No	Temporary employment	No
Locations of port-based EPZs	Not existing	.Barranquilla .Buenaventura .Cartagena .Santa Marta	.Esmeraldas	.Iquique .Punta Arenas .Arica

Source: Brochures, pamphlets, JICA studies, hearing etc.

5.1.3 Potentiality for EPZ in the adjacent areas of the Port of Balboa

5. It is the most favorable for an Export Processing Zone to be located in the vicinity of the port to impel the port development. In the Andean Countries, the majority of EPZs are located adjacent to the port, as shown in Table 5-1-3.

6. Furthermore, it is ideal to acquire the land of 100 ha or more for a EPZ, if possible. Among the EPZs shown in Table 5-1-3, the area of Barranquilla EPZ is 100 ha, while that of Iquique EPZ and Arica EPZ is 230 ha and 130 ha, respectively. In Panama, Fort Davis EPZ and Panama Teleport have areas of 100 ha, respectively.

7. Taking into consideration the above conditions, the southern part of the former site of Albrook Airport will be suitable for a future EPZ. The site, however, will not be available, because it is expected to be utilized as an alternative of the present Paitilla Airport.

8. Corozal area at the north-west of the Port of Balboa which is of 161.2 ha (54 ha of which is possessed by PCC) also will not be available as an EPZ, because there are already factories and houses, and a part thereof will be expected in the future to be used as the port facilities such as container yard, warehouses, CFS and container handling equipment.

9. It will be, consequently, suitable for a new EPZ in the adjacencies of the port to be set up in the future expansion area of the Port of Balboa with spacious land at the opposite side of the Port like Farfan area.

10. The following issues are of great importance to potential investors, when they actually intend to invest in an EPZ:

a) Land price
b) Wage rate
c) Price for utilities
d) Standard factory rental price
e) Cultural and recreational facilities
f) Preferential tax incentives, especially income tax
g) Quality of labor/employment incentives
h) Infrastructure availability
i) Local partner
j) Guaranteed managerial body

11. Table 5-1-4 shows the potentiality for an EPZ in the surrounding areas of the Port of Balboa.

Table 5-1-4 Potentiality for EPZ in Surrounding Area of Balboa Port

Items	Details	Observations
Available land	.Area .Location .Land/factory rental price	100 ha or more·····possible Within the surrounding area of the port To be as low as possible
Port Facilities	.Access to port .Shipping chance .Ship size accommodation .Container handling .Reefer container .Custom clearance	Good Good To be improved for container To be improved To be improved Fair
Labor Force	.Urban center .Unemployment rate .Skilled labor	Panama city (population: 0.8 million) High (13.8 % in '94) Insufficient
Public Services	.Inland transportation .Communications .Power supply .Water supply	Good Good, but expensive Good, but expensive Good
Existing Industry	.Availability in urban center .Availability of raw materials	Insufficient Insufficient
Possible Industrial Categories to be located in EPZ	Electric devices, electronics, metal, chemical, food processing, plastics, car parts, others	Higher level of wages compared with other Latin-American countries ·····Labor-intensive industries will not be suitable.

12. Table 5-1-5 shows a tentative land use plan of an EPZ with an area of 100 hectares.

Table 5-1-5 Land Use Plan of EPZ (tentative)

Land Use	Area (ha)	Descriptions
Factory lot	75.0	1.Small size 10 ha. 2. Medium size 30 ha 3.Large size 35ha
Road	15.0	Boulevard, Main road, Sub-road, Sidewalk, Patrol road
Administrative facility	1.5	Administration building, fire station
Service facility	2.0	Service building (restaurant, clinic, bank, etc.), Gas station, Bus terminal
Utility	2.0	Electric sub-station, Sewage treatment plant, Water supply tank
Park	4.5	Sports ground, Park, Garden
Total	100.0 ha	

13. As to the administration of EPZ, the administrative company of Esmelaldas EPZ (ZOFREE), Ecuador, is a mixed (public and private) body where 75 % of the paid-capital has been held by the Port Authority of Esmelaldas and others by public and private institutions and individuals; and Iquique EPZ, Chile, is managed by the "Zona Franca de Iquique S.A." (ZOFRI) which is a public-private corporation, while in Colombia the management was privatized in 1994 and Barranqilla EPZ is administrated by the "Zona Franca Industrial de Bienes y Servicios de Barranquilla S.A." which is a private company (till then the public corporation had managed it).

14. In Panama, five EPZs excluding Fort Davis EPZ which is a joint venture of ARI and a Taiwanese holding corporation are managed by private companies. However, as a proposed EPZ will be settled adjacent to the port in the Reverted Area, it is recommendable that the administration company (promoter & operator company) will be a mixed body (a joint venture of ARI or APN and a powerful private company),though it may have a demerit of being subject to an audit of the Contraloría General.

5.2 Other Land Use Related with Port Activities

5.2.1 Potentiality of Balboa Port for Maritime Complex

15. It can be said that the three powerful impetuses for the Panamanian economy are : 1)the Panama Canal, 2) the International Financial Center of Panama and 3) Colon Free Zone.

16. In 1970, the Bank Law was amended (Law No.238), granting various fiscal benefits to banks by adapting an approval system which provides a modern and flexible banking legislation. As a result, the number of banks increased from 24 in early '70 to 116 (including representative offices) in January '87, making Panama an International Financial Center. As of the end of September '93, 105 banks from all over the world are operating in Panama city.

17. Fortunately, the Port of Balboa is situated near the International Financial Center, Panama City. In accordance with the development of the Port of Balboa as a multipurpose port under concession system suggested by the "Public Policy for Integral Development" of the Government, it will become necessary to establish a branch or agent of banks, insurance companies, shipping companies etc. related to port activities for their convenience of services in the precincts of Balboa Port. Therefore, it is desirable to create a specific zone called "Maritime Complex" adjacent to the port. This maritime complex will contribute to attract ships to call at the Port.

5.2.2 Maritime Complex in Balboa Port

18. The actual land area of the Port of Balboa is 161.4 ha, almost all of which have been used or a part should be filled in when necessary for use. In accordance with the concessions to private sector, the entire area of the actual precincts of the Port will be utilized for them. It is, accordingly, expected to use the land adjacent to the actual port area for the maritime complex.

19. The Maritime Complex of the Port of Balboa will include the following installations:

a) Banks (including representative office)
b) Insurance companies
c) Shipping agents

d) Service center for cruise passengers
e) Seamen's training center (including Evergreen's nautical school)
f) World cargo distribution center (including maritime information center)
g) Container repair center
h) Maintenance and repair of vessels
i) Commercial complex (including duty-free shops)
j) Others

(Note) The items from d) to h) are included in ARI's project of the reverted areas.

