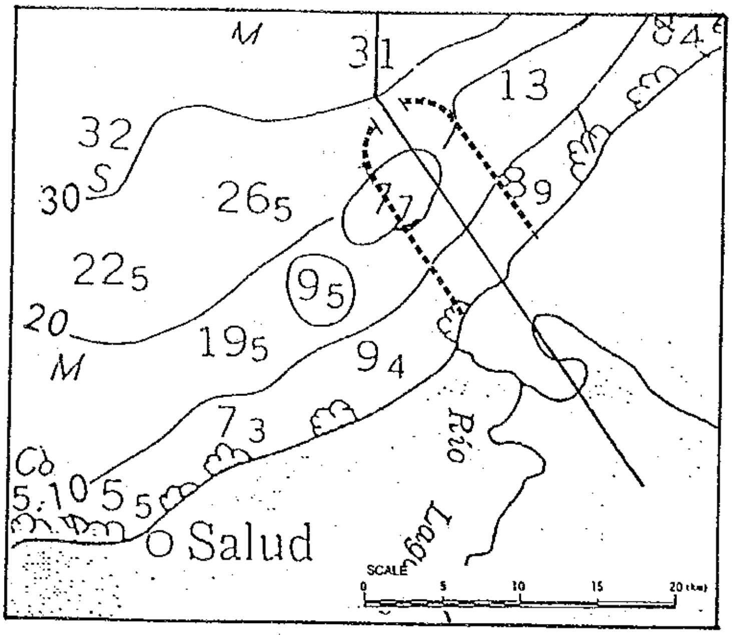
Existing breakwaters will be adequate for an enlarged existing canal or for a sea level canal on Route 14S. New breakwaters will be required for a canal on Route10. They should extend about 6 km offshore to provide shelter for the larger vessels in the more vulnerable stages of their approach to the canal.

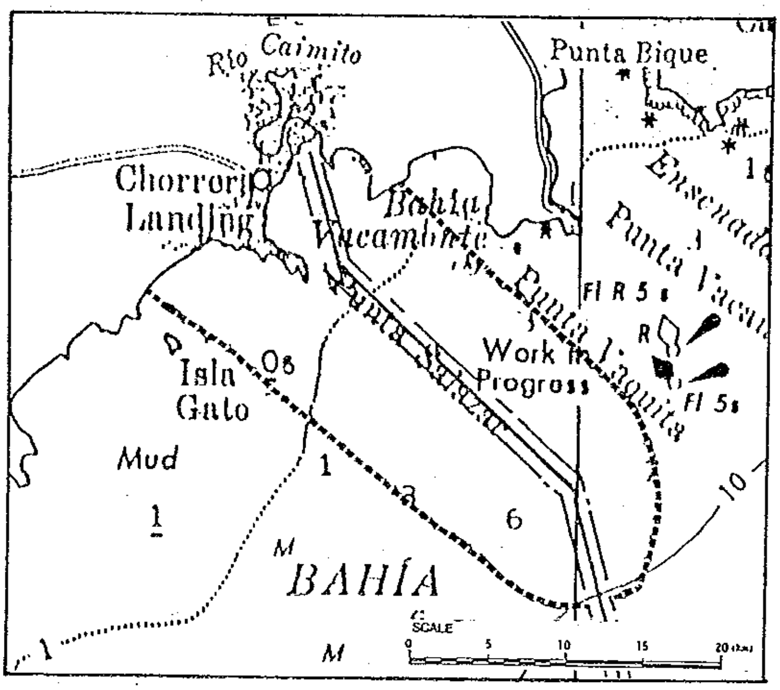
In case of route 10, one of the example of an alignment of the breakwaters in both coasts side is shown in Fig. 5.3.1.

In Atlantic side, the slope of the seabed is much steeper than that of Pacific side. So it is not realistic to extend breakwaters 6 km offshore where the depth is 35 m more. Therefore, it is recommendable to make stopping distance into the existing land area. The width between west breakwaters and east breakwater is decided to meet the space of turning basin of VLCC.

The typical cross section of breakwaters are shown in Fig. 5.3.2, 5.3.3. The type of breakwaters are chosen as sloping rubble mound with armor stones, considering the experience of the breakwaters in Vacamonte Fishing Port.



Atlantic Coast S:1/100,000



Legend
—— Channel
--- Breakwater

Pacific Coast S:1/100,000

Fig. 5.3.1 Breakwaters in Atlantic Coast and Pacific Coast

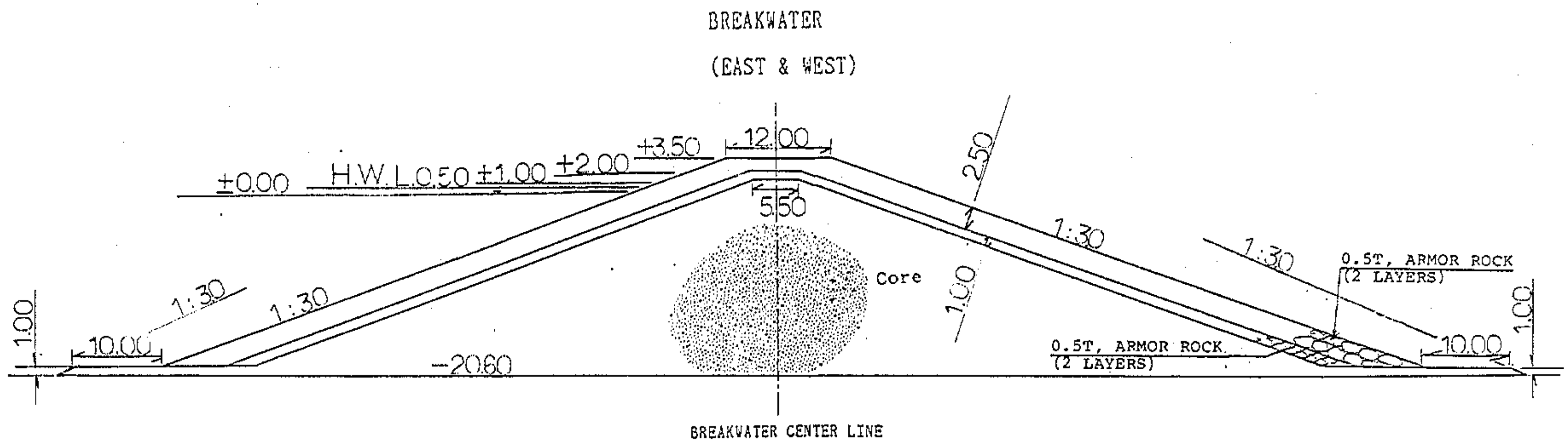


Fig. 5.3.2 Construction Method of Core and Armor Rock
(Atlantic Ocean)

BREAKWATER

(EAST & WEST)

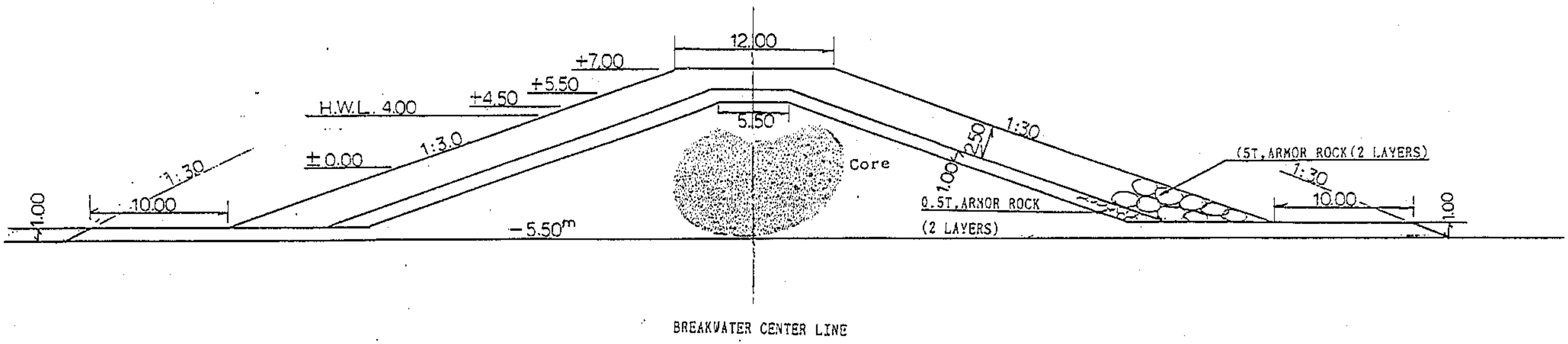


Fig. 5.3.3 Construction Method of Core and Armor Rock
(Pacific Ocean)

Table 5.3.3 Breakwater Length and Depth

	Length		Mean Depth
Atlantic Coast	East 3,280 m	(Total 7.380 km)	- 20.60 m
	West 4,100 m		- 20.60 m
Pacific Coast	East 6,300 m	(Total 14.9 km)	- 5.50 m
	West 8,600 m		- 5.50 m

Table 5.3.4 Volume of Core and Armor Rocks for Breakwater

	Atlantic Coast	Pacific Coast
Core	11,070,000 m3	5,580,000 m3
Armor Rock (0.5 ton/rock)	1,107,000 m3	894,000 m3
Armor Rock (5.0 ton/rock)	2,583,000 m3	2,533,000 m3
Total	14,760,000 m3	9,015,000 m3

5.4 Tidal Basin

In this section, an attempt is made to clarify for further study several aspects of the tidal basin which was studied and recommended by Ing. Demostenes Vergara Stanziola. (hereafter called Vergara's Plan)

5.4.1 Outline of Vergara's Plan

An entrance channel (Route 10) in the Pacific provides access to a vast cove or tidal basin with port functions, ship anchorages, etc. The canal will follow Route 10 through the Panama isthmus, protected from tidal currents by the tidal basins instead of barriers or gates. Its termination in the Atlantic would include another port cove, even though the possible dimensions here are smaller than those on the Pacific side.

The entrance channel to the Pacific (more than one (1) kilometer long), will permit the simultaneous "crossing" of two "giant ships" of 250,000 tons or more and simultaneously "a fortiori", crossing of one of these "giant ships" and one or more conventional ships. Its initial width, at an average level of water, or zero level, would be about 600 meters (approx. 2,000 feet), and the outlet width to the cove would be about 650 meters (2,100 feet).

Within the cove, dissipation of the 'tide streams' would occur in the interior within a few miles of the entrance. Only the streams coming from unusual tidal waters, joined with strong winds from the sea to the land, might affect the inlet of the terrestrial channel stretch.

The 'tide gate' would be unnecessary, since the stream would be almost eliminated from the terrestrial stretches.

Fig. 5.4.1 shows the alignment of the Tidal basin recommended by Ing. Vergara in the Pacific coast.

5.4.2 The Subject of Vergara's Plan

- Tidal current - Tidal gates might be unnecessary because the tidal basin has the effect of reducing tidal currents in the canal.

He calculated very roughly an entering speed of tidal currents using the Manning formula of 3 - 4.5 knots/hour. The speed depends on the opening dimensions at the tidal basin entrance and on the tidal range. The tidal basin size, its opening dimensions and the effect of the basin are not analyzed in this study.

- Area of anchorage basin - To meet requirements for anchoring capacity, 10,000 - 11,000 hectares is recommended for 2 giant ships and 200 conventional ships in Vergara's plan. However, this would depend on the distribution of ship sizes entering into the cove and it would be necessary to study ship sizes and distribution corresponding to traffic volumes through the canal.

- The plan for land use of areas reclaimed by construction of the breakwaters -
In Vergara's plan, it is described that vast "filter-breakwaters (embankments)" for many uses such as ports, management, tourism, residences, marine city, free zones etc. The above mentioned ideas are excellent, but the necessary land area, the volume of disposal of excavation and the cost of disposal must be studied.

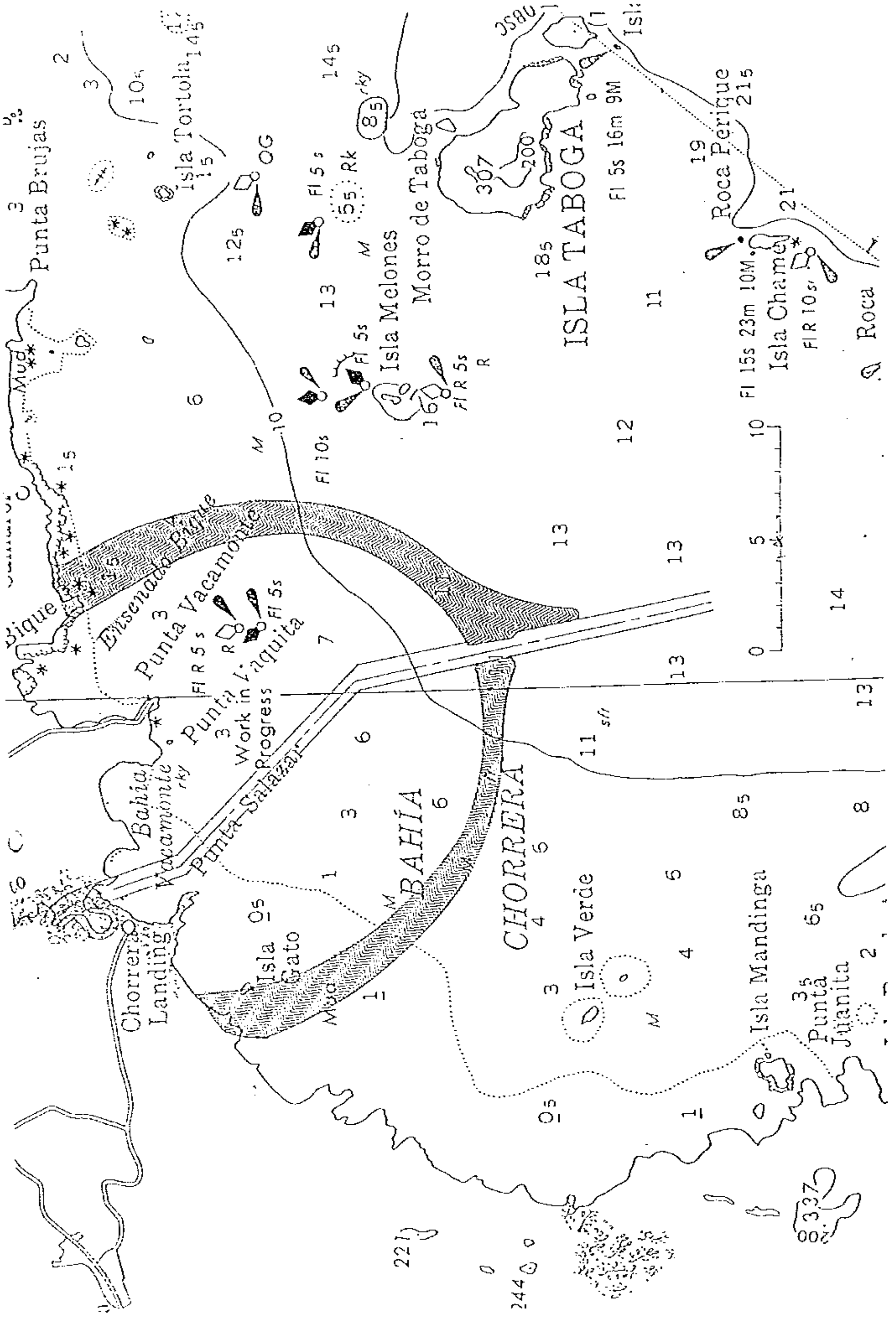


Fig. 5.4.1 Vergar's Breakwater in the Pacific Ocean

5.4.3 The Design of Embankment

There is little data on natural conditions such as wave conditions and soil conditions at sites to enable the design of the Embankment. Fig. 5.4.2 shows the wave conditions according to the data from Global Wave Statistics, compiled and edited by British Maritime Technology Ltd. Assuming this data is applicable, the design wave is likely to be 5.0m high (significant wave height) and would have a wave period of 12 second according to Global Wave statistics.

Latitude Range 0°N - 10°N
Longitude Range 80°W - 90°W

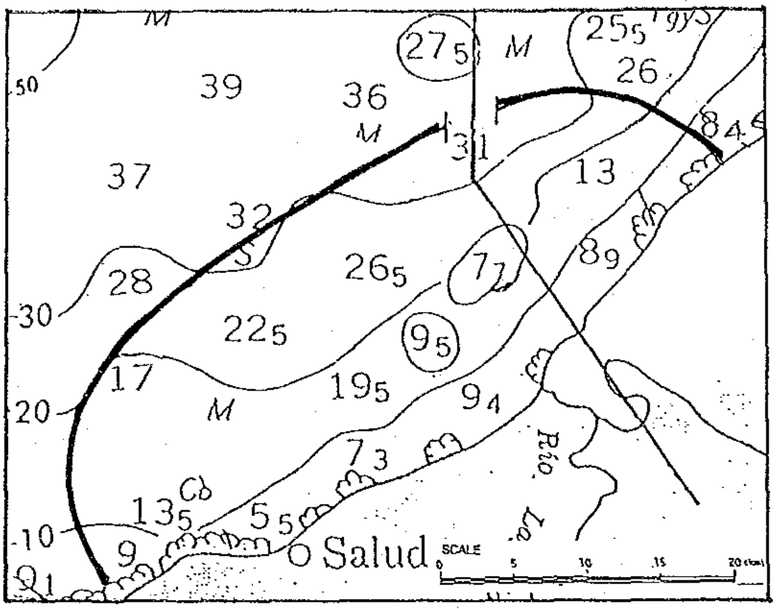
This means that the weight of armor stones for the embankment must be more than 10 tons. Soil conditions are also very important in design of the embankments. It is said that special improvements to the foundations were adopted in the case of construction of breakwaters for Vacamonte fishing port.

ALL DIRECTIONS

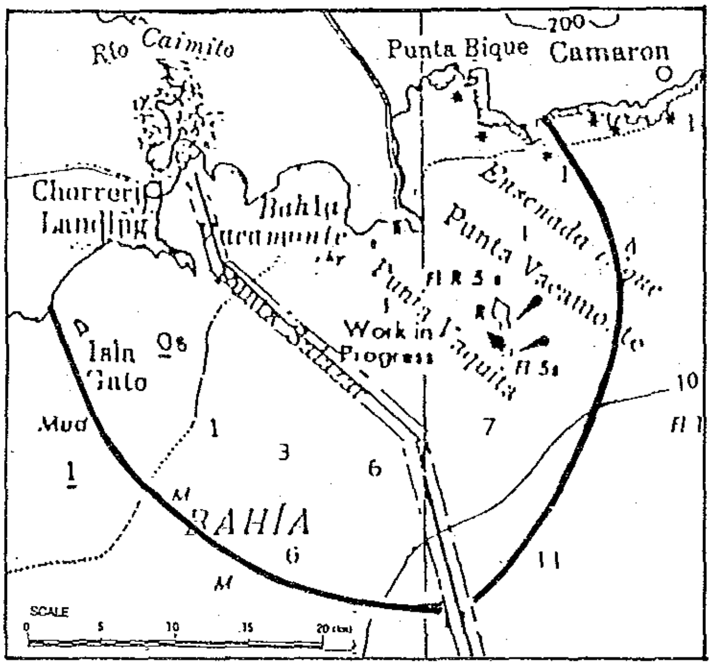
PERCENTAGE OF OBS = 100.00%
(INCLUDING 5.00% DIRECTION UNKNOWN)

SIGNIFICANT WAVE HEIGHT (m) \ ZERO CROSSING PERIOD (s)	<4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13	>13	TOTAL
TOTAL	26	153	299	276	155	62	20	5	1	-	-	1000
>14	-	-	-	-	-	-	-	-	-	-	-	-
13–14	-	-	-	-	-	-	-	-	-	-	-	..
12–13	-	-	-	-	-	-	-	-	-	-	-	-
11–12	-	-	-	-	-	-	-	-	-	-	-	-
10–11	-	-	-	-	-	-	-	-	-	-	-	-
9–10	-	-	-	-	-	-	-	-	-	-	-	-
8–9	-	-	-	-	-	-	-	-	-	-	-	-
7–8	-	-	-	-	-	-	-	-	-	-	-	-
6–7	-	-	-	-	-	-	-	-	-	-	-	-
5–6	-	-	-	-	-	-	-	-	-	-	-	1
4–5	-	-	1	1	2	1	1	-	-	-	-	6
3–4	-	1	6	12	11	7	3	1	-	-	-	41
2–3	1	10	42	63	48	23	8	2	1	-	-	196
1–2	6	64	159	153	79	28	7	2	-	-	-	498
0–1	20	79	92	48	15	3	1	-	-	-	-	258

Fig. 5.4.2 Wave Statistics



Atlantic Coast



Legend
Embankment
Channel

Pacific Coast

Fig. 5.4.3. Embankments in Atlantic Coast and Pacific Coast

5.4.4 Conclusion

For the construction of the embankments proposed by Mr. Vergara a tremendous volume of more than 100 million cubic meters may be necessary. If the construction materials are spoil from the canal excavation, the construction will be comparatively easy. However, before proceeding with a detailed consideration of this plan the following factors should be confirmed.