20. The area required for the maritime complex zone will be at least 30 ha including a reserved space. Table 5-2-1 shows a tentative land use plan of the maritime complex with an area of 30 ha.

21. As to the site, it is desirable that the maritime complex will be located in the area near the Port of Balboa and easily accessible to the City of Panama such as:

1) Corozal South
This zone covers an area of 54 ha and is possessed by PCC at present.

2) Southern part of the former Albrook Airport
A part of this area is possessed by APN and has been used as a yard for imported vehicles under concession.

22. In case that the Complex would be set up in the area 2), it will be an alternative to locate "Seamen's training center" (including Evergreen's nautical school) and "Maintenance & repair of vessels" in Corozal South, separate from the maritime complex, because this is located along the Panama Canal.

Table 5-2-1 Land Use Plan of Maritime Complex (tentative)

Land Use	Area (ha)	Descriptions
Service area	10.0	1. Administration office, Fire station (1 ha) 2. Bank, Insurance company, Shipping agent etc.(1 ha) 3. Service center for cruise passengers (2 ha) 4. World cargo distribution center, Maritime information center (2 ha) 5. Commercial complex (shop, restaurant etc.) (2 ha) 6. Others (Gas station, Bus terminal etc.) (2 ha)
Seamen's training center	5.0	including Evergreen's nautical school
Container repair center	1.5	
Maintenance & repair of vessels	3.0	
Road	3.0	Boulevard, Main road, Sub-road, Sidewalk
Utility	1.0	Electric sub-station, Sewage treatment plant, Water supply tank
Park	1.5	Park, Garden
Reserved	5.0	for future expansion
Total	30.0 ha	

VI PRELIMINARY TECHNICAL STUDY OF MAJOR PORT FACILITIES

6.1 Design Conditions and Criteria

(1) General Information

1. For the study on the short-term and long-term developments, the JICA study Team applies, so far as they are practical, the design standards and criteria and natural conditions that APN has already set forth for the design of the urgent improvement works of the piers at the Port of Balboa These design standards and criteria are previously detailed in this report.

2. The design standards and criteria which APN has not worked out, particularly those for the port facilities for accommodating over-panamax container vessels, will comply with Japanese standards and criteria where they are applicable. In proceeding with further study, the JICA Study Team refers to "Technical Standards for Port and Harbor Facilities in Japan" established and published by Bureau of Ports and Harbors, Ministry of Transport of Japan.

(2) Design Ships

3. Dimensions of the design ships for the short-term and long-term developments are set forth as shown in Table 6-1-1.

(3) Equipment to be Installed

4. APN has designed the improvement works of Pier No. 14 and No. 15 to carry container quay-side cranes having a 30.26 m rail gauge and for Pier No. 16 a 22.56 m rail gauge. The container quay-side cranes once installed at Pier No. 14 and No. 15 can be used at the container terminal at Diablo in the short-term development.

Table 6-1-1 Dimensions of Design Ships

	Terminal/Berth	Ship	Capacity	Overall Length	Beam	Draft
Short -Term	Container Terminal (Diablo)	Over-Panamax Container Vessel	6,000 TEU	300 m	40.0 m	13.0 m
Ditto	Pier No. 18 (North)	Passenger Ship	30,000 GT	230 m	27.5 m	8.5 m
Ditto	Pier No. 19	Small Craft (Passenger)	2,000 GT	88 m	13.2 m	4.0 m
Ditto	Tuna Boat Berths	Tuna Boat	5,000 DWT	109 m	16.4 m	6.8 m (*)
Ditto	Sand/Gravel Landing Berths	Sand Barge	700 DWT	58 m	9.7 m	3.7 m
Long-Term	Oil Berth	Oil Tanker	30,000 DWT	185 m	28.3 m	10.9 m
Ditto	Container Terminal	Over-Panamax Container Vessel	6,000 TEU	300 m	40.0 m	13.0-14.0 m

Note: (*) The design depth of tuna boats will be for light-loaded ones only.

5. The container terminals to be constructed both in the short-term and long-term developments are recommended to have a rubber tyred transfer gantry-crane (RTG) system. Containers will be stacked in 4 tires. However, in order to minimize the construction cost, no special foundation of RTG passage, like pre-stressed or reinforced concrete slabs are taken into account.

6. The container stacking yards are to have such pavement so that they can easily facilitate the computerization. To this end, the pavement is to be monolithic, like either asphalt or concrete pavement. Asphalt pavement is tentatively presumed for the cost estimate purpose.

(4) Subsoil Conditions

7. The JICA Study Team collected the subsoil information at Diablo and Farfan from APN and PCC. In addition, the team conducted subsoil investigation at the both sites. The summary of the information and the

results of the investigation are briefed as follows:

8. The two boreholes at Diablo confirmed the existence of sound rock at -3.5 m MLWS at about 300 m north of the pier of PCC, and at -8.58 m MLWS at the mangrove area, about 500 m north of Pier No. 18. Another borehole at the workshop area, about 200 m north of Pier No. 20 did not encounter either weathered or sound rock up to - 15 m MLWS. At each borehole, a layer of soft marine origin sediments exists, with a thickness of 5.60 m to 9.20 m. Residual soil, which has been created from weathered rock, underlies this layer with a thickness of 2 m to more than 5 m. See Appendix II.

9. From the facts mentioned above, the construction cost of the short-term development much depends on the selection of the face-line of the quay wall, which will consequently determine the required volume of rock dredging.

10. At Farfan, three boreholes are drilled, one inside the swampy area, one at the existing coast road, and one offshore. Each borehole encountered sound rock, at -8.00 m inside the swampy area, -6.21 m at the coast road and at - 10.81 m offshore all in MLWS. The sound rock is covered with about 5 m thick residual soil. About 2 m thick weathered rock is found on the top of the sound rock at the offshore borehole. Both at the swampy area and offshore, the marine origin sediments are found. But at the coastal road, instead of the sediments, a sand layer is encountered. See Appendix II. It should be noted that PCC's information of the subsoil at Farfan also indicates the existence of the rock at a shallow depth at both the swampy area and coastal road.

11. The construction cost of the long-term development, therefore, much depends on the selection of the face-line of the quay wall because of the rock dredging. However, the face-line selection cannot be much flexible because of the new canal alignment for the third lock.