1) Soil Conditions in The Area:

   To calculate the stability of the embarkment (slip failures may occur), soil conditions are required. Special soil improvements may be required with tremendous costs and an extended construction period.

2) Retaining Structures at The Entrance:

   Considering channel depths of-25m (in case of 300,000DWT ships) and embankment top level of about 5m, some special steel sheet pile type retaining structures in the deep sea area would be required with huge costs and a long construction period.

3) Tidal Current Analysis:

   Tidal current velocity without a tidal basin was calculated and tested in a 1/100 Model in 1940 and concluded that the velocity in the canal would exceed 4 knots.

   To avoid the consequences of the high current velocity, it is understood that tidal gates would normally be necessary.

   Instead of this tidal current construction, if the current velocity could be significantly reduced by a tidal basin system, an analysis of this system should be conducted as well as a review of the calculation and/or model testing which was carried out in 1940.

4) Structure of the Embankment

In order to estimate the cost of the embankment, considerable structure of the embankment has been studied.
Supposing to use the spoil of excavation for material and the experience of the construction work in Panama, slope rubble mound type is chosen. There is no wave data at the construction site, armor stone's weight is decided as the same as Vacamonte breakwaters.

If actual wave becomes more than 4 meters it would be suffered damages to some extent. The cross section is determined only to prevent tidal head about 7.0 m between inner side and outer side of the embankment. (cf. Fig. 5.4.4)

How to utilize the flat area utilize formed by the embankment has not been considered.

The alignment of the embankment is the same as in the Vergara's plan.

Canal excavation materials

The material of the embankment would be partially reused from canal excavation materials.

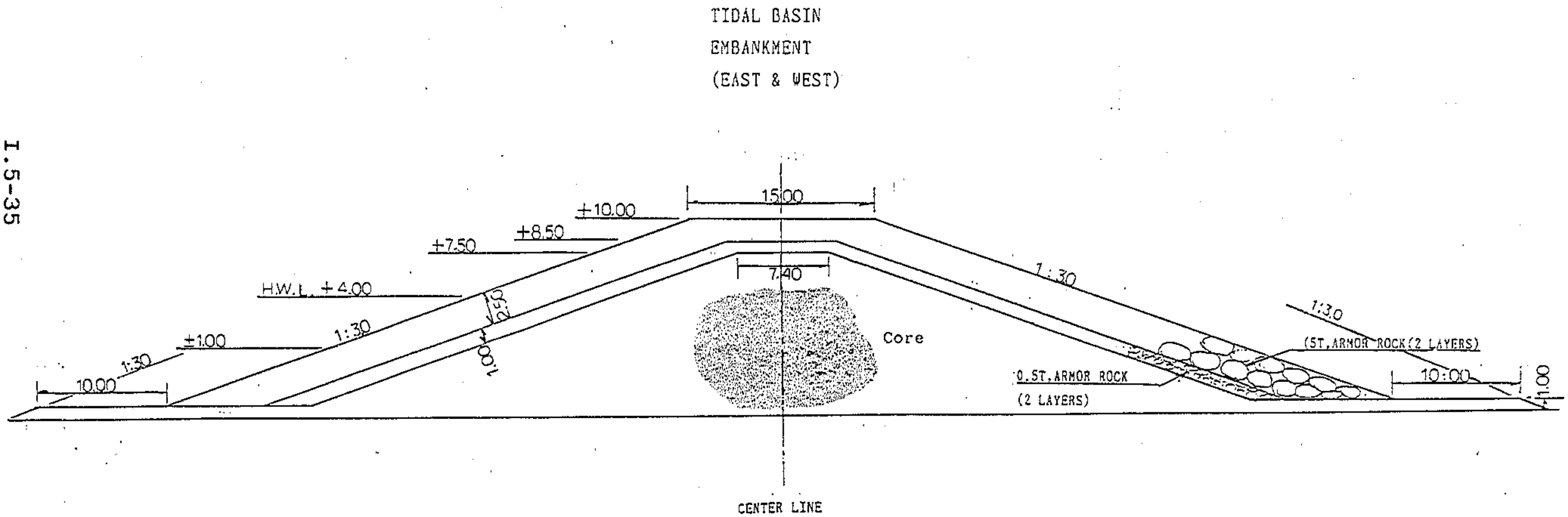


Fig. 5.4.4 Construction Method of Core and Armor Rock Pacific Ocean

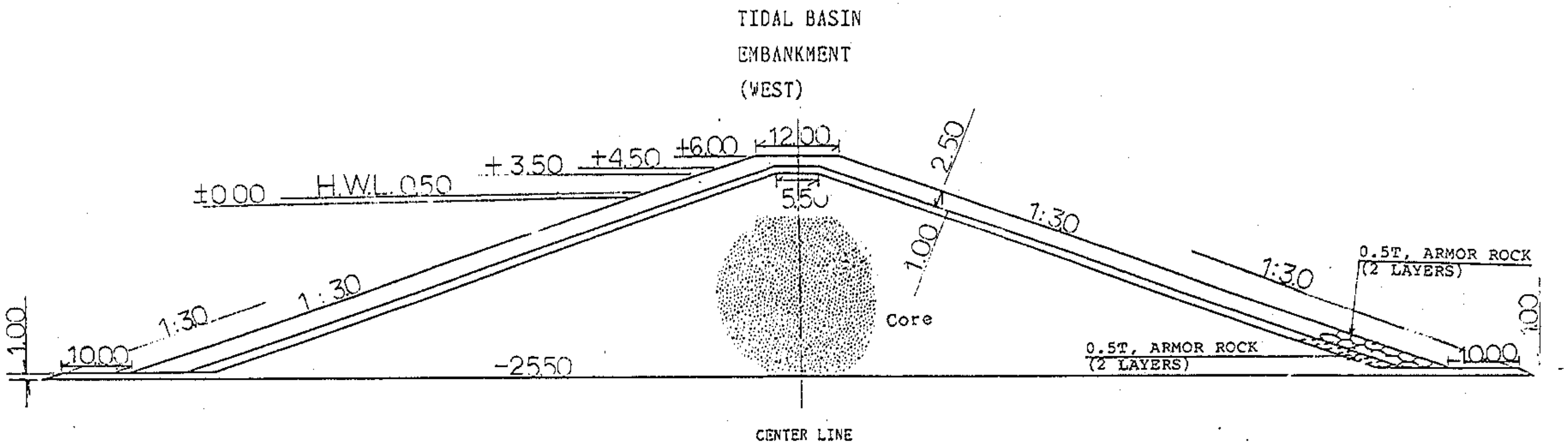


Fig. 5.4.5(1) Construction Method of Core and Armor Rock Pacific Ocean

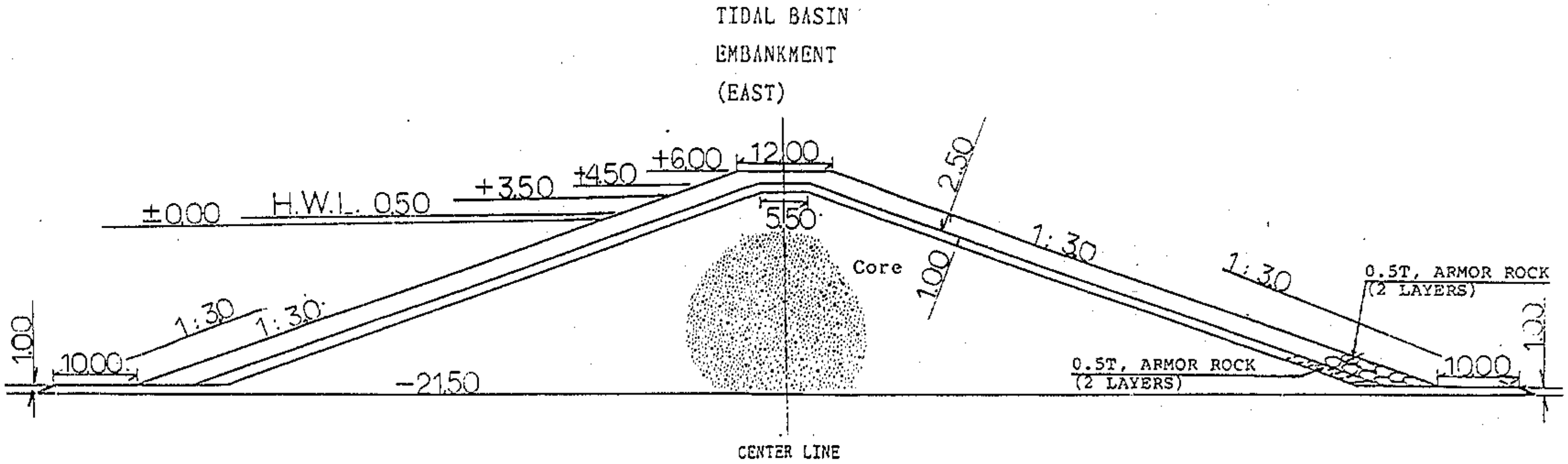


Fig. 5.4.5(2) Construction Method of Core and Armor Rock Pacific Ocean

Table 5.4.1 Embankment Length and Mean Depth for Tidal Basin

	Length			Mean Depth
Atlantic Coast	East	5,000 m	(Total 17.6 km)	- 21.50 m
	West	12,600 m		- 25.50 m
Pacific Coast	East	10,200 m	(Total 20.1 km)	- 5.50 m
	West	9,900 m		- 5.50 m

Table 5.4.2 Volume of Core and Armor Rocks for Tidal Basin

	Atlantic Coast	Pacific Coast
Core	43,012,000 m3	11,860,000 m3
Armor Rock (0.5 ton/rock)	3,546,000 m3	1,688,000 m3
Armor Rock (5.0 ton/rock)	7,268,000 m3	4,985,000 m3
Total	53,826,000 m3	18,533,000 m3

CHAPTER 6 - COMPLEMENTARY FACILITIES

6.1 General

The complementary system is a set of canal alternatives such as overland transportation by use of road, rail and pipeline systems when cargo volume exceeds the capacity of the existing canal. In order to make a comparison with canal alternatives, all fixed overland transportation costs (Port, landing/loading facilities, overland transportation terminals and its attached facilities, and transportation machinery such as trucks and rolling stocks) must be known.

The handling of cargo designated for overland transportation is very complicated due to the cargo type, condition, handling, shipping companies and exporting and destination countries. However, for a comparison of canal alternatives, these will be simplified and it will be assumed that cargo handled by roads and railways will be containerized and the entrance and exit of the cargo will be managed suitably at the overland freight terminals.

6.1.1 Cargo Handling Capacity

Cargo handling capacities are given in the following Table.

Table 6.1.1 Cargo Handling Capacity

Complementary Systems	Route	Capacity
		(mill.b./day)
F. Oil Pipeline & Associated Mooring Facilities	Western Panama Near Existing Petrol Terminals Location	0.5 1.0 1.5 2.0
G. Landbridge, Railway Associated Port and Terminal Facilities using Centerport Concept	Central Panama; Panama City to Colon	(mill.ton/yr) 10 20 30 40
H. Landbridge, Road & Associated Port and Terminal Facilities using Centerport Concepts	Central Panama	(mill.ton/yr) 10 20 30 40

6.1.2 Layout Plan of the Facilities

Railway system and road system composed of ports and terminal facilities are shown in Fig. 6.1.1.

The existing railway 74 km long with some improvement works and new port facilities near the Balboa Harbor in the east side of the canal have been proposed as a railway system for 10 Mill ton/year capacity.

Another new railway system with port facilities, for the capacities of 20, 30, 40, Mill ton/year, has been planned in the west side of the Canal. The length of the railway is 69 km and the gauge is 1,524 mm.

A road system, instead of a railway system, with new port facilities which are same to the case of railway system has been planned in the east side of the canal. The existing road of 82.5 km long with some improvement works is applied as for 10 Mill ton cargo volume/year case.

A new road with new port facilities has been proposed in the west side of the canal. This new road system covers cargo capacities of 20, 30, 40, Mill ton/year cases. The alignment of this road is almost same to that of the new railway system.

Fig. 6.1.1 shows the arrangement of these systems. The length of this new road is 70 km and the number of lanes is 2-4.

Each project cost is summarized in Table 6.3.5, 6.4.3 and 6.5.3.

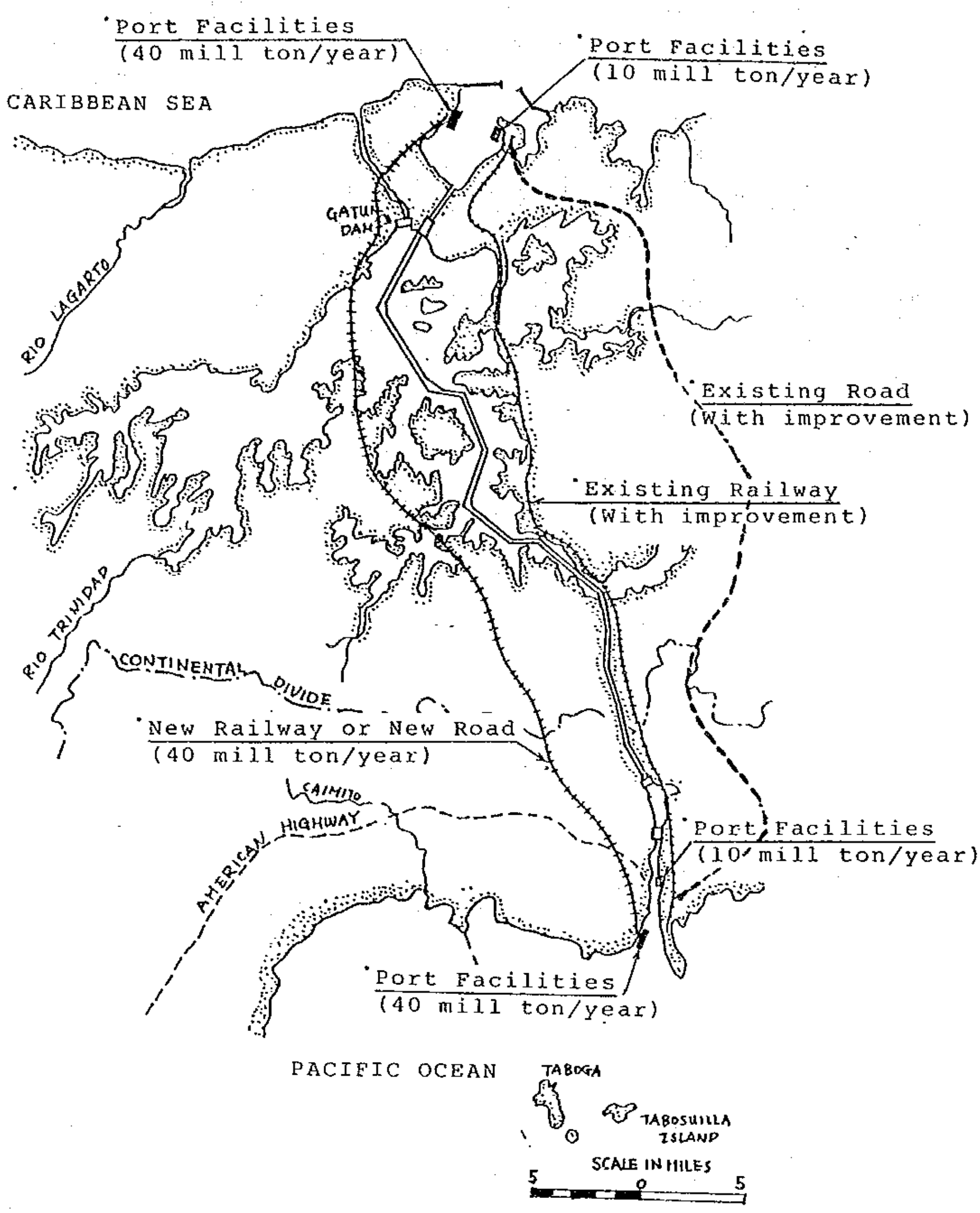


Fig. 6.1.1 Arrangement of Railway and Road System

6.2 Port Plan

Land Bridge Proposal

As complementary facility to the existing Panama Canal or to some of the 36 study cases considered elsewhere, the construction of container bases on both the Atlantic and Pacific Ocean sides and connection of the harbors by over land transportation has been considered. A study of the scale of harbor facilities required for handling annual freight volumes of 10,20,30 and 40 million tons per year has been carried out and the findings are given below.

The following assumptions have been made:

1. Targeted freight is in 40' container units with a weight of *30 tons (2 TEU) each.

2. Containers landed on the Atlantic side are loaded as is onto freight trains or trucks and transported overland to the Pacific side and reloaded onto ships (and vice versa). Freight destined for domestic Panama would not be handled.

3. 250 working days per year are assumed excluding Saturday and Sunday and other festive holidays.

4. Variation in volume handled daily is 1.2 (maximum volume handled daily/average volume handled daily).

5. Freight handling is 24 hours/day, however, with worker shift changes and rest periods the work day is 18 hours and the actual work day coefficient is therefore 0.75 (18/24).

6. Freight handling time for 1 container ship should be less than 2 days.

7. Each container crane is a Gantry crane and has a handling capacity of 20 units/hour.

8. Targeted ships, with consideration to recent container ship designs, will be 40,000 DWT (approx. 2000 TEU) (max. 50,000 DWT, 2800 TEU).

Note: *

A statistic data of a freight volume handled in YOKOHAMA Port in Japan in 1990 was 13.3 Mill Ton (export), 10.3 Mill Ton (import) and total 23.6 Mill Ton.

From the results, the weight of a 40' container unit (2-TEU) becomes 33.6 Ton/2-TEU for a packed container and 28.6 Ton/2-TEU for a empty container, then the weight of 30 Ton per 40' container as mean weight for mixed containers was applied in the studies.

Following Table 6.2.1 shows the freight volume actually handled and the number of containers in YOKOHAMA Port.

Table 6.2.1 Freight Volume and Number of Container

	(1)	(2)	(3)	(4)	(5)
	Mill Ton	Mill TEU	Ton/TEU	Mill Ton	Ton/TEU
Export Import	13.3 10.3	0.72 0.69	18.5 15.0	0.85 0.80	15.6 12.9
Mean	23.6	1.41	16.8	1.65	14.3

Note: (1) Shows Freight volume in Mill Ton.
(2) Shows the number of containers excluding empty ones.
(3) Shows the weight of a containers excluding empty ones.
(4) Shows the number of containers including empty ones.
(5) Shows the weight of a container including empty ones.

6.2.1 Required Number of Berths

The number of berths and cranes required for handling annual freight volumes of 10,20,30 and 40 million tons per year has been estimated in this section and the results are summarized below.

Handled freight volume	No. of berths required	No. of Gantry Cranes required
10 mill. tons	2	2 cranes x 2B = 4
20 mill. tons	4	2 cranes x 4B = 8
30 mill. tons	6	2 cranes x 6B = 12
40 mill. tons	8	2 cranes x 8B = 16

Details of the derivation of the number of berths required are given below.

(1) 10 million tons/year

Handled freight volume	10,000,000 t
Target ships	40,000 DWT
No. of 40' containers loaded per ship	1,000 units
Container unit weight	30 t/unit
Work days/year	250 days
Work hours coefficient	0.75
Crane capacity	20 units/hour
No. of cranes	2 units/berth
No. of containers to be handled per year (10 mill/30)	333,333
No. of ships arriving at the port per year (333,333/1000 containers/ship)	333
Crane capacity/berth/day (20 x 2 x 24 x 0.75)	720 containers
Maximum handling volume/day (720 x 1.2)	864 containers

Wharf time/ship (1000 units/[20x2])	25.00 hours
actual (25/0.75=33.3 hours/24)	1.39 days
Required no. of berths (333,333/[720x250])	1.9 berths

(2) 20 million tons/year

Handled freight volume	20,000,000 t
Target ships	40,000 D.W.T.
No. of 40' containers loaded per ship	1,000 units
Container unit weight	30 t/unit
Work days/year	250 days
Work hours coefficient	0.75
Crane capacity	20 units/hour
No. of cranes	2 units/berth
No. of containers to be handled per year	666,667
No. of ships arriving at the port per year	667
Crane capacity/berth/day	720 containers
Maximum handling volume/day	864 containers
Wharf time/ship	25.00 hours
actual	1.39 days
Required no. of berths	3.7 berths

(3) 30 million tons

Handled freight volume	30,000,000 t
Target ships	40,000 DWT
No. of 40' containers loaded per ship	1,000 units
Container unit weight	30 t/unit
Work days/year	250 days

Work hours coefficient	0.75
Crane capacity	20 units/hour
No. of cranes	2 units/berth
No. of containers to be handled per year	1,000,000
No. of ships arriving at the port per year	1,000
Crane capacity/berth/day	720 containers
Maximum handling volume/day	864 containers
Wharf time/ship	25.00 hours
actual	1.39 days
Required no. of berths	5.6 berths

(4) 40 million tons

Handled freight volume	40,000,000 t
Target ships	40,000 DWT
No. of 40' containers loaded per ship	1,000 units
Container unit weight	30 t/unit
Work days/year	250 days
Work hours coefficient	0.75
Crane capacity	20 units/hour
No. of cranes	2 units/berth
No. of containers to be handled per year	1,333,333
No. of ships arriving at the port per year	1,333
Crane capacity/berth/day	720 containers
Maximum handling volume/day	864 containers
Wharf time/ship	25.00 hours
actual	1.39 days
Required no. of berths	7.4 berths

6.2.2 Facility Scale

(1) Water facilities

For the assumed maximum container ship size of 50,000 DWT:

Water way: depth - 15 m,
width - 420 m (1.5 x ship length of 280 m)

Turning basin: depth - 15 m,
turning diameter to be 2 ship lengths
= 280 m x 2 = 560 m

(2) Mooring facilities

Container berth length: 350 m

(3) Marshaling Yard

350 m x 300 m = 100,000 m2

(4) Other Facilities (per berth)

. Gantry Crane	40 tons	2
. Yard Tractor	3 units (1 spare)	4
. Yard Chassis	6 units (2 spare)	8
. Straddle-Carrier System (40', 2 layer stack)	6 units (2 spare)	8
. Power facilities for refrigerate containers		1 unit
. Gantry Lighting System		1 unit

(5) Operations Center

1 operations center in the wharf area
(4 - 5 floors, total floor area 1,000 m2)

6.2.3 Site Plan

Firstly the expansion to Cristobal and Balboa harbors have been considered with reference to the Center Port Plan. On Telfers island in Cristobal harbor, it is possible to construct 5 new container berths (350 m x 5) and secure sufficient area for anchorage. At Balboa harbor, it is possible to construct 3 new berths (350 m x 3) in the Diablo area.

The existing facilities at Balboa harbor (Docks 14-15, approx. 580 m), because of berth water depth and structure, make it difficult to moor a 50,000 DWT container ship. Moreover, when considering that freight for domestic use in Panama is handled, it has been decided that containers for transit across Panama would not be handled using the existing facilities.

For a handled volume of 10 million tons/year, the Diablo region could be used but if volumes become greater than 20 million tons/year or greater it would become necessary to secure another area for cargo handling. This could be done by land filling the area around the current spoil dump area on the west side of the canal at the mouth.

At Cristobal harbor, for freight volumes of 10 million tons/year, 2 new container berths would be constructed on Telfers island. If freight volume were to reach 20 million tons/year, Cristobal would be connected to Balboa by a new road or rail and considering this, an area on the west side of the canal behind the scheduled anchorage expansion area, would be secured.

6.2.4 Facility Improvement and Construction Volumes

The crown height of the wharf would be 2.0 m above HWL.

Crown height of the wharf

Balboa harbor	8 m above M.L.W.S
Cristobal	2.6 m above MLW

(1) Balboa Harbor

Table 6.2.1 Construction Requirements

Freight volume	10 mill.tons	20 mill.tons	30 mill.tons	40 mill.tons
Wharf length	700 m	1,400 m	2,100 m	2,800 m
Bulkhead	150 m	800 m	800 m	800 m
Area	25 ha	42 ha	63 ha	84 ha
Land fill volume	0.8 mill.m^3	3.8 mill.m^3	5.7 mill.m^3	7.6 mill.m^3
Dredging volume	13.5 mill.m^3	71.5 mill.m^3	82.4 mill.m^3	93.3 mill.m^3

Table 6.2.2 Facility Improvements

Gantry cranes	4	8	12	16
Yard tractor	8	16	24	32
Yard chassis	16	32	48	56
Straddle-carrier system	16	32	48	56
Container power supply	1 system	1 system	1 system	1 system
Lighting	1 system	1 system	1 system	1 system
Operations center	1	1	1	1

(2) Cristobal Harbor

Table 6.2.3 Construction Requirements

Freight volume	10 mill.tons	20 mill.tons	30 mill.tons	40 mill.tons
Wharf length	700 m	1,400 m	2,100 m	2,800 m
Bulkhead	100 m	100 m	100 m	100 m
Area	24 ha	45 ha	66 ha	87 ha
Land fill volume	0.03 mill.m^3	3.4 mill.m^3	5.0 mill.m^3	6.4 mill.m^3
Dredging volume	9.2 mill.m^3	29.6 mill.m^3	36.4 mill.m^3	43.2 mill.m^3

Table 6.2.4 Facility Improvements

Gantry cranes	4	8	12	16
Yard tractor	8	16	24	32
Yard chassis	16	32	48	56
Straddle-carrier system	16	32	48	56
Container power supply	1 system	1 system	1 system	1 system
Lighting	1 system	1 system	1 system	1 system
Operations center	1	1	1	1

Table 6.2.5 Cost Estimation (10 Mil.Ton/Year)

Unit Mil. US$

	Cristobar	Balboa	Total
Port Construction	64.7	91.4	156.1
Gantry Crane	26.0	26.0	52.0
Tractor Head	0.6	0.6	1.2
Chassis	0.2	0.2	0.4
Straddle-Crriyer	11.3	11.3	22.6
Electric	2.0	2.0	4.0
Housing	11.2	11.2	22.4
Total	116.0	142.7	258.7

Table 6.2.6 Cost Estimation (20 Mil.Ton/Year)

Unit Mil. US$

	Cristobar	Balboa	Total
Port Construction	197.2	455.3	652.5
Gantry Crane	52.0	52.0	104.0
Tractor Head	1.2	1.2	2.4
Chassis	0.4	0.4	0.8
Straddle-Crriyer	22.6	22.6	45.2
Electric	2.3	2.3	4.6
Housing	12.8	12.8	25.6
Total	288.5	546.6	835.1

Table 6.2.7 Cost Estimation (30 Mil.Ton/Year)

Unit Mil. US$

	Cristobar	Balboa	Total
Port Construction	246.6	529.7	776.4
Gantry Crane	78.0	78.0	156.0
Tractor Head	1.8	1.8	3.6
Chassis	0.6	0.6	1.2
Straddle-Crriyer	33.9	33.9	67.8
Electric	2.6	2.6	5.2
Housing	14.4	14.4	28.8
Total	377.9	661.0	1039.0

Table 6.2.8 Cost Estimation (40 Mil.Ton/Year)

Unit Mil. US$

	Cristobar	Balboa	Total
Port Construction	296.1	612.6	908.7
Gantry Crane	104.0	104.0	208.0
Tractor Head	2.4	2.4	4.8
Chassis	0.8	0.8	1.6
Straddle-Crriyer	45.2	45.2	90.4
Electric	3.0	3.0	6.0
Housing	16.0	16.0	32.0
Total	467.5	784.0	1251.5

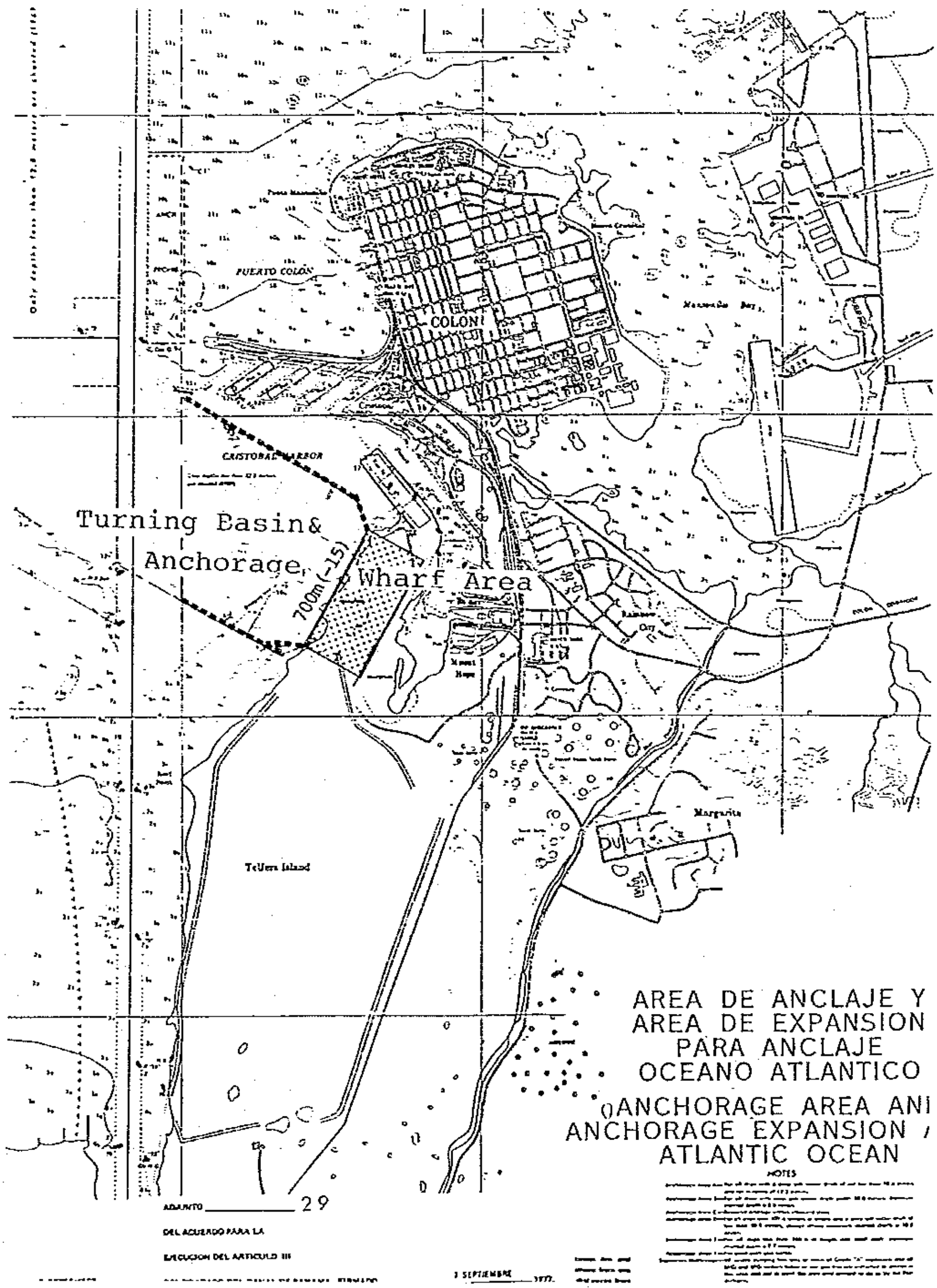


Fig. 6.2.1 Site Plan for 10 Mill.Tons/Year (Cristobal Harbor)

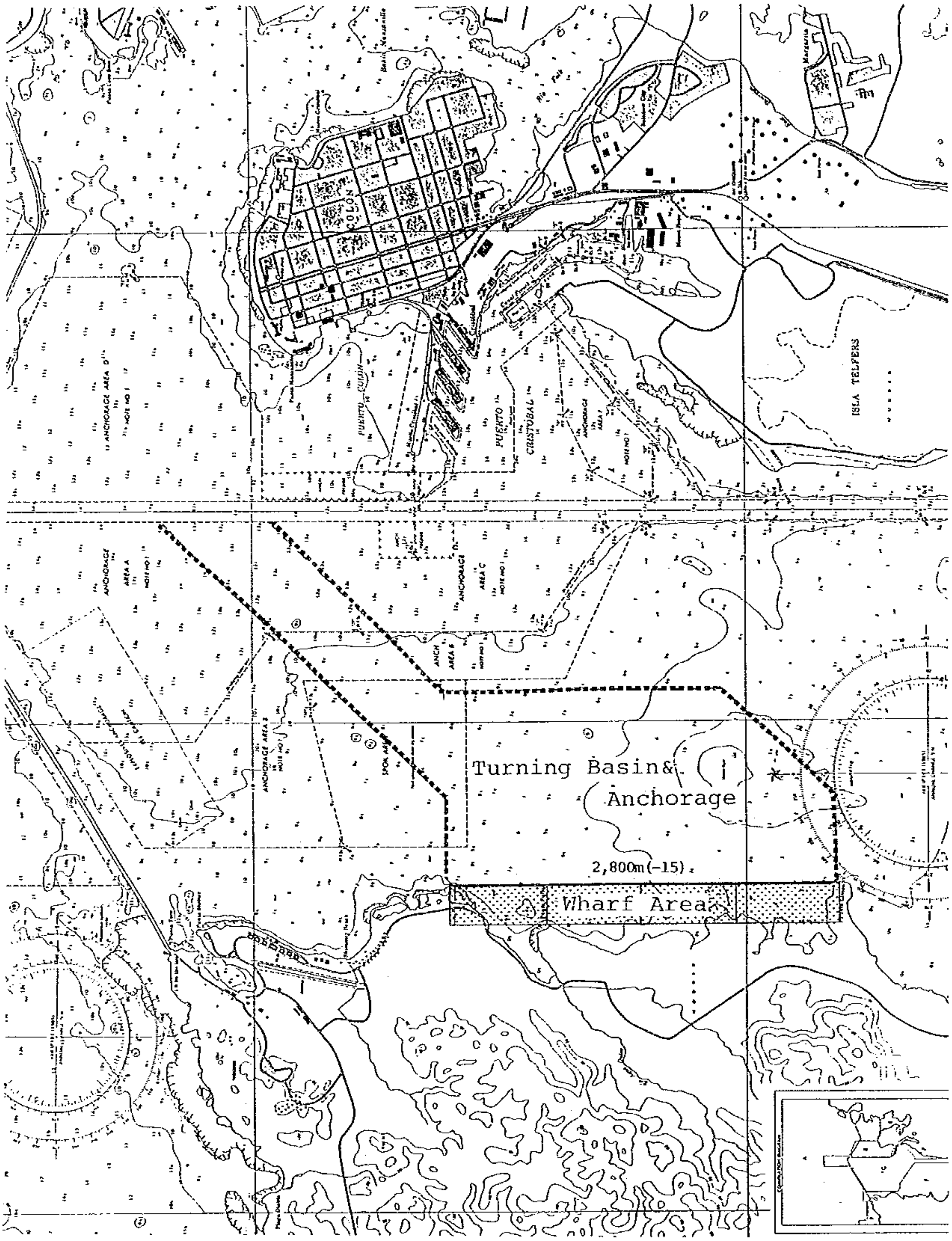


Fig. 6.2.2 Site Plan for 40 Mill.Tons/Year (Cristobal Harbor)

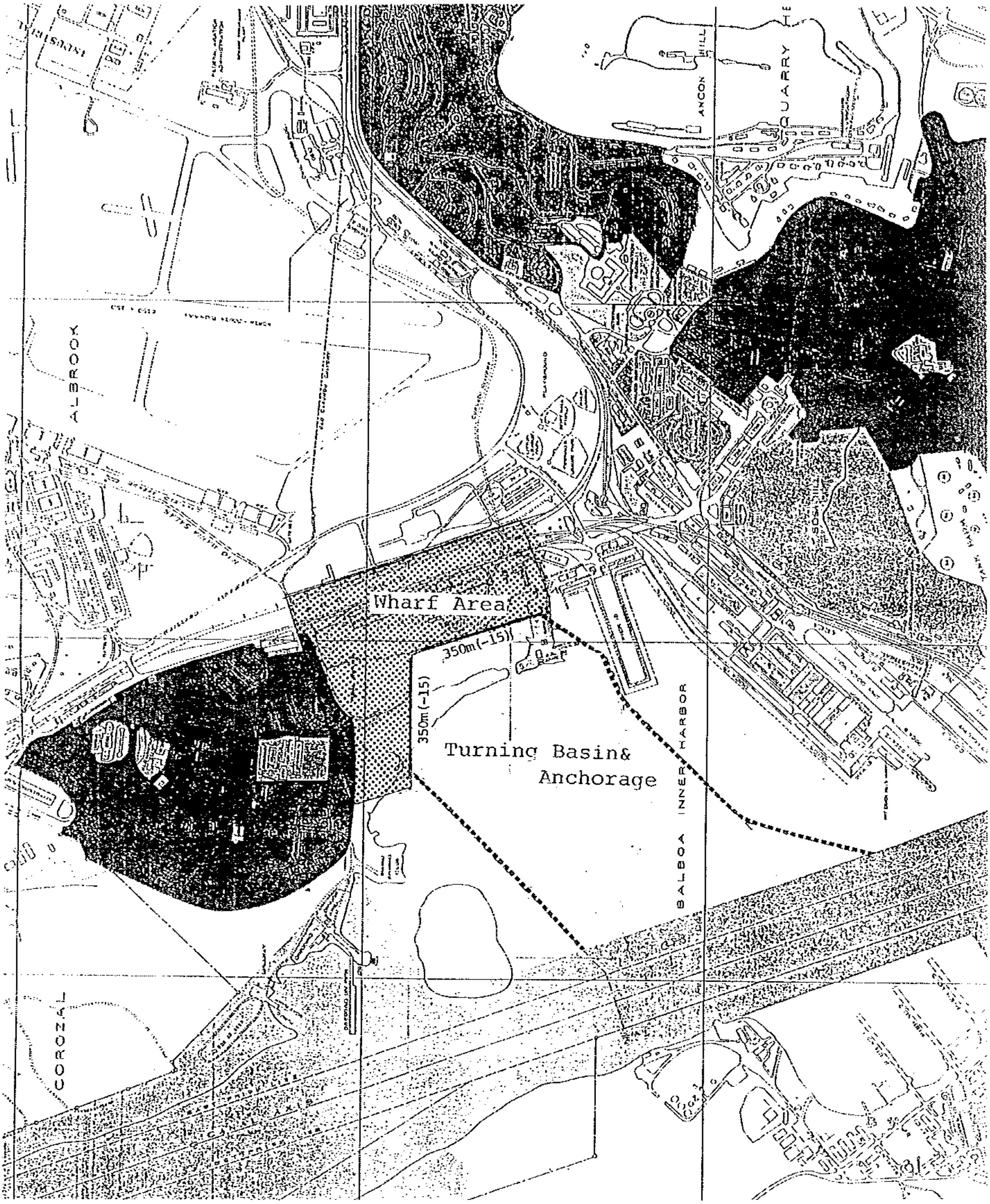


Fig. 6.2.3 Site Plan for 10 Mill.Tons/Year (Balboa Harbor)