12. PCC provided the subsoil information at the water area offshore the oil tank yard at Amador. The information reveals that under the marine origin sediments lies weathered residual rock, which can be excavated by a

powerful cutter suction dredger. This conclusion is based on the description on the boring logs as "Drills easily with water, but the core is recovered in poor fragmental condition because of the close jointing and weathering." See Appendix II.

(5) Tide

13. The highest recorded water at Balboa is + 5.918 m above MLWS and the tidal range is from + 5.345 M (MHHW) to - 0.466 m (MLLW). Because of these tidal conditions, the top elevation of the quay wall should be + 7.00 m above MLWS, except Sand/Gravel Landing Berth, and the fender system has to cover the verticality of about 6 m above MLLW. (The existing Sand/Gravel Landing Berths at Pier No. 20 are of a pontoon type. The landing is being carried out hydraulically. Therefore, the new one should be of the same type.)

(6) Seismic Force

14. The horizontal seismic force of 10 % of the gravity is applied as conforming to the design conditions for the improvement of the existing piers at the port of Balboa.

6.2 Improvement of Existing Facilities at the Port of Balboa

15. The JICA Study Team assumes that APN will proceed with the improvement of the piers of the Port of Balboa as already designed. The piers will accommodate non-gear container vessels up to the panamax size.

16. As all the detailed drawings are available with APN, the main features of the improvement of each pier are tabulated in Table 6-2-1.

17. In the design of the improvement works, cast-in-situ concrete piles of a 1.20 m diameter, which are driven into the rock bed by a pre-boring method, are chosen as the foundations of the rails for container quay-side cranes and of the widened concrete deck. The cast-in-situ concrete piles are technically sound because of the hard rock encounter within a short distance

below the seabed. For both the short-term and long-term port developments, as the subsoil is expected similar to that at the Port of Balboa, cast-in-situ concrete piles with proper dimensions are most probable for the container terminal quay.

Table 6-2-1 Improvement of Existing Piers

Pier	Deepening (MLWS)	Apron Widening	Remarks
No. 6	- 12.20 m (9.2 m)	None (19.51 m)	Rock exposes at sea bed.
No. 7	None (10.1 m)	None (13.26 m)	Seabed is rock.
No. 14	- 12.50 m (10.5 m)	37.50 m (18.75 m)	Provision of container crane rails of a 30.26 m gauge. Provision of concrete slab deck of 4.75 m width in front. Provision of retaining wall for connection to hinterland.
No. 15	- 12.95 m (10.1 m - 11.0 m)	35.62 m (16.76 m)	Provision of container crane rails of a 30.26 m gauge. Provision of concrete slab deck of 4.75 m width in front. Provision of concrete deck and retaining wall for connection to hinterland.
No. 16	- 12.95 m (10.0 - 10.4 m)	30.43 m (22.30 m)	Provision of container crane rails of a 22.56 m gauge. Provision of concrete deck and retaining wall for connection to hinterland.
No. 18	- 12.20 m (8.70 - 10.65 m)	None (61.47 m)	Provision of concrete deck at the center replacing fill.

Note: Parentheses indicate the present depth or width.

18. Assuming the deepening of Pier No. 18 up to - 12.20 m MLWS and provision of the concrete deck at the center of this pier to be carried out in the

urgent improvement works, the JICA Study Team concluded that no additional works, except the renovation of the transit shed as a passenger terminal and a platform for railway, are necessary in the short-term development to accommodate passenger ships of a 30,000 G.T. class (8.5 m draft) at this pier.

19. The container yard will be developed behind Pier No. 15 and Pier No. 16. The workshops of PCC there will be transferred to Corazol which US Army is planning to revert to Panama. Other buildings of APN and Panama Railway will be demolished.

6.3 Port Facilities at Diablo

(1) Dredging and Reclamation

20. The JICA Study Team confirmed the existence of sound rock at Diablo at about -3.5 m and -8.5 m MLWS. The development cost, therefore, much varies among the alternatives. The borehole exploration was conducted almost on the assumed face-line of the quay walls of these alternatives. Alternative Plan-D3 and D4 will require a considerable dredging of sound rock. Meanwhile, the face-line of the quay walls of Alternative Plan-D5 is selected so that the dredging will not encounter the sound rock.

21. The turning basin for the short-term development at Diablo is planned -12 m MLWS. As APN currently maintains the port basin - 12.95 m MLWS, no capital dredging is required.

22. For Alternative Plan-D3 and D4, dredging volume much exceeds reclamation fill. In these cases, the excess materials shall be disposed of on the west bank of the canal if permitted by PCC. Meanwhile, for Alternative Plan-D5, the soils to be dredged are mainly marine origin sediments, which should be disposed of to the shallow sea between Chorrillo and Amador Gulf Curse for reclamation. This reclamation can be used as the perimeter of Amador Gulf Curse and provided with mangrove plantation as an environmental mitigation measure. In case of Alternative Plan-D5, filling

materials must be imported for reclamation.

(2) Container Terminal Berth

23. In view of the large tidal range, the top elevation of the quay is to be + 7 m MLWS similar to that of the piers of Port of Balboa. The water depth of the quay is to be - 14 m MLWS for accommodating the over-panamax vessels at the berth box in future.

24. The varied elevation of the sound rock is one of the determinant elements for the structural type of the quay wall. For Alternative Plan-D3 and D4, the top elevation is higher than the required elevation of -14 m MLWS. For these alternatives, it should be technically reasonable to use the sound rock as the foundation of the quay wall rather than to excavate it to the required elevation. The superstructure will be of a concrete open deck supported on cast-in-situ piles or a gravity type of concrete blocks. Conceptual cross sections of the quay wall for Alternative Plan D3 and D4 are shown in Figure 6-3-1.

25. For Alternative Plan-D5, as the face-line avoids the rock encounter, a concrete open deck supported on cast-in-situ piles will be preferable; this type is applied for the existing piers of Port of Balboa. Or, a concrete caisson bulkhead can be applied since the residual soil is confirmed sufficiently hard to support the gravity of the quay wall. Figure 6-3-2 and Figure 6-3-3 show the conceptual cross sections.

26. The rail gauge of the container quay-side crane is to be 30.26 m since one of the two container cranes to be installed at Pier No. 14 and No. 15 can be transferred to Diablo when the container terminal is completed in the short-term development.

27. The container yard pavement will be monolithic as recommended for the rubber tyred gantry crane (RTG) system and computerization.

28. For buildings like the terminal office and CFS, the structures which prevails in Panama, like RC pile foundations, reinforced concrete columns,

beams and slabs, and brick wall, should be applied. However, for the CFS the roof members should be light members like steel truss beams because of their long span.