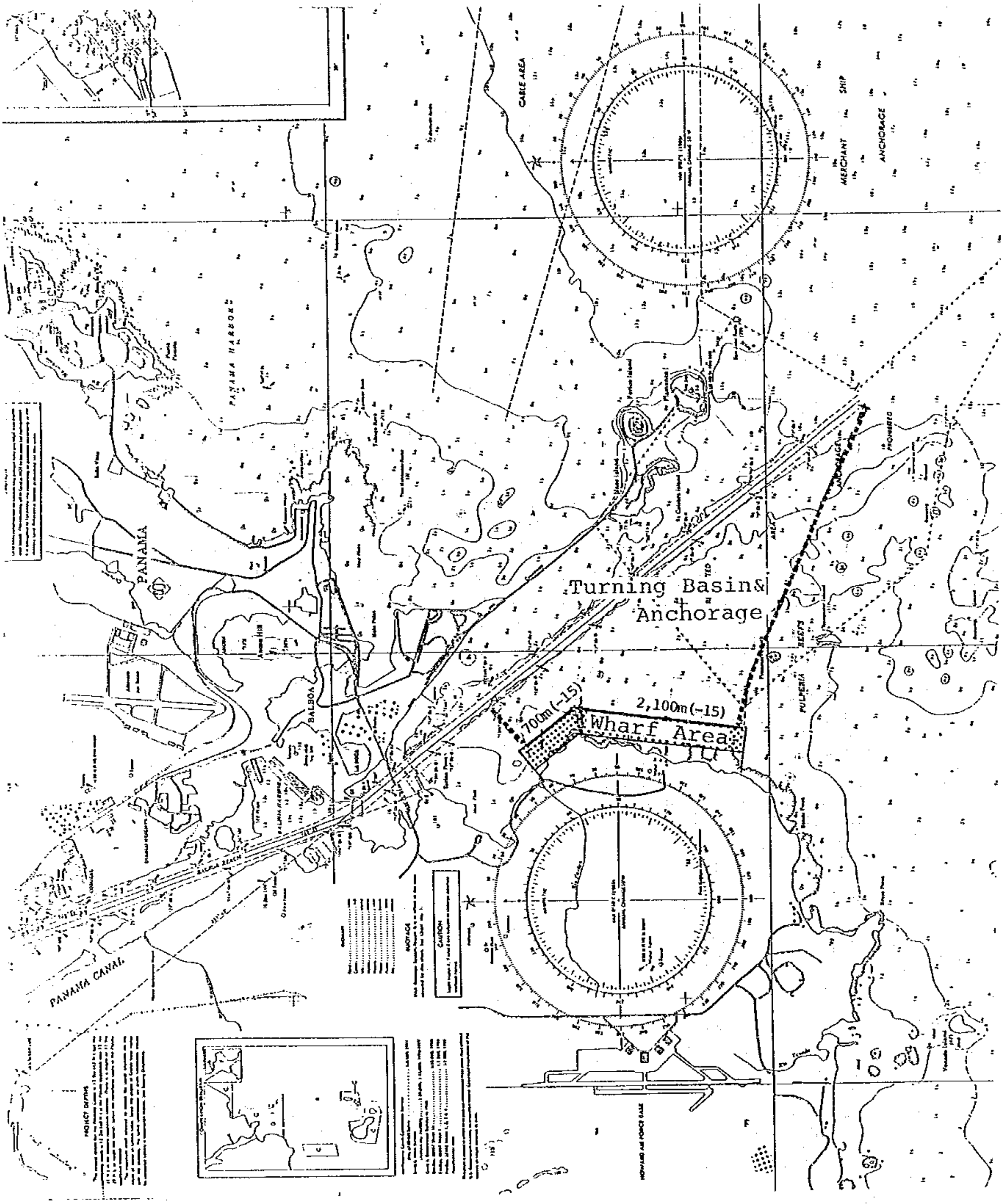


Fig. 6.2.4 Site Plan for 40 Mill.Tons/Year (Balboa Harbor)

6.3 Railway Plan

6.3.1 General Conditions

(1) Rail Freight Plan Objectives

In accordance with the request of the Secretariat the objective is to establish the scale and basis layout of rail facilities required to handle annual transportation volumes of 10 million, 20 million, 30 million and 40 million tons/year.

(2) Daily Freight Volume Projections

The scale of the rail freight facilities required is set by the daily freight volume and freight configuration. The traffic projections for setting the facility scale assume the following.

a) All of the target freight is in 40 foot containers, each weighing an average of 30 tons. (Ref to Page I.6-5)

b) Saturday and Sunday are holidays and there are 6 festive holidays per year giving 250 operational days per year.

c) Daily handling fluctuation (maximum daily volume/average daily volume) is 1.2.

With the above assumptions, the maximum daily volumes are as follows:

10 million tons/year	1,600 containers/day
20 million tons/year	3,200 containers/day
30 million tons/year	4,800 containers/day
40 million tons/year	6,400 containers/day

(3) Rail Freight Plan Preconditions

If the existing Balboa and Cristobal harbors located on the east side on the existing canal and harbor facilities are improved and expanded to 5 berths (each berth being 350 m), an annual volume up to 10 million tons could be handled. When the annual volume is more than 10 to 15 million tons/year, the surrounding conditions are such that securing sufficient berth numbers for the expansion of existing harbor facilities and securing sufficient space around the cargo handling area would be difficult. For this reason it is proposed that for more than 20 million tons annually, new harbor facilities for Balboa and Cristobal harbors would be constructed on the west side of the existing canal.

For an annual freight volume of 10 million tons it is anticipated that the number of containers would amount to 1,600 units per day. The existing Balboa and Cristobal harbors on the east side of the canal would be improved and used for freight terminals. The present railway could be improved and strengthened and used as for rail freight.

In the event that the annual freight volume being handled is 20 million tons per year or more, a new railway line(s) on the west bank of the canal has been proposed for the following reasons.

a) Construction of a new freight terminal and a new rail line(s) on the west side of the canal would affect almost no residential areas and access would be convenient.

b) All annual freight volume of 20 million tons per year or more would mean 3,200 containers per day which would exceed the maximum capacity of the existing railway line.

c) If the existing railway line on the east side of the canal is used for freight, 2 major bridges crossing the canal would be necessary.

6.3.2 Outline of Transportation Plan

(1) Ocean Container Terminal and Railway Container Terminal Relationship

The ocean terminal and rail terminal must be managed in a closely interrelated way although the terminals would be partitioned and managed separately with transportation between the two being done by truck and trailer.

Accordingly, a gate at the truck and trailer entrance of the rail terminal would be erected and manned.

If possible, there should be just one Rail Container Terminal collecting freight from or distributing to the ocean container terminals.

Transportation distance by truck and trailer should be as short as possible and to this end the Rail Container Terminal would be constructed in the vicinity of the ocean container terminals. If it is unavoidable that the ocean terminals are some distance away making the transportation distance by truck and trailer large, multiple rail container terminals should then be situated at various appropriate locations.

In principle, rail transportation should arrive loaded with containers at the Rail Container Terminal and after unloading, containers destined for the other terminal should be loaded for departure. In the same way, truck and trailer transportation should arrive at the terminal loaded with containers for rail collection and after unloading them, depart for the various ocean terminals with containers for distribution.

Rail transportation management should be limited to the Rail Container Terminal with the trailers carrying the freight between the rail and ocean terminals coming under ocean container terminal management.

(2) Ocean container terminal locations and basic concepts of the rail freight transportation plan

a) 10 million tons/year

Ocean container terminals in the case of a 10 million ton/year volume, would be located on the east side of the canal on both the Atlantic and Pacific ocean sides. The proposals are shown in Fig. 6.3.2, 6.3.3 and 6.3.4. The existing railway lines (currently not in use) would be improved and strengthened.

Atlantic coast side
(Cristobal side or Colon side)

The proposal divides the ocean container terminal into 2 sites with ocean container terminal (A) adjoining the south east section of dock 9 and terminal (B) 1 km to the South on Telfers Island on the other side of the Canal Frances inlet.

Because each ocean container terminal would be some distance from a central Rail Container Terminal, it would not be efficient to consolidate the Rail Container Terminal in one location. Hence two separate Rail Container Terminals have been proposed.

The Rail Container Terminal for Ocean Container Terminal (A) (Rail Container Terminal (A)) will be situated in the area between Ocean Container Terminal (A) and Mount Hope Yard with Mount Hope Yard being converted for use as sidings.

The Rail Container Terminal for Ocean Container Terminal (B) (Rail Container Terminal (B)) will be constructed behind Ocean Container Terminal (B) with a new line diverging from the existing line. The rail sidings would adjoin the Rail Container Terminal.

Pacific coast side (Balboa side)

The proposed divides the Ocean Container Terminal into 2 sites, the northern side of pier 18 (Ocean Container Terminal (A)) and the southern side (Ocean Container Terminal (B)) as shown in Fig. 6.3.3. It would be preferable to locate a Rail Container Terminal next to each Ocean Container Terminal however, because of severe space limitations, only one Rail Container Terminal has been proposed. It would be located on the western side of Ocean Container Terminal (A). This site is now occupied by the Diablo Yard, which is on the main line and would be converted for use as the Rail Container Terminal with rail sidings located beside it and repair yards constructed on the southern side.

Rail line

Restoration and strengthening of the rail line (a single track currently not in use) would be carried out, Passing Lanes new two stations where trains will pass, and signal automation for steep gradient sections etc., would be provided allowing efficient and safe freight transportation between ocean container terminals.

Freight transportation distance	:	Approximately 74 km
Gauge	:	1,524 mm
Permitted weight	:	15 tons
Maximum gradient	:	Approximately 1.3%
Minimum curve radius	:	300 m

Rolling stock

The trains will be made up of 30 freight cars (empty weight approx. 15 tons, freight weight of 30 tons, freight car length of approx. 15 m) each carrying one 40' container.

Diesel electric locomotives which are widely used throughout the world will be used, and coupled locomotives each with a power capacity of apprx. 2,000 ps and locomotive weight of approx. 80 ton are considered under following condition.

Scheduled speed: Approx. 23 m.p.h. (37 km/h)
Scheduled time : Approx. 2 hr.

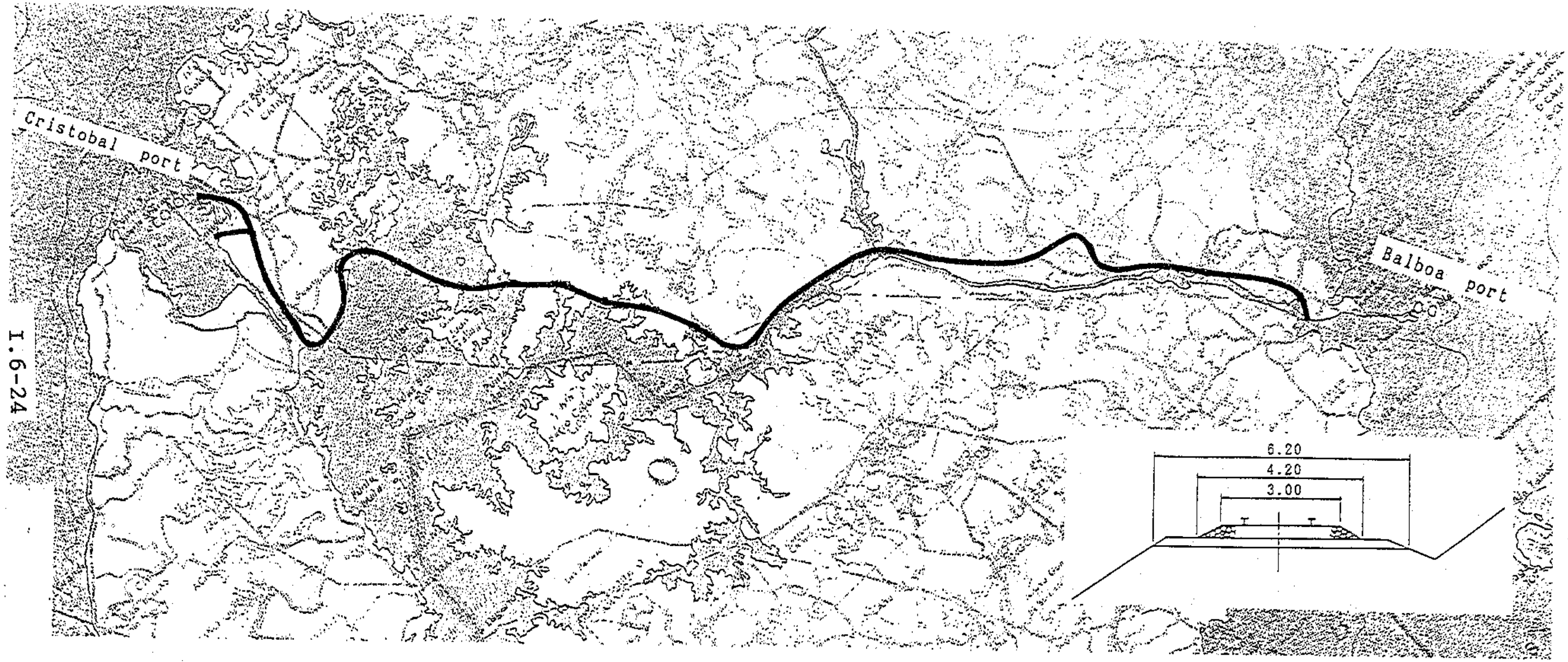


Fig. 6.3.1 Existing Railway Improvement Plan

b) 20 million tons/year and above

In the case of 20 million tons per year and above, the Ocean Container Terminal on both the Atlantic and Pacific coast sides would be on the west bank of the canal. However there is as yet no definite proposal and preliminary locations shown in Figs. 6.3.2, 6.3.5 and 6.3.6 have been adopted.

Rail freight transportation will be carried out using new lines (double track) constructed along the west bank of the canal.

Atlantic coast side

The proposed location of the Ocean Container Terminal is on the west side of Limon Bay, in contrast to the proposal for 10 million tons/year, locating ocean container terminals (A) and (B) on the eastern shore.

The Rail Container Terminal will be constructed in the area behind the Ocean Container Terminal with the rail sidings located beside it.

Pacific coast side

The Port Plan in Section 6.3 proposes that the Ocean Container Terminal should be located on the west bank of the canal near Guinea Point and on the coastline extending Point.

It is proposed that the Rail Container Terminal will be constructed in the area behind the Ocean Container Terminal.

However, due to space restrictions resulting from the hills behind, it would be difficult to locate the rail sidings and repair yards next to the Rail Container Terminal. Therefore, the proposed location of the parking tracks and repair yards is on the plain to the west of Fartan Hill, even though this is about 2 km away.

Rail lines

A new line with a double track and automatic signal is proposed for 20 million tons/year and above.

To allow for the occurrence of breakdowns etc., passing stations with side tracks will be constructed every 20 or 30 kms (in other words, at two locations between Cristobal and Balboa) for use as shunting stations with power and signal facilities. The power will be supplied from the container terminals (or the repair yard) at each end to the respective shunting stations.

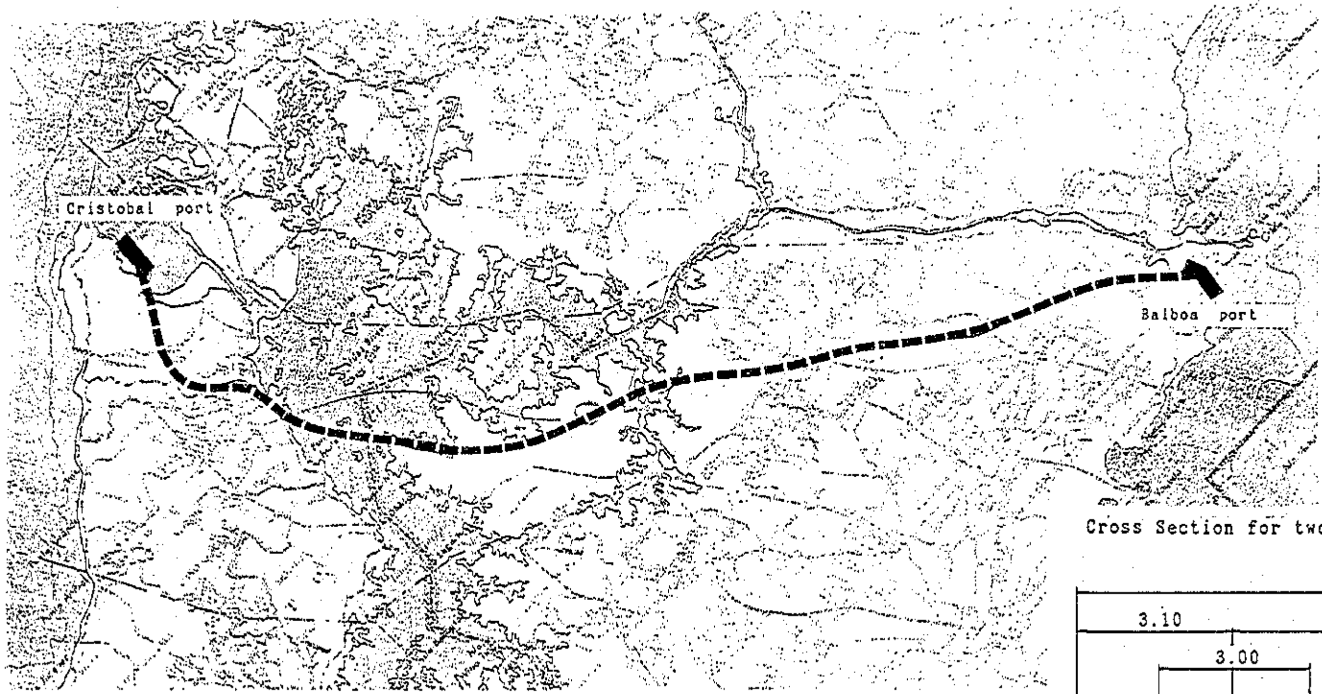
Freight transportation distance	:	69 km
Gauge	:	1,524 mm
Permitted weight	:	15 tons
Maximum gradient	:	1.0% or less, ie less than that of the existing line
Minimum curve radius	:	500 m

Rolling stock

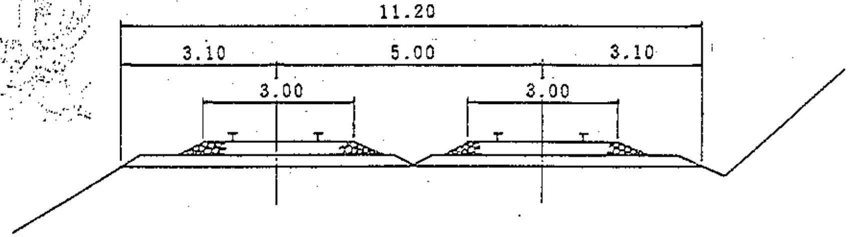
The same train as used the existing line is considered, but their speed capability would be increased due to good line condition.

Scheduled speed: Approx. 31 m.p.h. (50 km/h)
Scheduled time : Approx. 1.5 hr

Layout Plan of New Railway



Cross Section for two Truck



Profile

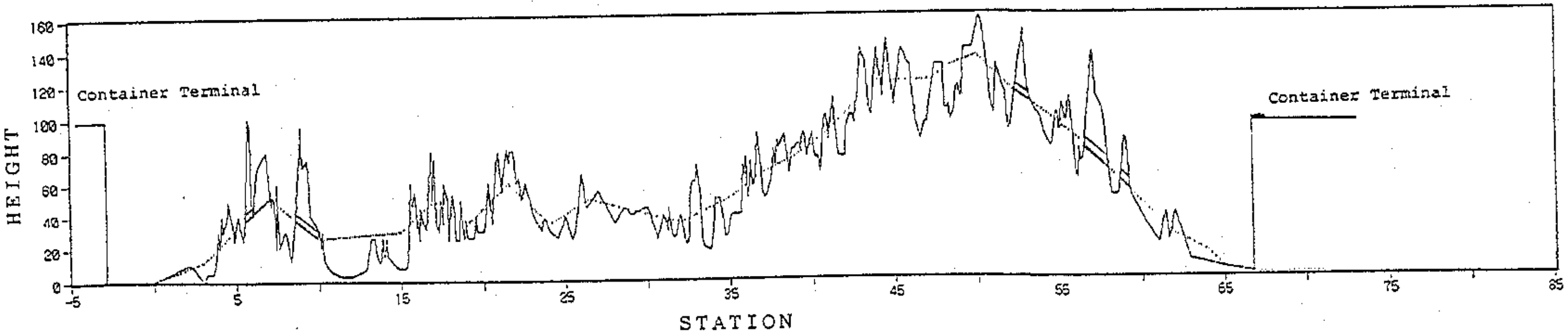


Fig. 6.3.2 Layout Plan for Location of New Railway

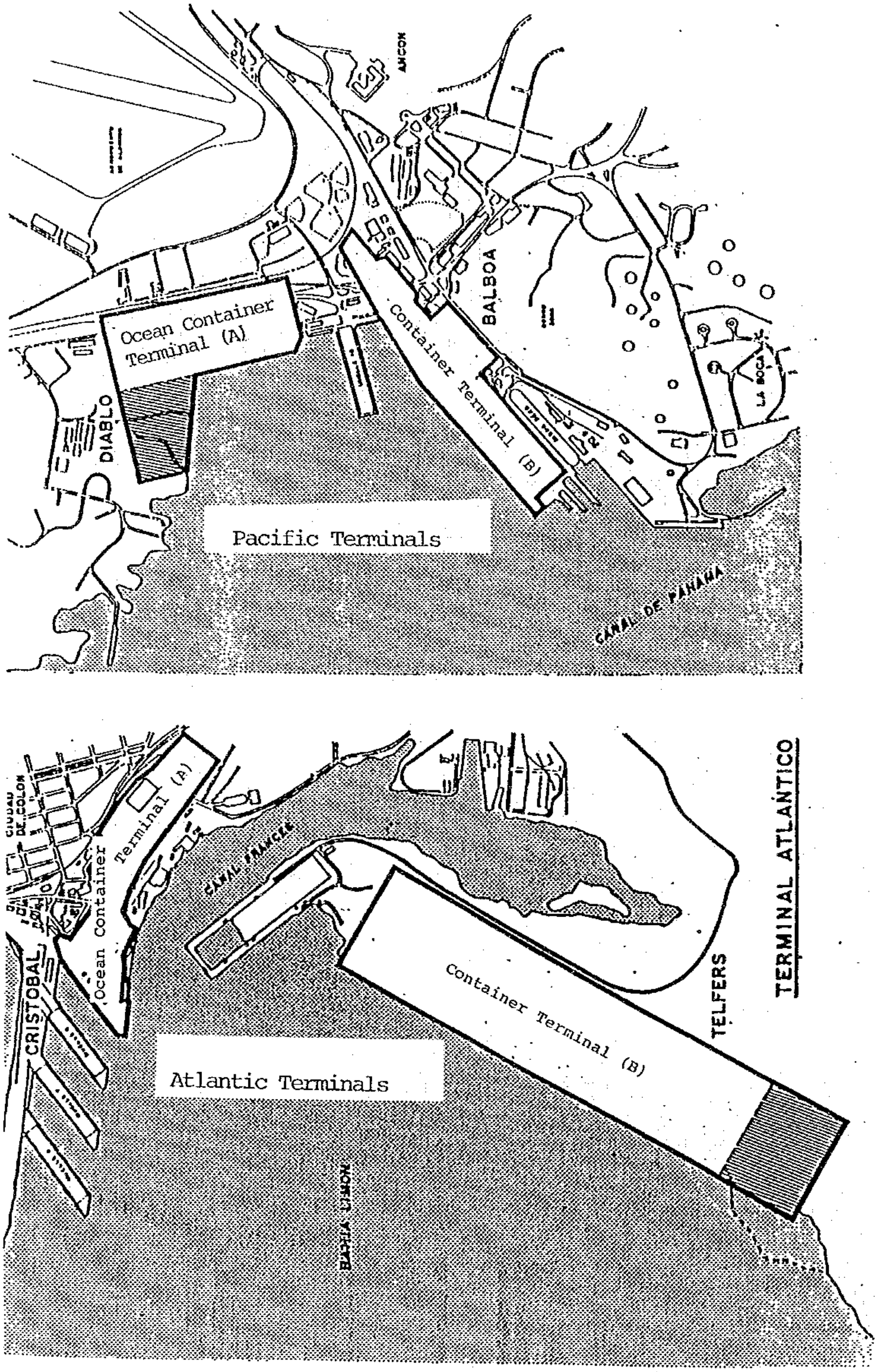


Fig. 6.3.3 Container Terminals (For 10 Million Tons/Year)

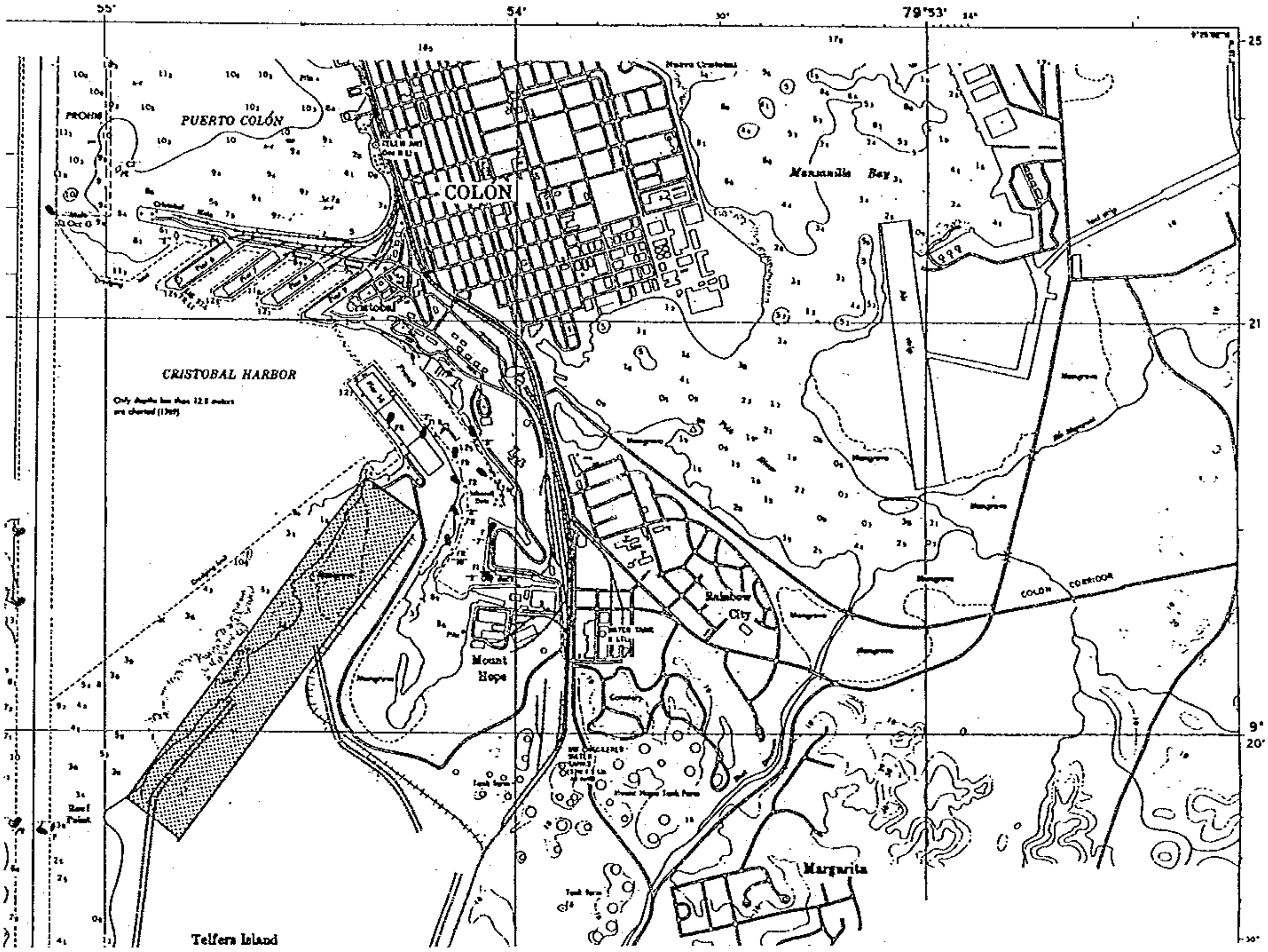


Fig. 6.3.4 Atlantic Side Rail Container Terminal B
(10 Million Tons/Year)

Fig. 6.3.5 Container Terminals (For 20 Million Tons/Year)
Atlantic Side

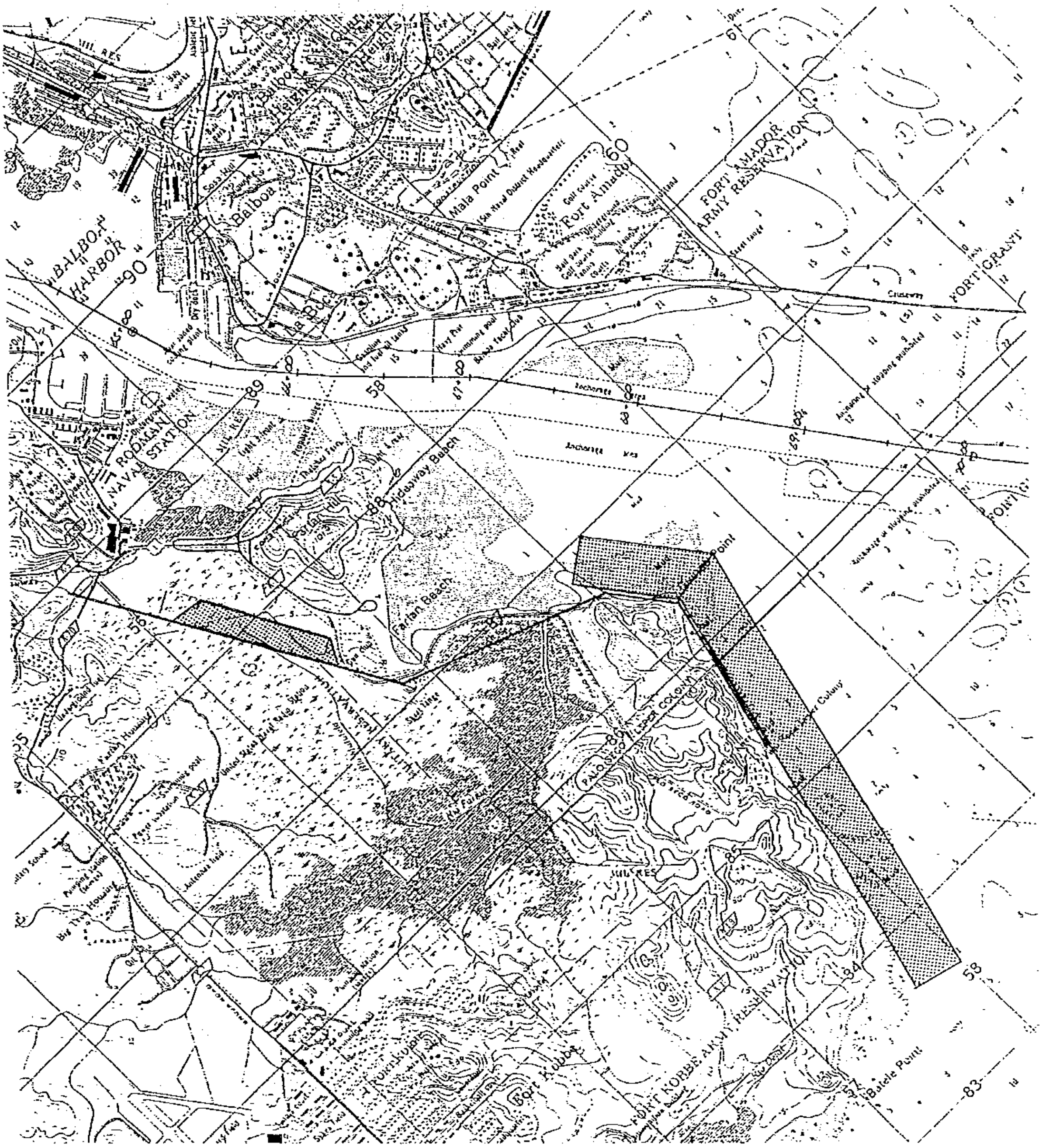


Fig. 6.3.6 Container Terminals (For 20 Million Tons/Year)
Pacific Side

6.3.3 Train Operation Plan and Cost Estimation

(1) Number of trains operating (daily)

Using a 30 car train with one 40' container per car, the required numbers of trains operations one way and train operating pitch are shown below.

Table 6.3.1 No. of Required Trains/Day and Train Operation Pitch

Annual Volume (t/year)	Daily Volume (containers/day)	Number of Required Trains Operation One Way (trains/day)	Train Operation Pitch (min.)	Comments
10 mill.tons	1,600	27	40	Round trip of 54 trains/day. Track capacity of a single track is usually 80 to 90 trains/day hence a single track (upgraded existing) would be adequate.
20 mill.tons	3,200	54	20	Round trip of 108 trains/day. New double track is proposed. Because the expected volume is quite high. Double tracks would be preferable considering future increases in volume handled.
30 mill.tons	4,800	80	14	The track capacity for double track is usually 130 to 150 trains/day on each track therefore double track required and has adequate capacity.
40 mill.tons	6,400	107	10	Double tracks required, no capacity problem.

(2) Number of locomotives, freight cars and rail sidings to be provided. See Table 6.3.2.

Table 6.3.2 No. of Provided Locomotives, Freight Cars and Rail Sidings Except Two Sidings for Loading and Unloading.

Volume handled daily (containers/day)	Usage	Coupled locomotives (couples)	Freight cars (cars)	Number of rail sidings Atlantic Coast	Number of rail sidings Pacific Coast
1,600	Cars in operation	7	9 x 30 = 270	3	2
	Held in reserve for maintenance	1	1.5 x 30 = 45	-	1
	Held in reserve for operation	1	1 x 30 = 30	-	1
	Total	9	345	3	4
3,200	Cars in operation	10	12 x 30 = 360	4	4
	Held in reserve for maintenance	2	2 x 30 = 60	-	2
	Held in reserve for operation	1	1 x 30 = 30	-	1
	Total	13	450	4	7
4,800	Cars in operation	14	16 x 30 = 480	6	6
	Held in reserve for maintenance	2	2.5 x 30 = 75	-	2
	Held in reserve for operation	1	1 x 30 = 30	-	1
	Total	17	585	6	9
6,400	Cars in operation	19	21 x 30 = 630	9	9
	Held in reserve for maintenance	3	3 x 30 = 90	-	3
	Held in reserve for operation	1	1 x 30 = 30	-	1
	Total	23	750	9	13

(3) Rail Container Terminal Facility. See Table 6.3.3.

Table 6.3.3 No. of Required Gates and Track Lanes

Volume Handled Day (containers)	Transfer Crane	No. of Gates Required	No. of Track Lanes
1,600 (30 containers unloaded and loaded in 40 mins)	2	1	1
3,200 (30 containers unloaded and loaded in 20 mins)	3	1	1
4,800 (30 containers unloaded and loaded in 14 mins)	5	2	2
6,400 (30 containers unloaded and loaded in 10 mins)	6	2	2

(4) Cost Estimation

Table 6.3.4 Cost Estimation

Unit: Mill. US$

(Mill. Tons/Year)	10	20	30	40
Railway construction	27	239	239	239
Rail and Track	10	28	29	31
Housing	17	23	23	23
Rolling stock	66	90	150	157
Repair shop	10	10	10	10
Container terminal	7	10	14	17
Electric facilities	2	3	4	5
Signal	10	36	36	36
Total	149	439	505	518

From the above the land bridge railway and associated port and terminal facilities were used.

Furthermore is thought that the maintenance costs for these facilities will be about 7% of the overall costs.

Table 6.3.5 Project Cost of Railway System

Unit: Mill. US$

(Mill. Tons/Year)	10	20	30	40
Port	259	835	1,039	1,251
Railway	149	439	505	518
Total	408	1,274	1,544	1,769

6.4 Road Plan

6.4.1 General Conditions

(1) Plan Objective

The objective of the road plan is to establish the scale of road facilities required to handle annual transportation volumes of 10, 20, 30 and 40 million tons/year.

(2) Traffic Volume Estimates

The scale of road facilities required will be estimated according to the volume of traffic anticipated to use the roads. (The units of traffic volume for the facility scale estimate will be in thousands.)

a) The targeted freight will be 40' containers with an average weight of 30 tons.

b) Saturday and Sunday are considered holidays and there are 6 festive holidays per year giving 250 working days per year.

c) The daily handling variation rate (maximum handling rate/average daily rate) is 1.2.

d) It is also assumed that the effects of induced (flow on) trafic would increase trafic volumes by 25%.

e) The pcu (passenger car units) conversion rates for each 40' container trailer will be 4.0.

f) Resulting traffic volume increase

Freight Volume (tons/year)	Traffic Volume (pcu/year)	Traffic Volume/Day (average for 250 working days)	Traffic Volume/Day (Maximum) (pcu/day)	Including Flow-on (pcu/day)
10 million	1.3 million	5,300	6,400	7,800
20 million	2.7 million	10,700	12,800	15,600
30 million	4.0 million	16,000	19,200	23,400
40 million	5.3 million	21,300	25,600	31,200

* Total for both directions, pcu conversion rate = 4.0

(3) Road Plan Preconditions

The existing Balboa and Cristobal harbors are situated on the east side of the existing canal and if these harbor facilities are upgraded to their maximum of 5 berths (with 1 berth equaling 350m), a maximum of 10 million tons per year can be handled. However, space limitations are such that if volumes are in excess of about 10 or 15 million tons/year it would be difficult to establish sufficient berths and storage space for expanding the harbor facilities on the east side of the existing canal. For this reason, in the case of 20 million tons/year and over being handled, it is proposed that new facilities in Balboa and Cristobal harbors would be constructed on the west side of the existing canal.

For freight transportation up to 10 million tons/year, a daily transportation volume of 7,800 - 10,000 pcu's would be expected. In this case, the terminal facilities at Balboa and Cristobal harbors on the east side of the existing canal would be upgraded and used. This would allow use of the existing Transistmica highway if upgraded.

In the case of freight transportation being 20 million tons/year or more, a new road is proposed for the west bank of the canal for the following reasons.

a) A new ocean container terminal would be constructed on the west, away from residential areas making access by a new west bank road convenient.

b) A yearly freight transportation volume of 20 million tons would mean a daily volume of 16,000 - 20,000 pcu's and a new road could provide for this capacity.

c) Traffic conditions on the existing Transistmica highway are congested and although there is a plan to expand it to 4 - 6 lanes in the near future, it would still be necessary to construct a new trans-isthmian road in order to handle the increase in traffic which would result from the land bridge.

6.4.2 Outline of Transportation Plan

(1) Ocean Container Terminal and Truck Terminal Relationship

Ocean Container Terminals consist of facilities for loading and unloading ships at the wharves and temporary storage facilities for the handled cargo. Truck terminals are used not only as bases for overland freight transportation between truck terminals, but also for distribution and delivery to the Ocean Container Terminals. There must be close liaison between the management of the Ocean Container Terminals and the Truck Terminals but the two areas are under separate jurisdiction with transportation between the two being carried out by truck and trailer.

Two truck terminals would be required, one on the Pacific side and one on the Atlantic side. In order to make the freight transportation distance from the Ocean Container Terminal as short as possible and this improve efficiency it is proposed that the terminals should be constructed in the area behind the Ocean Container Terminal.