(3) Tuna Boat Berths

29. The top elevation of the tuna boat berth should be + 7.0 m MLWS similar to the existing piers. The front depth is to be - 7.5 m MLWS for a 5,000 DWT class cargo vessel.

30. For Alternative Plan-D3, the tuna boat berth is allocated at Diablo near the pier of PCC where the sound rock is confirmed at about - 3.5 m. Because of the rock encounter, an L-shape concrete retaining wall is preferable as the structure. Figure 6-3-4 shows the conceptual cross section.

31. For Alternative Plan-D4 and D5, the tuna boat berth is allocated near the existing Pier No. 20 where the sound rock is deeper than - 15 m MLWS and covered with marine origin very soft sediments underlain by very hard residual soils. Because of this subsoil formation, a concrete open deck supported on cast-in-situ concrete piles is preferable. Figure 6-3-5 shows the conceptual cross section.

(4) Sand/Gravel Landing Berths

32. Existing Sand/Gravel Landing Berths are allocated at Pier No. 20, north of Pier No. 18 across the port basin. At present, the landing of sand and gravel is carried out hydraulically from the barges which are moored to the floating pontoon. Unloaded sand and gravel are temporarily stacked at the open yard behind Pier No. 20. Because of the huge tidal changes, a floating berth is preferable for future development.

33. The front depth of the berths is to be -4.0 m MLWS. The top elevation is to be + 6.0 m MLWS, slightly higher than MHHW.

34. For Alternative Plan-D3, Sand/Gravel Landing Berths are planned at the land area where workshops exist at present. As the sound rock will be

encountered at about - 3.5 m MLWS, the berth should be a combination of a floating pontoon and slope protection. Stacking area should be allocated near the berths.

35. For Alternative Plan-D4 and D5, the berths are planned near the public boat ramp at Diablo, 150 m north of the pier of PCC. The water area should be deepened up to - 4 m for the pontoon and turning basin. Across the existing road, the swampy area is reserved as a sand stacking area. Figure 6-3-6 shows the technical concept of the berths.

6.4 Oil Terminal Berth at Amador

36. Oil Terminal Berth is planned as a part of the long-term development at the water area in front of the tank yard at Amador, where PCC has conducted a number of borehole exploration. According to the exploration results, the seabed surface is made of marine origin sediments of varied thickness from 2 m to 5 m. Below the surface sediments, the weathered rock exists up to about 5 m to 9 m below MLWS, which are underlain by "sound rock." The drilling characteristics of the "sound rock" is described, however, as "Drills easily with water, but core is recovered in fragmental condition because of the close jointing and weathering." Therefore, the "sound rock" can be dredged by a powerful cutter suction dredger. The seabed elevation is more or less at MLWS.

37. The dredging will be relatively costly because of the weathered rock. The dredged materials can be disposed of across the Amador Causeway by reclaiming a land, preferably for the expansion of the golf course.

38. The oil terminal is comprised of three berths; one (- 14 m deep and 280 m long, Main Berth) for accommodating a 30,000 DWT class tanker, two (- 7.5 m deep and 130 m long, Sub-Berth No. 1, and -5.5 m deep and 100 m long, Sub-Berth No. 2) for a smaller oil barge.

39. The turning basin should be dredged up to - 12 m MLWS. However, Main Berth is to be designed for future deepening up to -14 m MLWS.

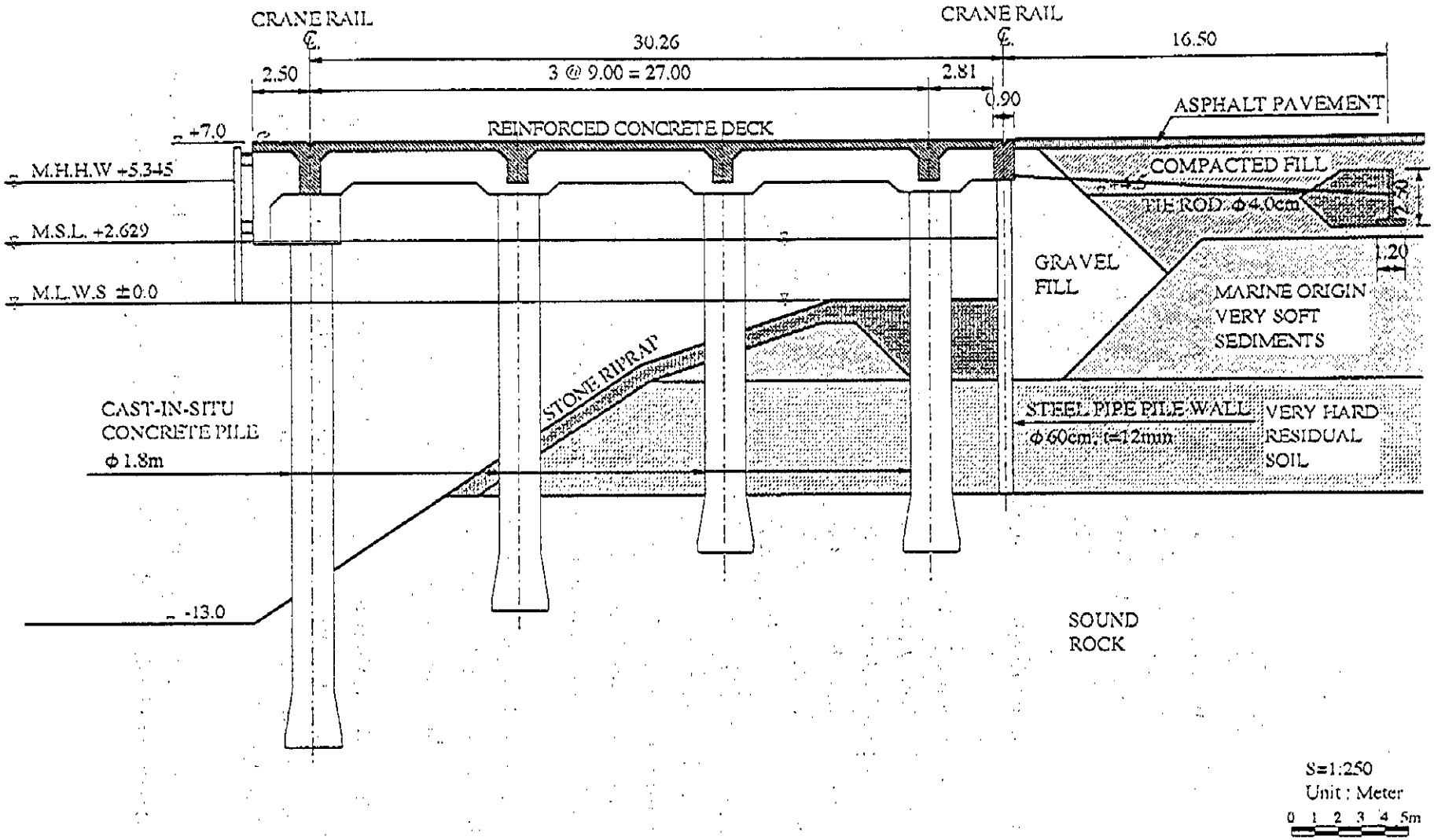


Figure 6-3-1 Conceptual Cross Section of Container Terminal Berth Alt.-1

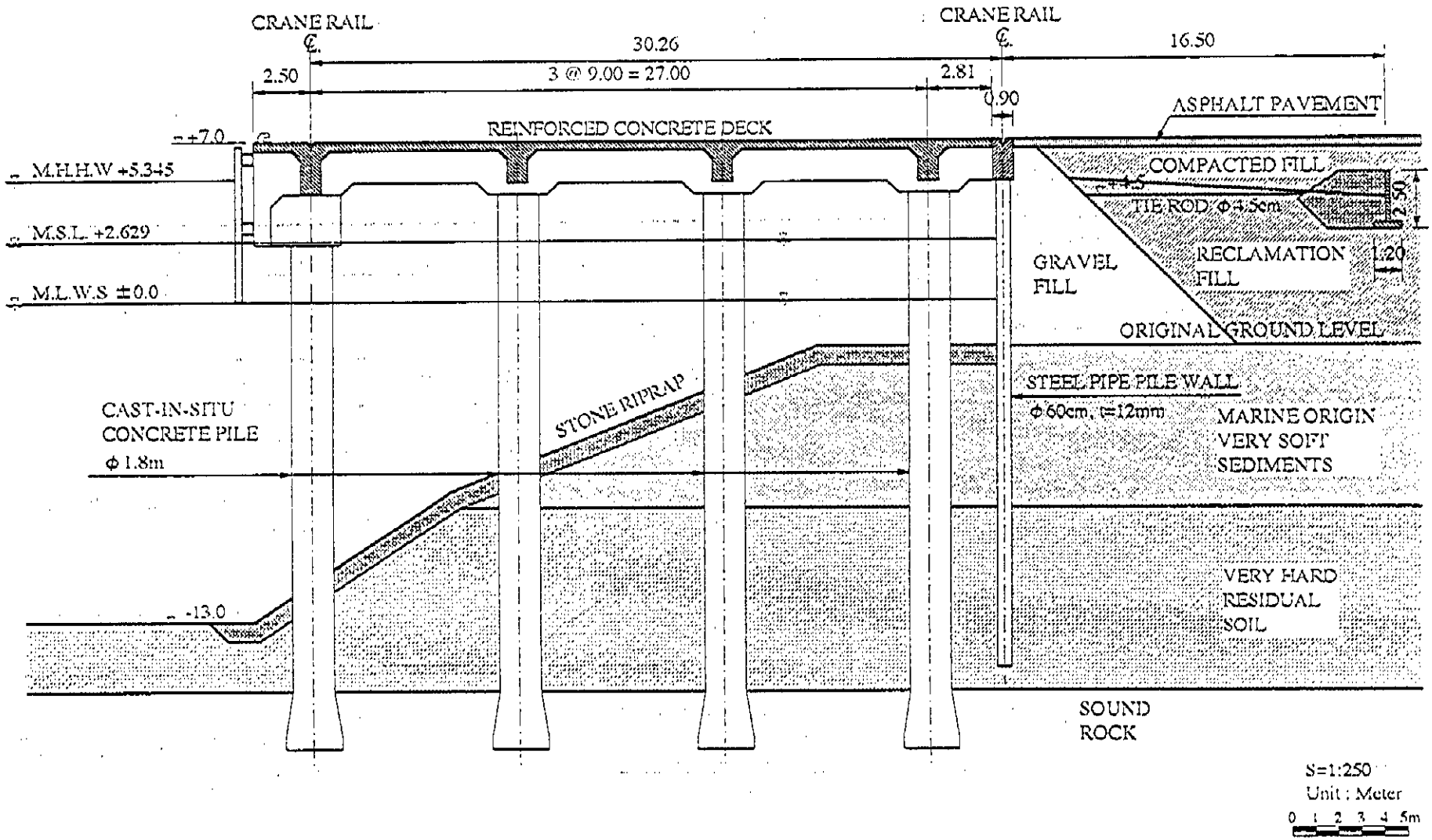


Figure 6-3-2 Conceptual Cross Section of Container Terminal Berth Alt.-2

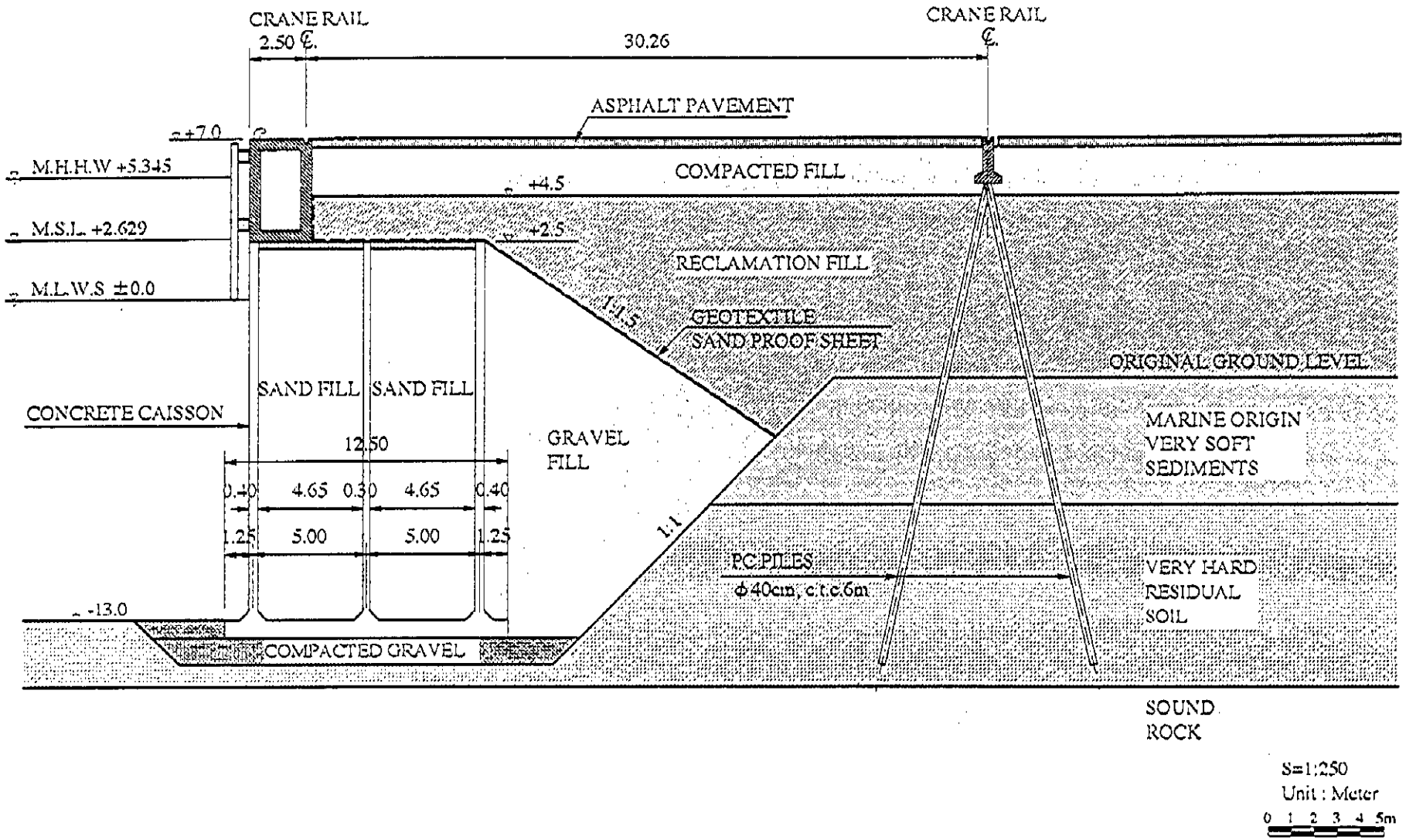


Figure 6-3-3 Conceptual Cross Section of Container Terminal Berth Alt.-3

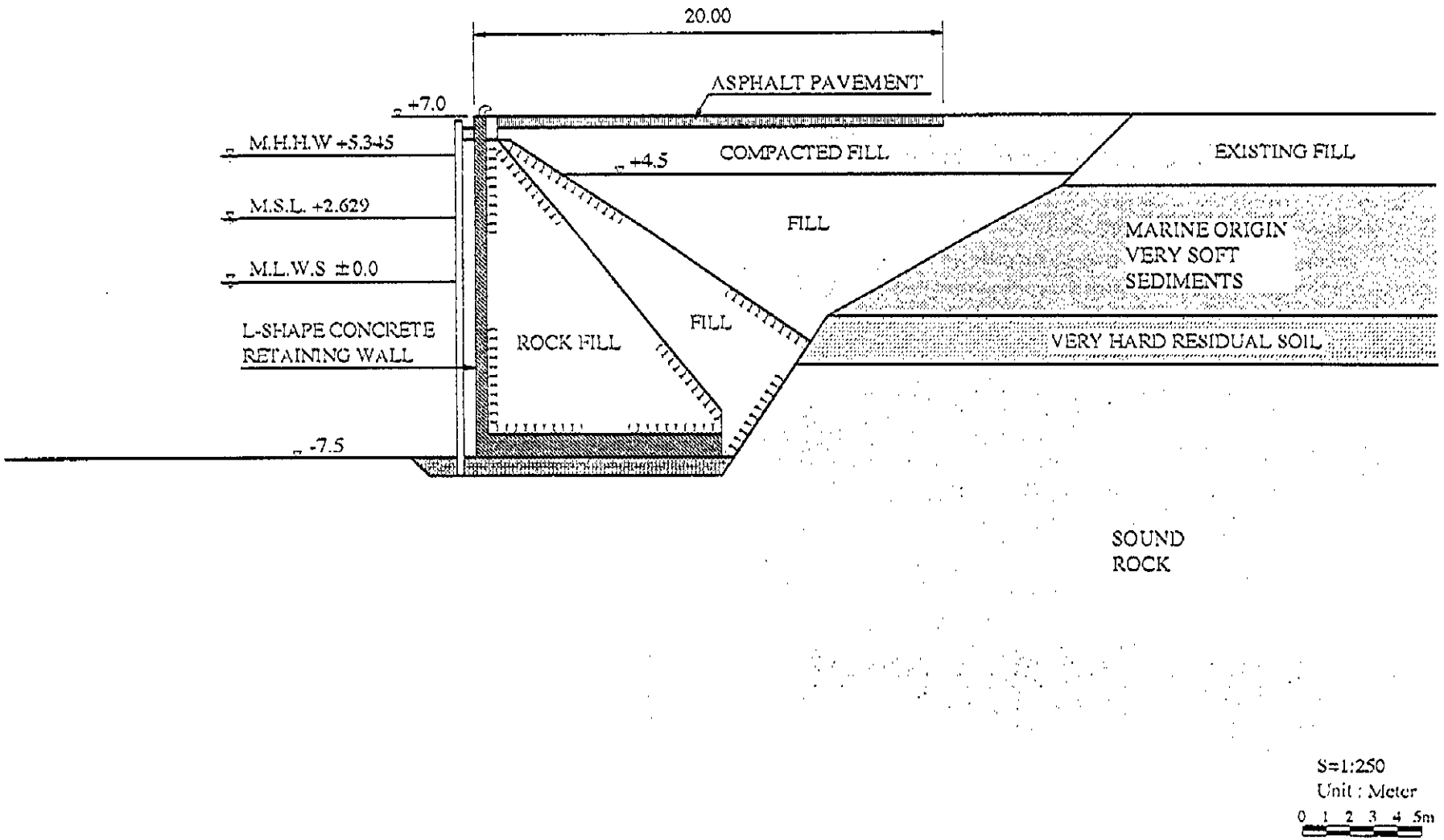


Figure 6-3-4 Conceptual Cross Section of Tuna Boat Berth (Diablo) Alt-1