Trucks and trailers will come into the Truck Terminal loaded from the Ocean Container Terminal and the freight will be stored with the trailer for dispatch to the other Truck Terminal. The receiving Truck Terminal will then store the freight, with trailer, or dispatch it to the Ocean Container Terminal. Road transportation facility costs will apply between the truck terminals while transportation costs for the sector between the Truck Terminal and Ocean Container Terminal will be calculated as part of the Ocean Container Terminal management costs.

(2) Ocean Container Terminal Locations and Basic Concepts of Road Freight Transportation Plan

a) Condition of the Existing Road

The Transistmica Highway is the only significant road currently connecting Panama and Colon. It serves as a trunk road, with roads branching off it connecting to the various regions. The Transistmica Highway passes through relatively hilly country with sections where the surface and vertical alignment standards are low. In addition, the road was constructed almost 30 years ago and with almost no alternative roads, other routes have been established using this road as the trunk route. The distance between Colon (Cristobal Port) and Panama (Balboa Port) is approximately 84.7km with the 6.6km between Colon city and Cativa and 15.2km between Panama city and Isidro being 4 lanes while the rest of the route, 62.5km, is 2 lanes. The sectors close to Colon and Panama cities, including the cities themselves, carry high volumes of mainly urban traffic.

The section between Panama city and the surrounding area is already approaching its traffic capacity and will require the construction of a new road in the future. (ref. Fig. 6.4.1)

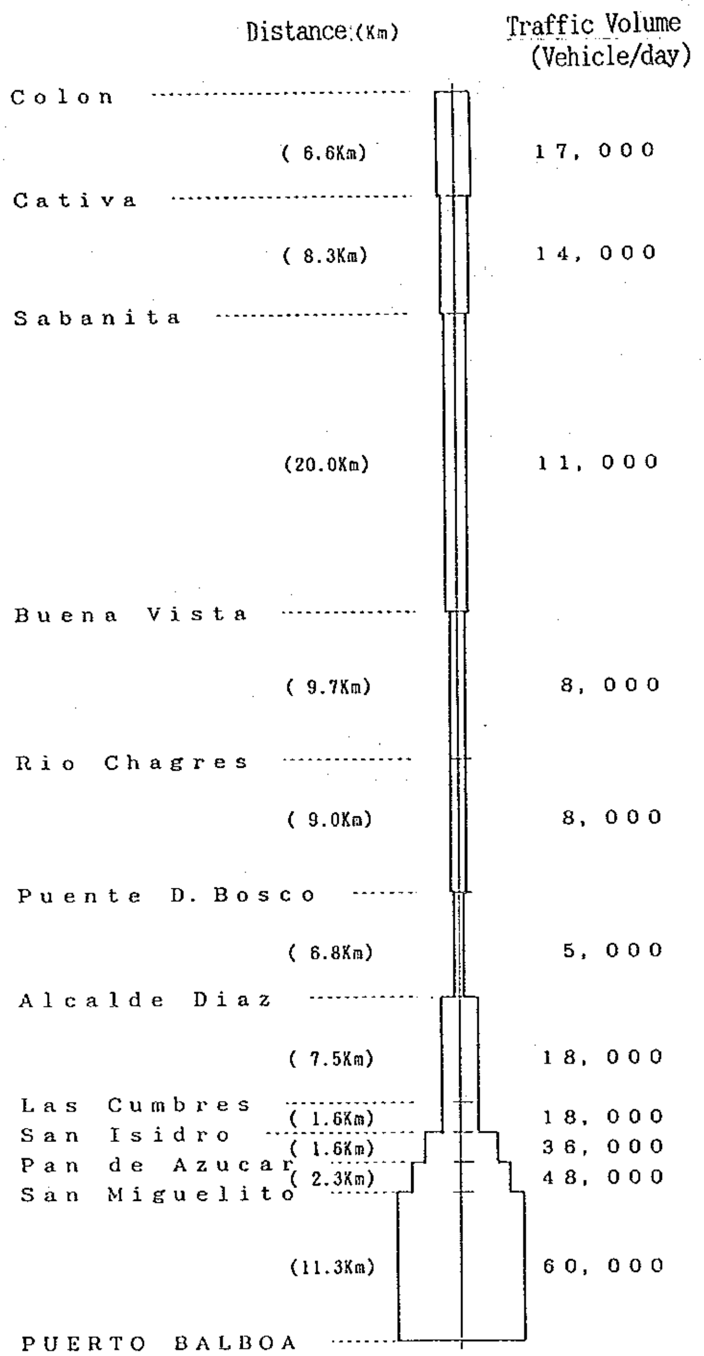


Fig. 6.4.1 Existing Traffic Volume at Colon Panama Road

b) 10 Million Tons/Year

The Ocean Container Terminals on both the Atlantic and Pacific sides would be located on the east bank of the canal and the freight transportation will be handled by the existing road after being upgraded.

1) Atlantic Side

The Ocean Container Terminal will be located on 2 sites as in the Port Plan and it is proposed that the Truck Terminals should be located in the site identified in the Rail Freight Plan for the rail container terminal.

2) Pacific Side

The Truck Terminal on the Pacific side will also be located on the site set out in the Rail Freight Plan for the rail container terminal.

3) Road Plan

The existing facilities would be used as much as possible, however in Panama city, Colon city and their surrounding areas, traffic capacity is already at saturation point. Moreover, the Alcalde Diaz-Buena Vista section where traffic volume is relatively small, is hilly and the road alignment is below standard.

Because the scale of the existing road is small, raising the design speed as part of the road improvements would have a great effect on the route. The bridge between Rio Chargres and Sabanita can be widened to 4 lanes but there would not be enough width for the center median. In consideration of the increase in heavy vehicle traffic and traffic safety, a new bridge is proposed in preference to widening the existing bridge. Considering the hindrance to traffic flow the land bridge traffic volume and natural traffic volume increases along with the huge increase in traffic due to the development of new branch routes, a road improvement plan has been proposed as follows:

Design speed	80km/h
Maximum grade	5%
Minimum radius	300m
Road length	82.5km
Cross section	
Cristobal Port - Cativa	widened from 4 to 6 lanes (6.6km)
Cativa - Sabanita	widened from 2 to 6 lanes (8.3km)
Sabanita - Alcalde Diaz	widened from 2 to 4 lanes (45.5km)
Alcalde Diaz - San Isidro	widened from 2 to 6 lanes (7.5km)
San Isidro - Balboa Port	the construction of new San Miguelita Oeste, Corredor Norte 4 lane road (14.5km)

(ref. Fig. 6.4.2, 6.4.3 and 6.4.4)

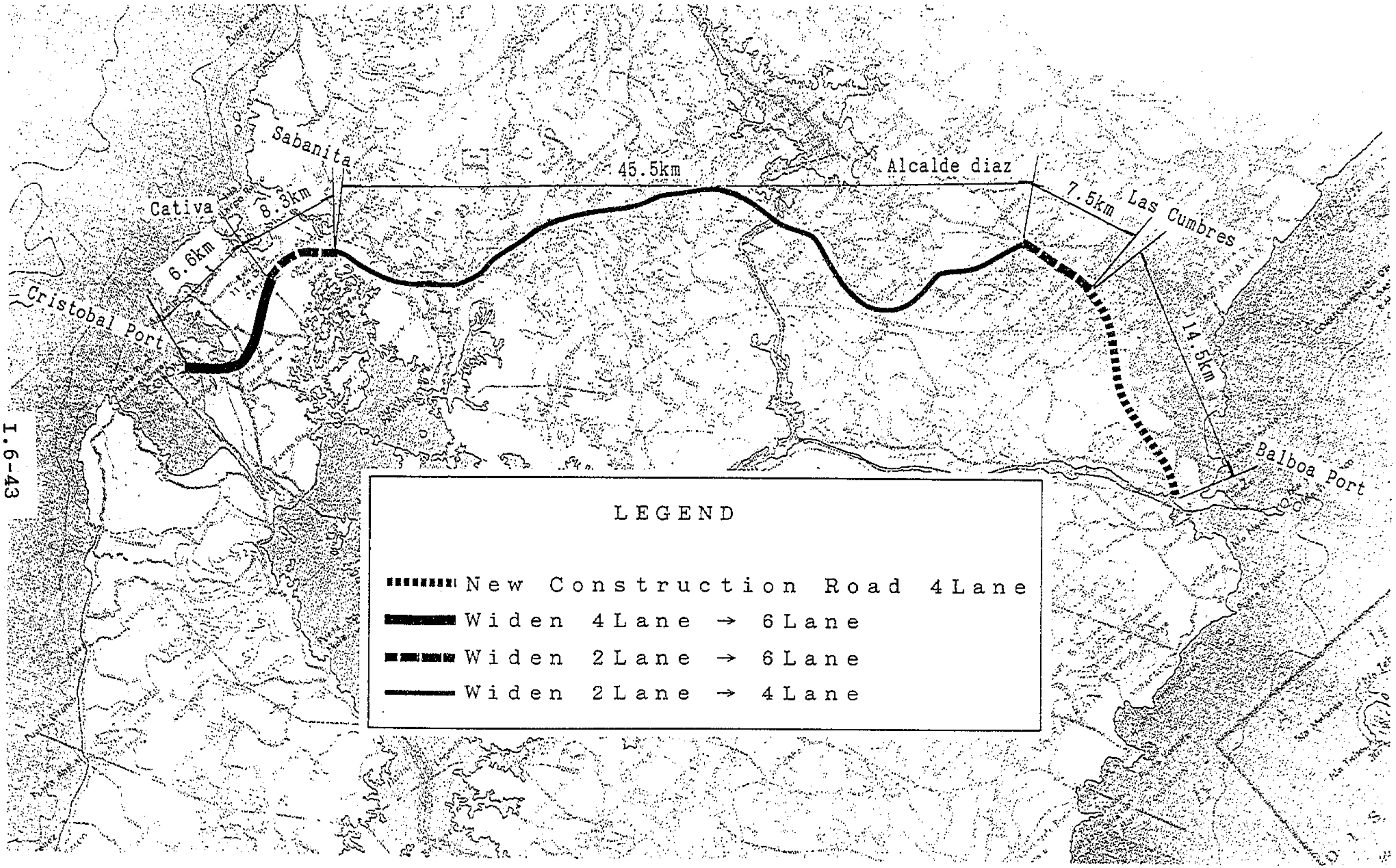


Fig. 6.4.2 Existing Road Improvement Plan

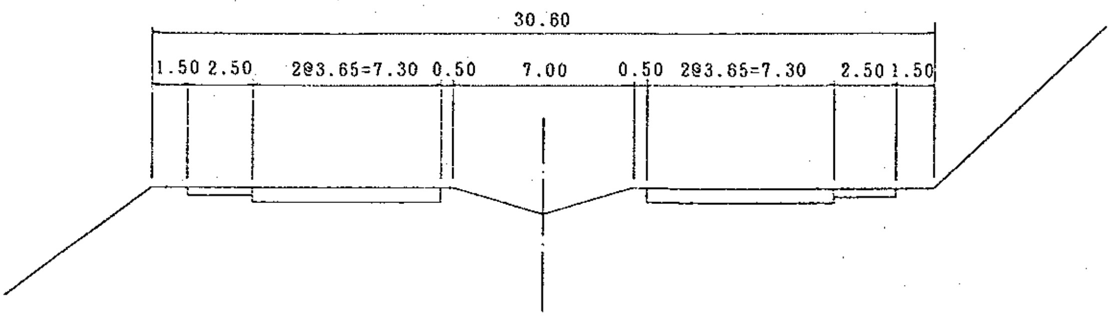


Fig. 6.4.3 Cross Section of Winding Road for 10 Mil. Ton/Year (4 Lanes)

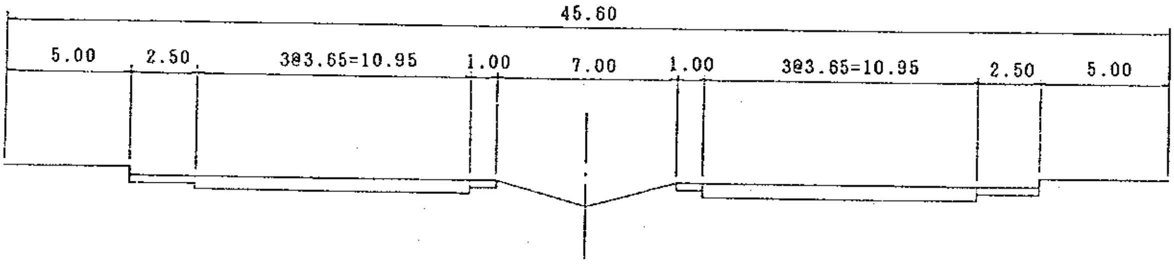


Fig. 6.4.4 Cross Section of Winding Road for 10 Mil. Ton/Year (6 Lanes)

c) More than 20 Million Tons/Year

In the case of a container freight volume of 20 million tons/year or more, the Ocean Container Terminal would be constructed on the west bank of the canal on both the Atlantic and Pacific sides.

1) Truck Terminal

It is proposed that one Truck Terminal would be located in the area behind the Ocean Container Terminals on both the Atlantic and Pacific sides. A vehicle repair shop will built next to each of these terminals.

2) Road Plan

If the existing road is upgraded to handle 20 million tons/year, approximately 16,000 containers/day will cross the land bridge and will be added to the increase in traffic already expected. Because of the conflict with everyday traffic, traveling speed would be reduced along with an increase in traffic accidents and a negative effect on the environment surrounding the route.

Moreover, if the existing road is used, major bridges will be required in two places to cross the canal at a cost of approximately US$100 million. In the case where the volume is 30 million tons/year, the volume of traffic will be 23,400 veh./day and for 40 million tons/year, 31,200 veh./day. This would require the construction of a 4 lane highway exclusively for freight transportation use in order to handle requirements for 30 million tons/year or more.

Therefore, a new road is proposed on the west bank of the canal to handle freight movement requirements for container freight volumes of 20 million tons/year or more. Land bridge freight would be carried by large truck and trailer units and it would be necessary to make the Atlantic - Pacific crossing in a short time frame. Therefore the following standards have been adopted as the basis for provision of a dedicated road.

Design speed	120km/h
Maximum grade	2.5%
Minimum radius	1,000m
Road length	70km
Cross section	
20 million tons/year	2 lane (ie. 1 lane in each direction)
30 million tons/year	4 lane (ie. 2 lanes in each direction)
40 million tons/year	4 lane (ie. 2 lanes in each direction)

(ref. Fig. 6.4.5, 6.4.6, 6.4.7 and 6.4.8)

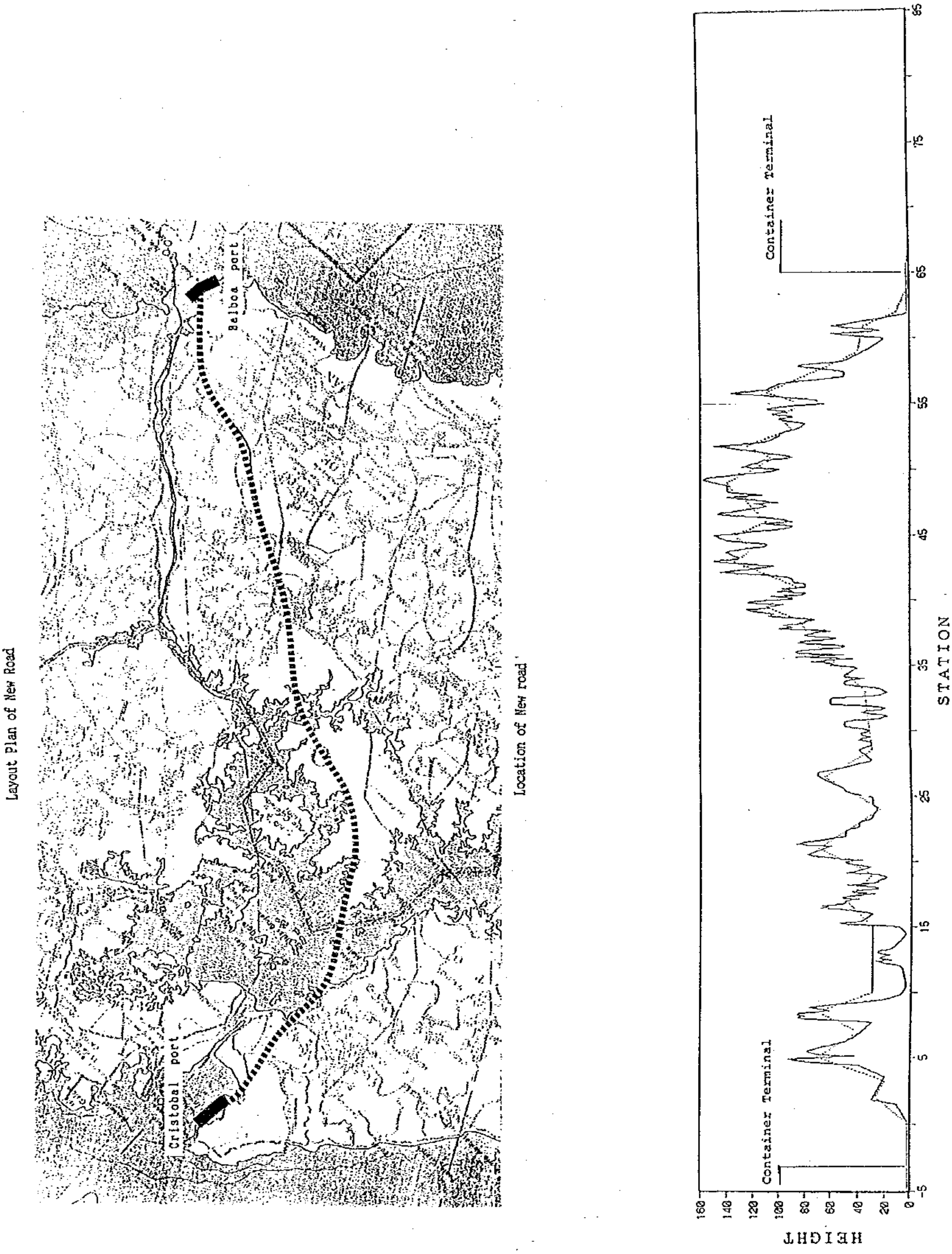


Fig. 6.4.5 Layout Plan for Location of New Road

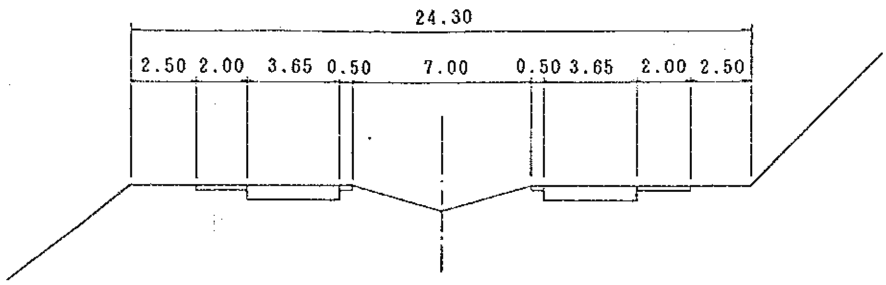


Fig. 6.4.6 Cross Section of New Road for 20 Mill. Ton/Year

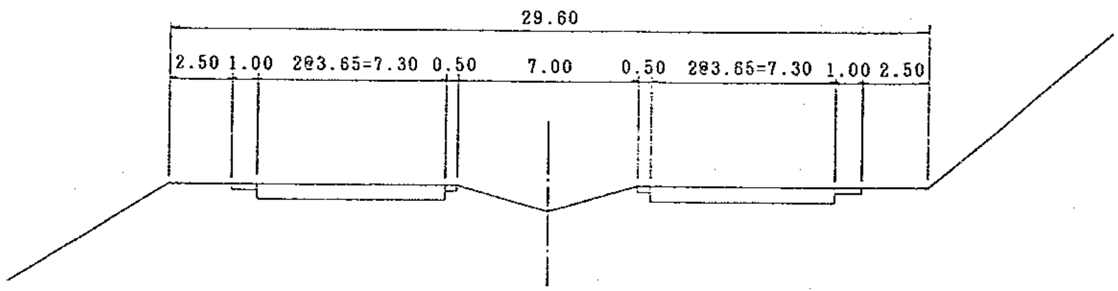


Fig. 6.4.7 Cross Section of New Road for 30 Mill. Ton/Year

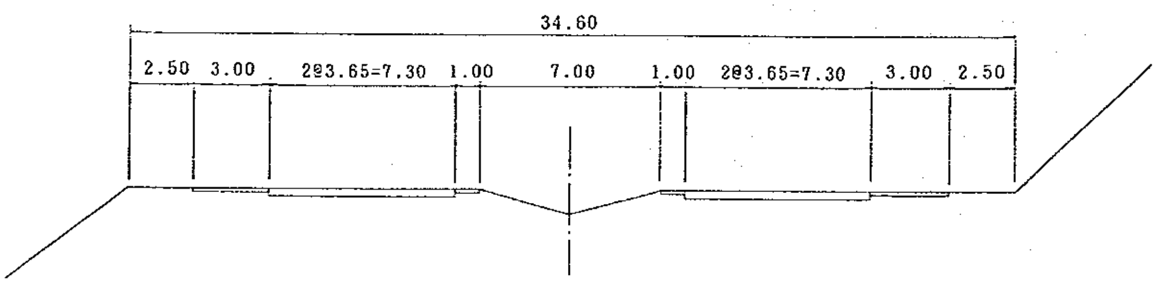


Fig. 6.4.8 Cross Section of New Road for 40 Mill. Ton/Year

6.4.3 Truck and Trailer Operation Plan

For each volume handled daily (40' containers assumed), the transported distance, the traveling speed, time taken and the required number of truck and trailer units are calculated below. The calculated traveling speed includes provisions for traveling at 40km/h on normal roads and 80km/h on dedicated freight transport roads and also allows for 40 minutes operating time inside the terminal. Moreover, the number of trips is for one way trips and when using normal roads, the truck and trailer combination consists of only 1 trailer while on the dedicated roads the combination consist of 2 trailers.

Table 6.4.1 Daily handling volume of 40' containers and number of truck and trailer units required

Volume handled annually (mill.tons/year)	Containers per day (max.)	Transport distance (km)	Traveling speed (km/h)	Time taken (hrs)	No. of one-way trips(*)	Containers per vehicle	Required No. of vehicles
10	1,600	82.5	30	3.5	2	1	800
20	3,200	70	60	1.8	4	2	400
30	4,800	70	60	1.8	4	2	600
40	6,400	70	60	1.8	4	2	800

(*) per vehicle per day

Table 6.4.2 Cost Estimation

Unit: Mill. US$

Freight volume handled (mill. tons/year)	10	20	30	40
Road construction	171	284	331	368
Housing	13	14	18	20
Truck units for truck & trailers	211	106	159	212
Repair shops	10	10	10	10
Truck terminal	7	10	14	17
Electric facilities	2	3	4	4
Total	414	427	536	631

From the above the land bridge road and associated port and terminal facilities were used.

Centerport costs are indicated below.

Furthermore is thought that the annual maintenance and management costs for these facilities will be about 7% of the overall costs.

Table 6.4.3 Project Cost of Road System

Unit: Mill. US$

(Mill. Tons/Year)	10	20	30	40
Port	259	835	1,039	1,251
Road	414	427	536	631
Total	673	1,262	1,575	1,882

6.5 Oil Pipeline Plan

6.5.1 Existing Facilities (Trans-Panama Pipeline System)

(1) Outline

At present the Trans-Panama Pipeline System, made up of the pipeline and 2 pumping stations between Charco Azul Terminal on the Pacific side and Chiriquid Grande Terminal on the Atlantic side and situated approximately 350 km to the west of Panama City, is able to pump up to 800,000 barrels per day (BPD). The crude oil runs out from the Chiriqui Grande Terminal Crude oil storage tank by gravity flow to the offshore loading buoy and waiting tanker. The pipeline system is controlled from the Operations Control Center at Puerto Armuelles Station by the Supervisory Control and Data Acquisition (SCADA) System using a microwave communications system.

The pipeline was constructed to facilitate the transportation of Alaskan North Slope (ANS) crude oil, carried by supertankers from the Alaska Valdez Terminal, to the Eastern United States without having to use the Panama Canal and has been operated by Petroterminal de Panama since 1983. The volume of ANS crude oil being transported through the Panama canal has been markedly reduced due to the operation of the pipeline. The existing Trans-Panama Pipeline System route is shown in Fig. 6.5.1.

The main facilities on the existing Trans-Panama Pipeline System are listed below and are summarized on Table 6.5.1.

Route of the 82 mile, 36 and 40-in, line that connects Atlantic and Pacific Oceans across Western Panama.

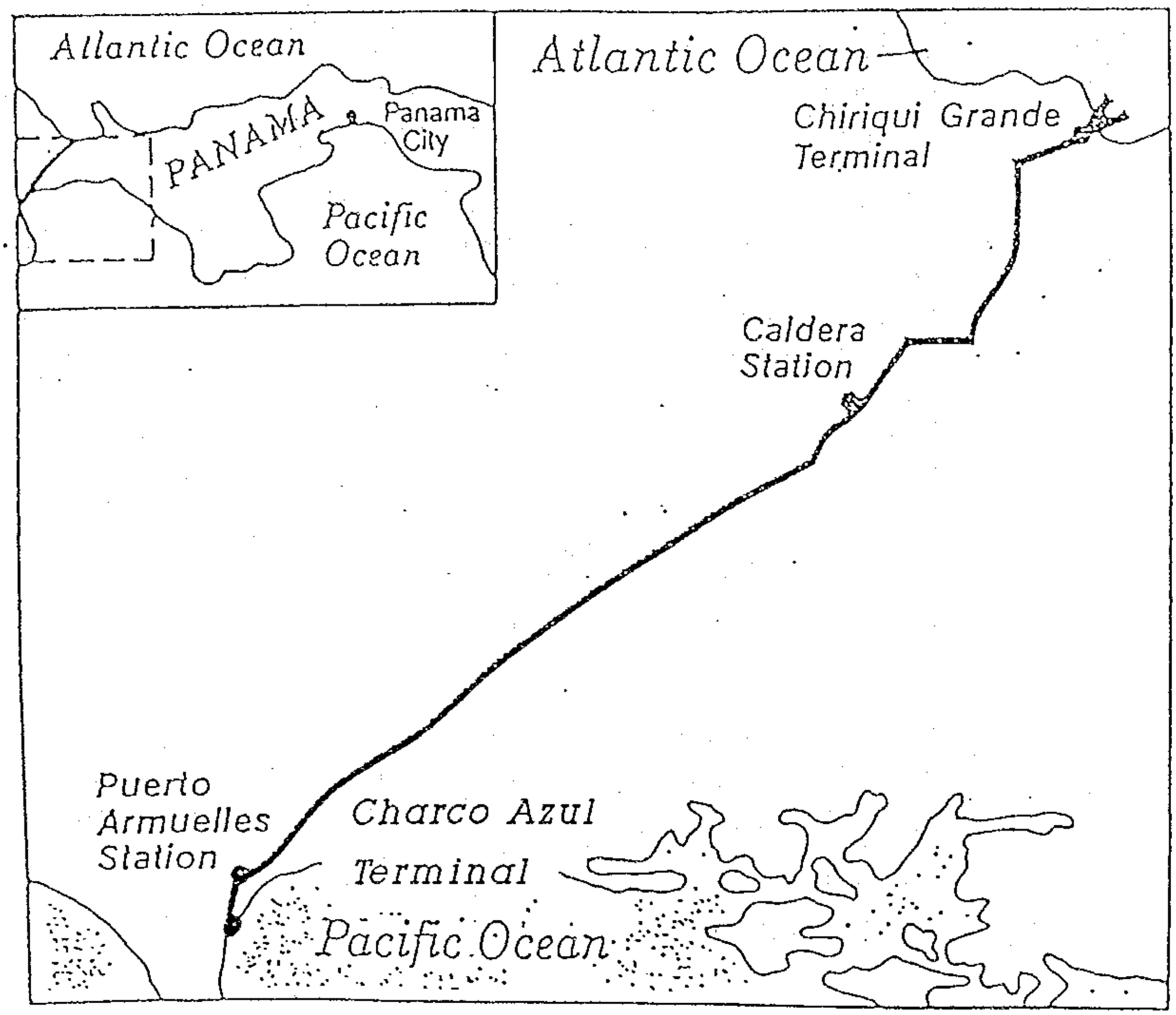


Fig. 6.5.1 Existing Trans-Panama Pipeline System Route

Table 6.5.1 Existing Pipeline Facilities

CASE	CHARCO AZUL TERMINAL	PUERTO ARMUELLES STATION	CALDERA STATION	OIL PIPELINE	CHIRIQUI GRANDE TERMINAL
EXISTING TRANS-PANAMA P/L CAPACITY 0.8 MILLION B/DAY	· JETTY NO.1/NO.2/NO.3 · CRUDE OIL/BALLAST LINES · CRUDE OIL STORAGE TANK (3 × 833,000 BBL/EA.) · BOOSTER PUMPS (2 × 500HP/EA.) · BALLAST WATER TREATMENT FACILITIES BALLAST WATER TANK (3 × 120,000 BBL/EA.) · FIRE AND ENVIRONMENTAL PROTECTION SYSTEM · ELECTRIC POWER SUPPLY SYSTEM	· PIPELINE PUMPS (4 × 5,000 HP/EA. CAPA. 200,000 BPD/EA. PARALLEL OPERATION) · ELECTRIC POWER SUPPLY SYSTEM	· PIPELINE PUMPS (4 × 5,000 HP/EA. CAPA. 200,000 BPD/EA. PARALLEL OPERATION) · ELECTRIC POWER SUPPLY SYSTEM	(*1) A 40 in × 50 MILES (*2) A 36 in × 32 MILES CAPACITY 800,000 BPD	· CRUDE OIL STORAGE TANK (3 × 833,000 BBL/EA.) · BALLAST WATER TREATMENT FACILITIES BALLAST WATER TANK (3 × 120,000 BBL/EA.) · FIRE AND ENVIRONMENTAL PROTECTION SYSTEM · ELECTRIC POWER SUPPLY SYSTEM · CRUDE OIL/BALLAST LINES · CALM BUOYS (2 × 60,000 BPH/EA.)

NOTE : (*1) BETWEEN PUERTO ARMUELLES STATION AND CALDERA STATION
(*2) BETWEEN CALDERA STATION AND CHIRIQUI GRANDE TERMINAL

Charco Azul Terminal (Pacific Coast)

- Jetty No.1
  - Length : 1,000 ft
  - Maximum ship size : 270,000 DWT
  - Unloading rate : 110,000 barrels/hour
  - Crude oil line : (1 x 48 in.)
  - Ballast water line: (1 x 24 in.)
  - Diesel line : (1 x 12 in.)

- Jetty No.2
  - Length : 1,200 ft
  - Maximum ship size : 120,000 DWT
  - Loading/Unloading rate : 60,000 barrels/hour
  - Crude oil line : (1 x 36 in.)
  - Ballast water line : (1 x 24 in.)

- Jetty No.3
  - Maximum ship size : 60,000 DWT
  - Loading rate : 50,000 barrels/hour
  - Crude oil line : (1 x 36 in.)
  - Ballast water line: (1 x 36 in.)

- Crude Oil Storage Tank
  - Number : 3
  - Capacity : 833,000 barrels/ea.

- Booster Pumps : 2 x 500 HP/ea.

- Ballast Water Treatment Facilities
  - Ballast Water Tank (3 x 120,000 barrels/ea.)

- Fire and Environmental Protection System

- Electric Power Supply System

Puerto Armuelles Station

- Pipeline Pumps
  - Number : 4 (parallel operation)
  - Motor : 5,000 HP/ea.
  - Total capacity : 800,000 barrels/day

- Electric Power Supply System

Caldera Station

- Pipeline Pumps
  - Number : 4 (parallel operation)
  - Motor : 5,000 HP/ea.
  - Total capacity : 800,000 barrels/day

- Electric Power Supply System

Pipeline

- Total Pipeline Length : 82 miles

- Pipeline Size
  - 50 miles of 40" dia. pipe between Puerto Armuelles Station and Caldera Station
  - 32 miles of 36" dia. pipe between Caldera Station and Chiriqui Grande Terminal

- Maximum Design Rate : 800,000 barrels/day

Chiriqui Grande Terminal

Onshore Facilities

- Crude Oil Storage Tank
  - Number : 3
  - Capacity : 833,000 barrels/ea.

- Crude Oil Loading Line
  (2 x 36 in. x 3,600 m/ea.)

- Ballast Water Treatment Facilities
  - Ballast Water Tank (3 x 120,000 barrels/ea.)

- Fire and Environmental Protection System

- Electric Power Supply System

Offshore Loading Facilities

- Submarine Crude Oil Line
  (2 x 36 in. x 2,000 m/ea.)

- Submarine Ballast Water Line (2 x 30 in. x 2,000 m/ea.)

- Catenary Anchor Leg Mooring (CALM) Buoy
  - Number : 2
  - Loading rate : 60,000 barrels/hour each
  - Maximum ship size : 160,000 DWT

(2) Operating Conditions & Future Demand Projections

The average transported volume (pumping rate per day) from 1983 to 1988 of the Trans-Panama Pipeline System is shown below.

Year	Pumping Rate (1000.barrels/day)
1983	680
1984	568
1985	633
1986	590
1987	594
1988	474

In studying projections for demand on the pipeline system, demand reduction factors listed below and as published in "The Transisthmian Alternatives For Increasing The Throughput Across Panama, May 1990" must be considered.

a) Consumption on the American west coast has been increasing.

b) Since 1988 a 16 inch four-corners pipeline (California) has been joined to the 30 inch all American pipeline and 70,000 barrels/day of ANS crude oil can be shipped to the Texas market without using the Trans-Panama Pipeline System.

c) It is projected that there will be a reduction in the production volume of ANS crude oil unless there are new oil field discoveries.

d) There is a possibility of increased ANS crude oil sales to Pacific rim nations.

6.5.2 Proposed Facilities

The following 4 cases are the pipeline capacities to be investigated by this component study.

Case No.	Pipeline Capacity (Mill.barrels/day)
1	0.5
2	1.0
3	1.5
4	2.0

New facilities required for each of the above cases are estimated based on the following preconditions.

a) The existing Trans-Panama Pipeline System (Maximum design rate of 800,000 barrels/day) would be used to maximum capacity and new facilities would be added to or expand the existing facilities when the required capacity is more than 80,000 barrels/day.

b) Because the existing facilities have a capacity of 800,000 barrels/day, Case (1) which called for a 0.5 mill barrels/day capacity would not require the construction of new facilities.

c) The following is the design rate for the new facilities based on a) and b) above.

Case No.	Design Rate (barrels/day)
2	200,000
3	700,000
4	1,200,000

d) The new pipeline would be single pipeline and constructed adjoining the existing pipeline route.

e) Expansion requirements for the unloading facilities at Charco Azul Terminal and the loading facilities at Chiriqui Grande Terminal are estimated upon the following.

Case 2

The existing unloading and loading facilities can be utilized without major modifications.

Case 3 and 4

The construction of a new jetty of the same scale as the existing jetty No.1 at the Charco Azul Terminal unloading facilities would be required and the construction of new facilities of the same scale as the existing loading facilities at the Chiriqui Grande Terminal would also be required.

The proposed pipeline facilities in each case, based on the above preconditions, are shown in Table 6.5.2.

Table 6.5.2 Proposed Pipeline Facilities

CASE	CAPACITY (MILLION BPD)	CHARCO AZUL TERMINAL	PUERTO ARMUELLES STATION	CALDERA STATION	OIL PIPELINE	CHIRIQUI GRANDE TERMINAL
1	0.5	NONE	NONE	NONE	NONE	NONE
2	1.0	· CRUDE OIL STORAGE TANK (3 × 200,000 BBL/EA.) · BOOSTER PUMPS (2 × 170 HP/EA. CAPA. 100,000 BPD/EA.) · FIRE PROTECTION SYSTEM · ELECTRIC POWER SUPPLY SYSTEM	· PIPELINE PUMPS (2 × 2,500 HP/EA. CAPA. 100,000 BPD/EA. PARALLEL OPERATION) · ELECTRIC POWER SUPPLY SYSTEM	· PIPELINE PUMPS (2 × 2,500 HP/EA. CAPA. 100,000 BPD/EA. PARALLEL OPERATION) · ELECTRIC POWER SUPPLY SYSTEM	(*1) A 24 in. × 50 MILES (*2) A 22 in. × 32 MILES CAPACITY 200,000 BPD	· CRUDE OIL STORAGE TANK (3 × 200,000 BBL/EA.) · FIRE PROTECTION SYSTEM
3	1.5	· JETTY (1 × 260,000 DWT) · CRUDE OIL/BALLAST LINES · CRUDE OIL STORAGE TANK (3 × 700,000 BBL/EA.) · BALLAST WATER TANK (3 × 120,000 BBL/EA.) · BOOSTER PUMPS (4 × 300 HP/EA. CAPA. 175,000 BPD/EA.) · FIRE PROTECTION SYSTEM · ELECTRIC POWER SUPPLY SYSTEM	· PIPELINE PUMPS (4 × 4,400 HP/EA. CAPA. 175,000 BPD/EA. PARALLEL OPERATION) · ELECTRIC POWER SUPPLY SYSTEM	· PIPELINE PUMPS (4 × 4,400 HP/EA. CAPA. 175,000 BPD/EA. PARALLEL OPERATION) · ELECTRIC POWER SUPPLY SYSTEM	(*1) A 38 in. × 50 MILES (*2) A 34 in. × 32 MILES CAPACITY 700,000 BPD	· CRUDE OIL STORAGE TANK (3 × 700,000 BBL/EA.) · BALLAST WATER TANK (3 × 120,000 BBL/EA.) · FIRE PROTECTION SYSTEM · CRUDE OIL/BALLAST LINES · CALM BUOYS (2 × 60,000 BPH/EA.)
4	2.0	· JETTY (1 × 260,000 DWT) · CRUDE OIL/BALLAST LINES · CRUDE OIL STORAGE TANK (6 × 600,000 BBL/EA.) · BALLAST WATER TANK (3 × 120,000 BBL/EA.) · BOOSTER PUMPS (6 × 340 HP/EA. CAPA. 200,000 BPD) · FIRE PROTECTION SYSTEM · ELECTRIC POWER SUPPLY SYSTEM	· PIPELINE PUMPS (6 × 5,000 HP/EA. CAPA. 200,000 BPD/EA. PARALLEL OPERATION) · ELECTRIC POWER SUPPLY SYSTEM	· PIPELINE PUMPS (6 × 5,000 HP/EA. CAPA. 200,000 BPD/EA. PARALLEL OPERATION) · ELECTRIC POWER SUPPLY SYSTEM	(*1) A 48 in. × 50 MILES (*2) A 44 in. × 32 MILES CAPACITY 1,200,000 BPD	· CRUDE OIL STORAGE TANK (6 × 600,000 BBL/EA.) · BALLAST WATER TANK (3 × 120,000 BBL/EA.) · FIRE PROTECTION SYSTEM · CRUDE OIL/BALLAST LINES · CALM BUOYS (2 × 60,000 BPH/EA.)

NOTE : (*1) BETWEEN PUERTO ARMUELLES STATION AND CALDERA STATION
(*2) BETWEEN CALDERA STATION AND CHIRIQUI GRANDE TERMINAL

6.5.3 Cost Estimation

In 6.3.2 the cost estimation for each case of proposed pipeline facilities is shown in Table 6.5.3. The cost estimation is calculated based on the preconditions underneath it.

(1) Direct Construction Costs

- Pipeline costs consist of facility construction costs and material costs. The unit cost is US$16.0/in-m.

- The crude oil and ballast water tank construction costs include material and civil work costs. The tank erection unit cost is US$6.0/BBL with a capacity of less than 200,000 BBL and US$8.0/BBL with more than 200,000 BBL. Furthermore, civil work cost is assumed at 20% of the above tank erection cost.