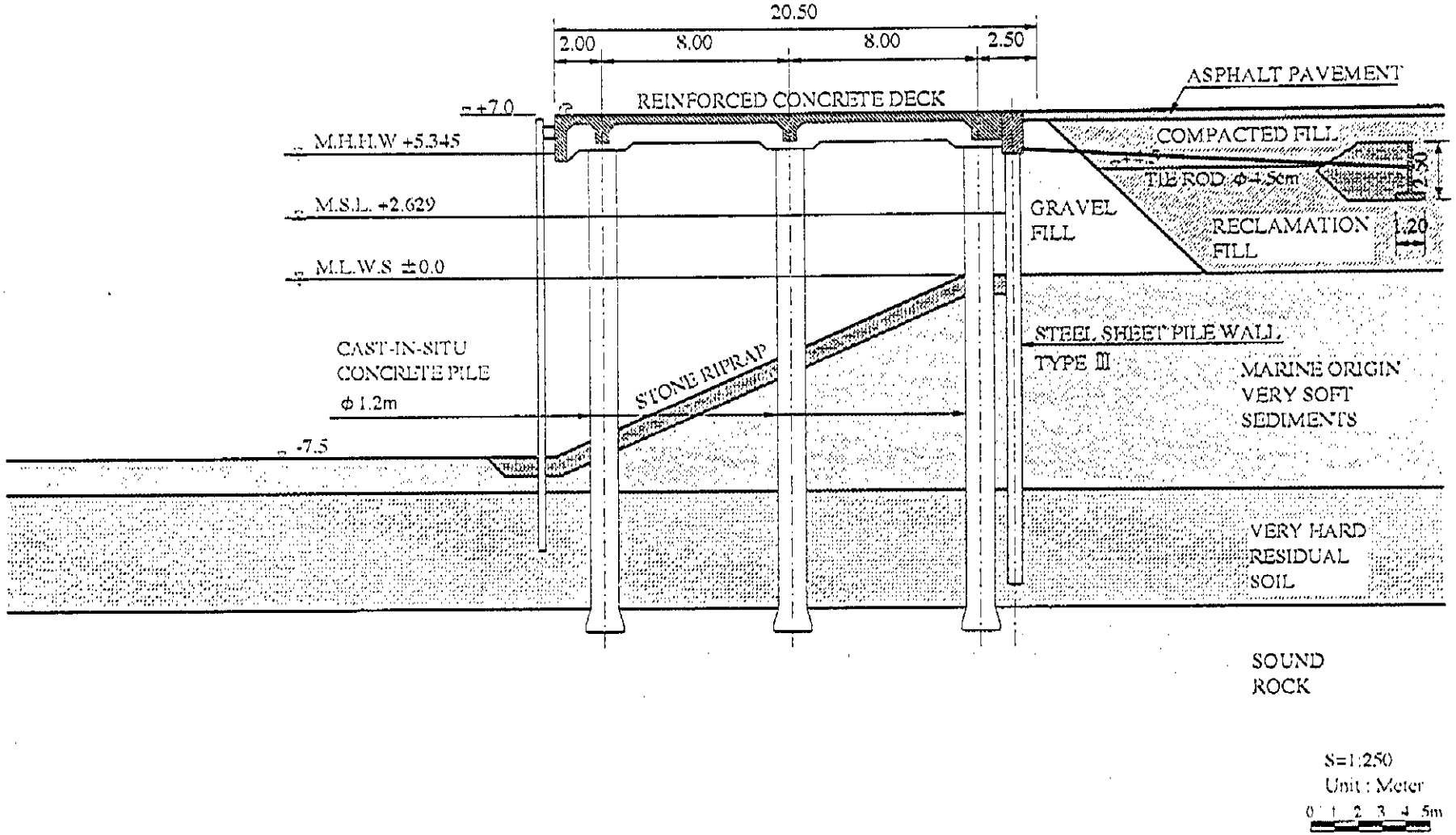


Figure 6-3-5 Conceptual Cross Section of Tuna Boat Berth (Diablo) Alt-2

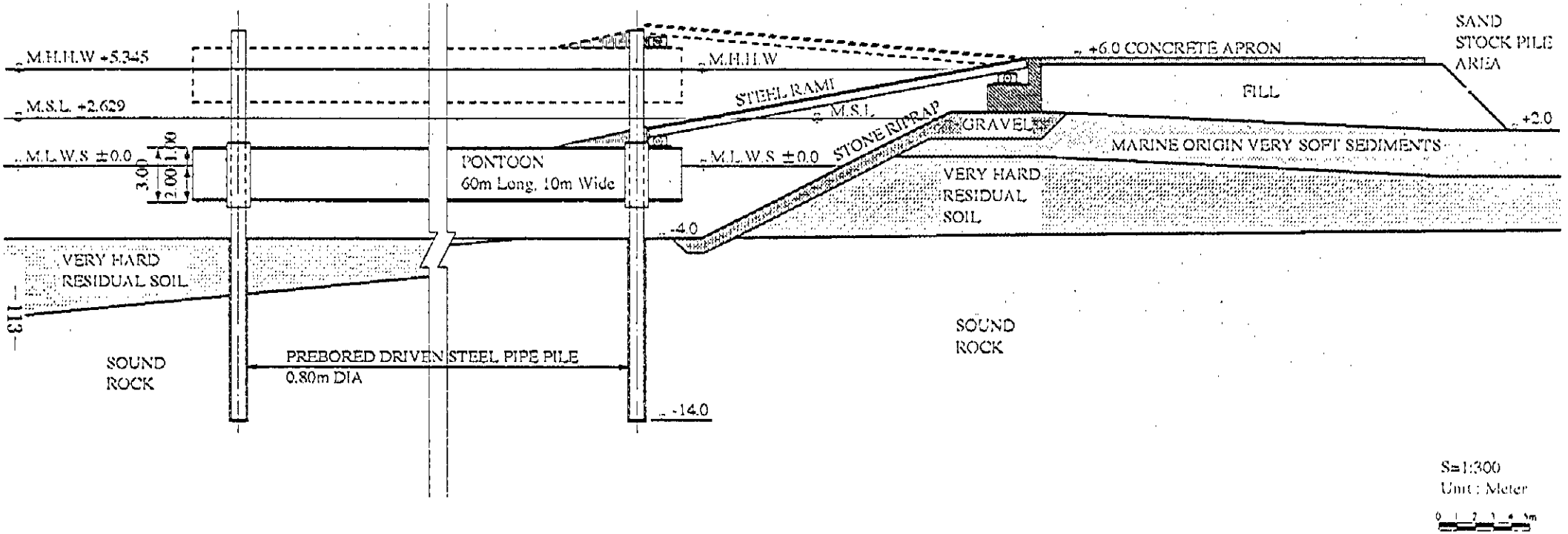


Figure 6-3-6 Conceptual Cross Section of Sand / Gravel Landing Berth

40. Main Berth is composed of two breasting dolphins, two mooring dolphins, one unloading platform and access trestle. All the dolphins and platform can be built with steel pipe piles, some of them should be batter ones to resist the lateral forces such as berthing force and seismic force. The steel pipe piles shall be rested into pre-bored holes through the weathered rock or into the sound rock and filled with reinforced concrete. Most of the pulling-out force acting on the piles shall be carried to the weathered rock or sound rock with embedded anchor rods or wires. Figure 6-4-1 shows the conceptual cross sections of Main Berth.

41. Sub-Berth No. 1 and No. 2 should be a concrete continuous deck, which can accommodate various sizes of oil tankers, supported on steel pipe piles to be built as mentioned above. The conceptual cross section of Sub-Berths is also shown in Figure 6-4-1.

6.5 Port Facilities at Farfan

(1) Dredging and Reclamation

42. The navigation canal will shift toward Farfan when the third lock is operational in future. In addition, a 600 m turning basin must be provided between the canal channel and the berths. The face-line of the container terminals of the long-term development is, therefore, chosen rather close to the coast. Meanwhile, the subsoil exploration confirmed the existence of sound rock at about - 11 m MLWS about 100 m offshore from the coast. A considerable dredging of sound rock is inevitable.

43. Based on the borehole exploration and information provided by PCC, about 175,000 m3 of sound rock must be excavated. As the rock is too hard to excavate by a cutter suction dredger, the dredging will be carried out by a special equipment for rock excavation, such as a heavy bucket or chisel, or by use of explosives. In either case, the dredging will be very expensive.

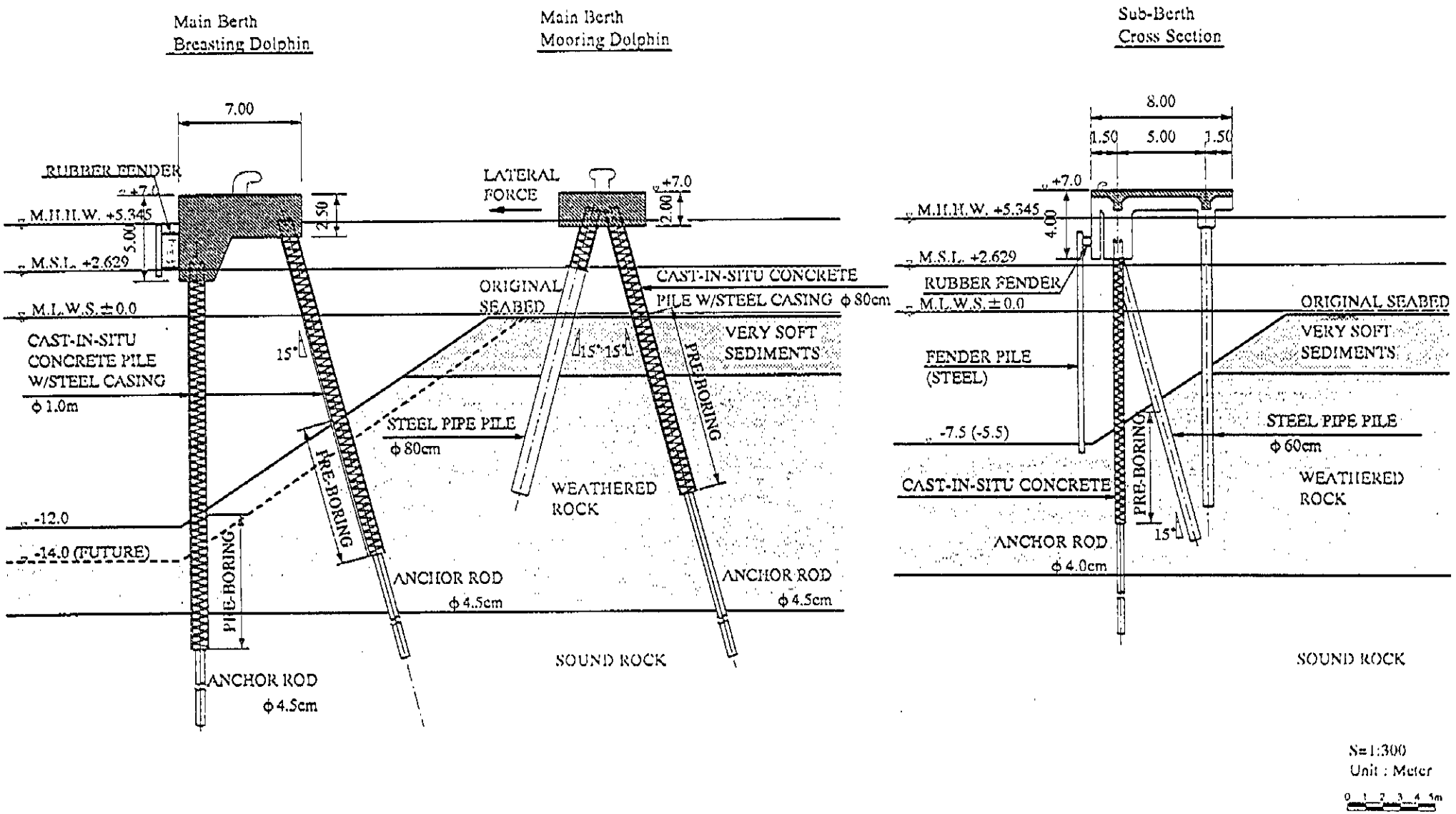


Figure 6-4-1 Conceptual Cross Section of Oil Berth

44. The turning basin should be dredged up to -14 m MLWS for accommodating over-panamax container vessels. The front depth of the quay wall, however, should be - 15 m MLWS for future deepening. The top elevation of the container terminal berth should be + 7.0 m MLWS similar to that of the existing piers of Port of Balboa.

45. Because the quay wall is to be built on the sound rock, it is more economical to minimize the rock excavation. In this view, a concrete open deck supported on the cast-in-situ piles will be preferable. A gravity type of bulkhead, like concrete caisson wall or concrete block wall, are discarded for involvement of the rock excavation. Figure 6-3-1 can be referred to as a conceptual cross section of the container terminal berth for the long-term development at Farfan.

(2) Container Terminal

46. The design criteria mentioned for the container terminals at Diablo for the short-term development are valid for the long-term development at Farfan except the crane rail gauge, which should be determined best for over-panamax container vessels and huge tidal range.