- Pump facility costs consist of machinery costs, civil work costs and installation costs. The machinery unit cost is US$260/HP for less than 500 HP and US$300/HP for more than 500 HP. Furthermore, civil work and installation costs are assumed at 40% of the above machinery cost.

- Supporting facilities necessary to operate the pipeline, unloading and loading facilities, and pump facilities include water disposal facilities, power facilities, instrumentation facilities, fire protection facilities, various utility facilities, communications facilities and buildings. The supporting facility costs include the costs such as piping work, electrical work, instrumentation work, installation work and civil work. The supporting facility costs are assumed at 10% of the total pipeline cost, unloading and loading facility cost and pump facility cost.

(2) Indirect Construction Costs

- Design costs and construction supervision costs will be 15% of the direct construction costs.

- General management costs will be 12.5% of the direct construction costs.

(3) Contingency

Contingency will be 25% of the total direct and indirect construction costs.

Table 6.5.3 Cost Estimation

Unit: Mill. US$

Category	Case 2 1,000,000 BPD	Case 3 1,500,000 BPD	Case 4 2,000,000 BPD
1. Direct construction costs	71	200	276
1.1 Pipeline costs	(49)	(77)	(98)
1.2 Unloading facility costs	(6)	(61)	(76)
· Jetty	0	36	36
· Crude oil tank	6	20	35
· Ballast tank	0	3	3
· Crude/ballst lines	0	2	2
1.3 Pump facility costs	(4)	(8)	(26)
1.4 Loading facility costs	(6)	(36)	(51)
· Crude oil tank	6	20	35
· Ballast tank	0	3	3
· Crude/ballst lines/calm buoys	0	13	13
1.5 Supporting facility costs	(6)	(18)	(25)
2. Indirect construction costs	20	55	(76)
2.1 Design and construction supervision costs	(11)	(30)	(41)
2.2 General management costs	(9)	(25)	(35)
3. Contingency	23	(64)	88
Total	114	319	440

Note: The value in ( ) shows subtotal.

CHAPTER 7 - PRELIMINARY REVIEW OF IMPACTS

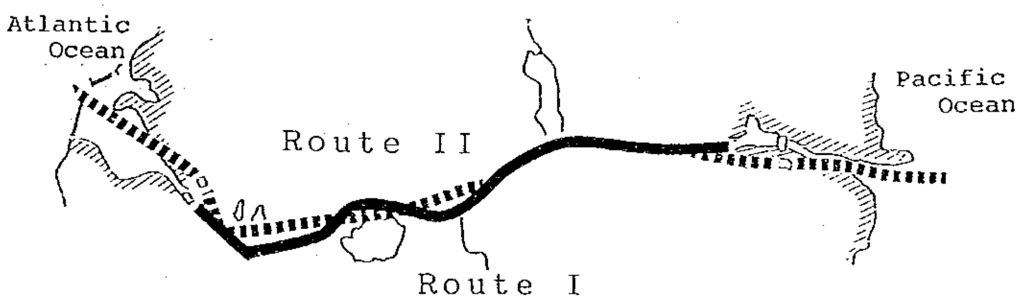
7.1 General

In case of the Route 10 Sea level canal construction study case, for example, the potential for sea water to flow from the Pacific Coast side to Atlantic Coast side will happen, or the area surrounding this Sea level canal will be divided in two parts, then a construction of a new bridge connecting these separated areas become necessary, or huge amount of excavated materials will be disposed at a low land area in the vicinity of the canal line. These incidents are inevitable for the canal construction, and of course create a great environmental impact to be resolved.

In this chapter such potential impacts created as a result of design and construction schemes are just identified and listed without resolution.

7.2 Lock System Canal Cases

7.2.1 Impact on Existing Canal



There are two routes considered for the Lock system canal as shown above. The following matters should be carefully considered during the planning and implementation of construction works.

(1) Dredging works in the Gatun lake should be executed while maintaining the highest levels of safety for ship transiting along the existing Gatun lake route. Therefore, construction methods and schedule should be carefully planned taking safety aspects into consideration.

(2) For a shift in operation to the new canal from the existing canal, a shut down period of about 10 days (for high rise lock cases) and two month (for low rise lock cases) would be required.

(3) Pedro Miguel locks become redundant (in the 55' and 30' water level cases) and the upper lock of Miraflores Locks must be demolished and the approach to the lower locks modified. (in the 30' water level cases)

(4) The existing canal and the rest of Miraflores locks would be available simultaneously with completion of the new canal.

7.2.2 Environmental Impact

(1) The lockage water supply is insufficient for the new locks operation and a water pumping system would be required. Direct pumping of sea water into Gatun Lake would result in increased salinity in the Gatun Lake water and changes to the lake ecology would result. Hence recycling of lockage water only using a recycling pond has been proposed. While the effect on salinity in Gatun Lake would be much less, survey and analysis would still be required.

(2) To increase the lockage water, new dams are also proposed at Rio Trinidad and Rio Ciri Grande approximately 3-9 km upstream from where these rivers flow into Gatun Lake.

The construction works of these dams and new lakes made as the result of completion of these dams will generate an environmental impact.

(3) The lock system canal cases, the lake levels are planned as 90', 85', 55', and 30'. These increased or decreased lake levels might cause some environmental impact in the surrounding area and aquatic creatures.

(4) Access channels 24.3-21.9 km long in the Pacific Ocean side; 11.8-12.5 km in the Atlantic Ocean side and 19-25 m deep are planned.

During construction works and after completion of the works will cause an impact greatly.

(5) Barrier dams planned in the lake in the cases of 55' and 30' lake water levels might causes an impact to the aquatic creatures.

Also a people using the lake as a transportation measures will be suffered an impact greatly.

(6) The excavated material from the new canal construction works would be disposed or in valley near the canal route so it may be necessary to divert small rivers and some of them might be artificially reconstructed. Natural areas would also be affected locally by spoil placement and recovery could take some time. Plant and animal life would be affected and further studies of this aspect are required.

(7) Dissolved and suspended sediment from the excavated and disposal areas is likely to contaminate the Gatun Lake water during the construction period and until regeneration occurs.

(8) The potential for interchange of ocean biota through the lock canal would be increased by larger ships and higher transits, especially for the low rise canal systems. The risks would be difficult to quantify but further study would be required.

7.2.3 Socio Economic Impacts

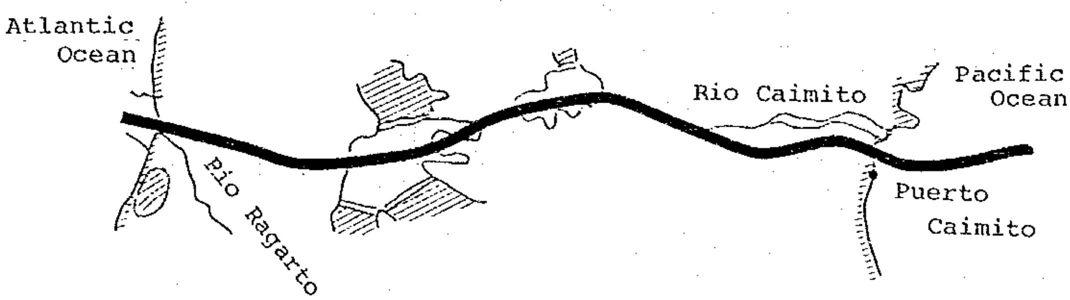
(1) The Pan American Highway (k5) Bridge over the existing canal should be reconstructed because the span and clearance of the bridge is insufficient for passing the larger size ships.

(2) The railway terminal at the existing Gatun locks may need to relocated to the new lock site.

(3) The road (no. 836, R-6) may be cut by the new locks hence a new bridge over the locks would be required.

7.3 Sea Level Canal (Route 10)

7.3.1 Impacts on the Existing Canal



Above Figure shows the Route 10 Sea Level Canal alignment. The canal route begins in the bay of Chorrera at the mouth of Rio Caimito and reaches the Atlantic Coast side near the mouth of Rio Lagarto via Plains, Gatun Lake, and the continental divide.

The Route 10 is about 16 km from the existing canal route, so Route 10 Sea Level Canal construction works would not directly affect the existing canal operations.

7.3.2 Environmental Impacts

(1) The first and biggest problem is the potential for sea water to flow from the Pacific Coast side to Atlantic Coast side, the direction of net flow. Marine and estuarine plants and animals could be transferred from the Pacific Coast to the Atlantic Coast and the resulting impact could be of the first magnitude.

This potential requires serious study and examination before the construction works begin.

(2) The excavation volume of the canal is tremendous so that valleys in the upper reaches of the Rio Caimito, Rio Bermardino, Rio on the Pacific Coast side and Rio Los Hules, Rio Pescado, and Rio Tinajones in the central section of the Canal and Rio Lagaruto and Rio Quebrado in the Atlantic Coast side would be used as disposal areas for the excavated material.

The small upstream rivers and streams of these main rivers would be diverted and partially realigned to artificial culverts.

The filling operation and the water way diversions would cause significant changes to the ecology of these areas.

(3) A diversion channel connecting a western part of Gatun lake to the Rio Lagarto is planned and this will cause an impact in the surrounding area and to the aquatic creatures in the lake.

(4) Breakwaters planned 7.4-14.9 km long in both Ocean coast sides will create an impact greatly.

7.3.3 Socio Economic Impact

(1) Dwellings and inhabitants from a village near Puerto Caimito on the Pacific Coast side will be impacted because the village site is at the entrance of the sea level canal.

(2) Dwellings and inhabitants from Palmas Bellas village located near the mouth of Rio Lagaruto in the Atlantic Coast side would be impacted in part.

(3) Disposal areas of the excavated material mentioned above would be quite flat and could be made available. (for agreeable housing areas, commercial areas and industrial areas) These areas will give an impact greatly.

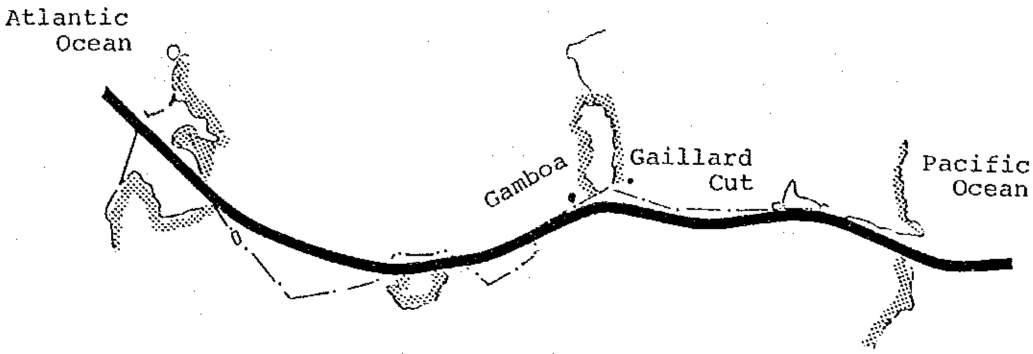
(4) A new bridge for the Pan American Highway should be constructed connecting Panama city and the separated western district.

(5) The road (no. 75, K-18) from La Correra to the northern district is cut by the new canal. Transportation to and from northern district would be obliged to use the Pan American Highway.

(6) For the road (no. 836, R-6), a new bridge should be constructed connecting Colon and the western district.

7.4. Sea Level Canal (Route 14S)

7.4.1 Impact on Existing Canal



The figure show the Sea Level Canal alignment for Route-14S Entering from the Pacific Coast side, the Sea Level Canal route passes hilly areas through the continental divide, parallel to the existing canal zone through the Culebra Cut, then joins the existing canal near Gamboa.

In the Gatun Lake zone the route is the same as the High Rise Lock Canal route.

(1) The matters that require special attention concerning dredging and shut down periods are almost the same as in the High Rise Lock Canal cases.

(2) Pedro Migel Locks, Miraflores Locks and the existing canal through most of Culebra Cut become redundant.

(3) The Gatun Dam becomes redundant.

7.4.2 Environmental Impacts

(1) Sea water from both Oceans would flow in alternate directions with the tides, although the net flow direction would be from the Pacific to the Atlantic, and some ecological changes would be inevitable. The potential for interchange of ocean biota would be greatest in the absence of tidal gates or locks. In order to reduce these ecological effects, surveys and analysis would be required and special facilities to reduce sea water flow to the opposite side should be developed.

(2) The matters that require special attention regarding the environmental effects of solid disposal in the inland area would be similar to those described for the High Rise Lock cases.

(3) Socio Economic Impact

The matters that demand special attention concerning socio economic effects would be similar to those described for the lock system cases.

APPENDIX

APPENDIX 1 : WATER MANAGEMENT SIMULATION

AP 1-1 RAINFALL AND DISCHARGE GAGE LOCATIONS IN CANAL ZONE

AP 1-2 AVERAGE RAINFALL IN CANAL ZONE

AP 1-3 WATERSHED YIELD

AP 1-4 DISCHARGE TABLE

AP 1-5 SPECIFIC DISCHARGE

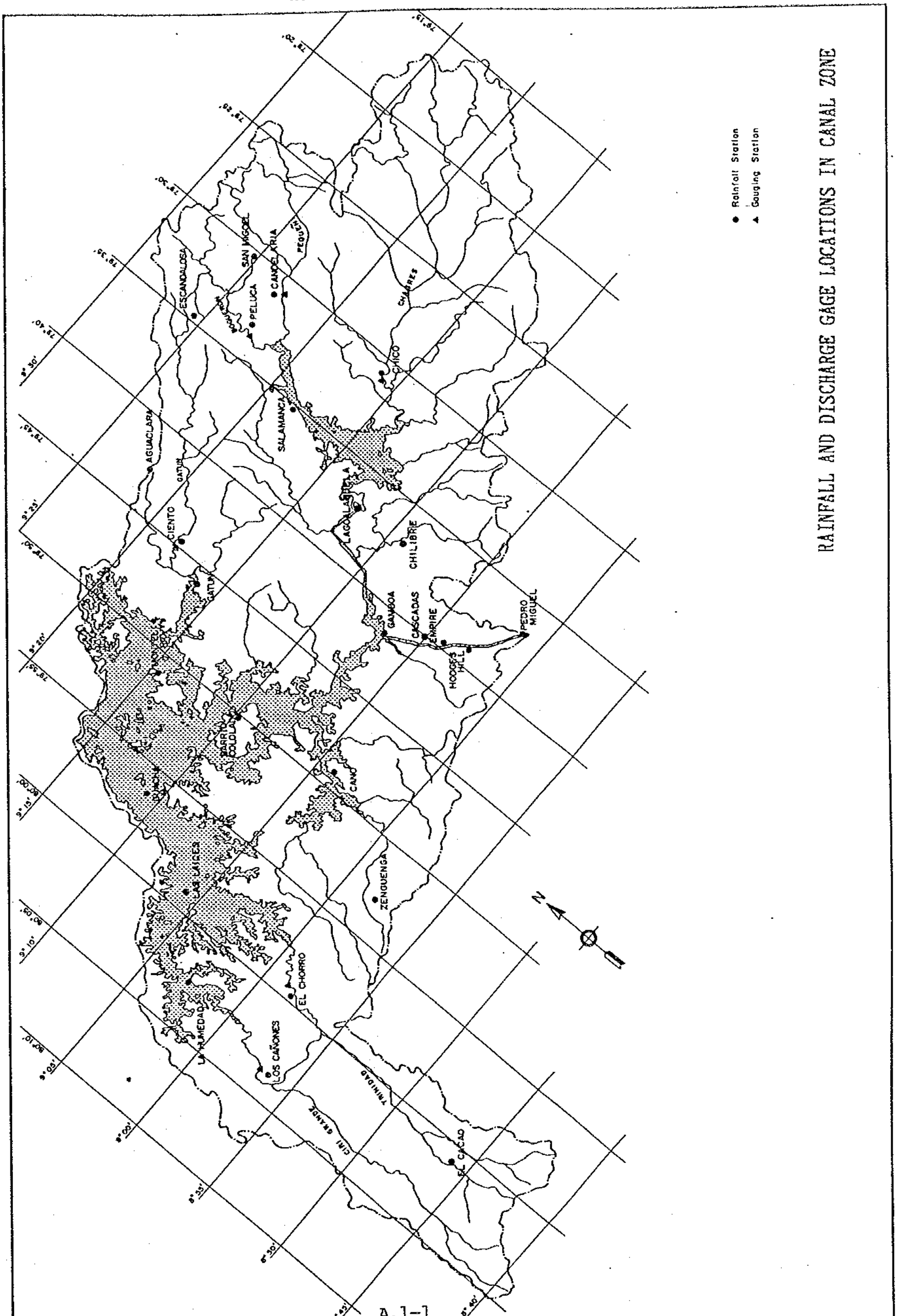
AP 1-6 MONTHLY EVAPORATION

AP 1-7 FLOWCHART FOR WATER BALANCE SIMULATION

AP 1-8 RELATIONSHIP BETWEEN DISCHARGE AND LOCKAGE WATER REQUIREMENT

AP 1-9 WATER BALANCE SIMULATION

AP 1-1 RAINFALL AND DISCHARGE GAGE LOCATIONS IN CANAL ZONE



AP 1-2 AVERAGE RAINFALL IN CANAL ZONE

AVERAGE RAINFALL IN CANAL ZONE

(UNIT : m/m)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Agua Clara	108.3	54.6	55.4	157.1	371.0	335.8	319.8	374.2	325.6	512.9	539.4	348.2	3,502.3
Barrio Colorado	65.3	31.8	27.1	93.7	274.5	263.5	271.3	306.8	259.1	347.4	421.1	242.8	2,604.4
Candelaria	114.7	57.7	45.3	165.8	336.5	341.5	330.7	350.2	320.4	350.2	388.9	302.3	3,104.2
Chico	39.6	14.4	13.3	83.6	278.8	310.0	317.5	337.5	322.3	387.6	345.3	174.1	2,624.0
Ciento	100.8	11.1	38.0	129.6	314.3	307.7	311.7	336.4	13.7	501.7	501.7	304.1	2,870.8
El Chorro	68.7	30.0	29.0	93.0	266.5	245.1	197.3	260.6	276.8	326.0	313.6	167.3	2,273.9
Escandalosa	133.9	78.6	65.2	204.7	351.6	338.2	343.5	320.5	283.2	333.6	436.9	313.6	3,203.5
Salamanca	10.9	13.8	15.2	93.5	251.7	286.3	256.7	287.7	275.9	326.6	331.8	167.3	2,317.4
San Miguel	152.1	74.4	74.8	222.4	379.6	354.8	352.1	358.3	324.4	348.4	424.9	356.4	3,422.6
La Humedad	71.8	39.8	31.1	115.9	252.7	247.0	194.3	235.1	254.5	303.1	324.9	183.1	2,253.3
Lago Alajuela	29.5	13.7	16.0	83.9	271.9	290.6	276.2	287.9	290.3	359.9	332.0	131.3	2,383.2
Empire	22.9	15.9	11.2	94.4	212.6	251.9	233.2	231.4	258.0	326.4	278.6	106.9	2,043.4
Guacha	78.9	32.5	31.0	133.2	231.1	221.2	213.1	252.8	221.3	309.0	327.6	206.1	2,257.8
Pedro Miguel	30.1	10.2	10.9	87.2	245.8	240.3	203.3	228.7	234.3	311.4	272.6	132.7	2,007.5
Hodges Hill	24.6	17.5	8.2	106.2	216.7	164.1	166.9	183.6	217.2	279.9	188.5	105.9	1,679.3
Gamboa	33.7	17.2	13.8	75.1	253.4	249.8	246.9	247.3	246.3	306.1	297.3	137.7	2,124.6
Gatún	90.1	42.0	40.9	124.0	314.3	282.9	325.1	335.3	293.5	392.6	518.0	317.8	3,076.5
Las Raices	61.6	23.0	27.6	101.2	239.7	217.1	206.0	231.1	237.8	302.2	310.8	189.5	2,147.6
Montelirio	69.3	31.7	32.5	92.9	276.8	255.2	275.2	319.5	271.7	377.9	452.0	280.1	2,734.8
Peluca	100.2	50.9	40.3	164.5	328.2	322.9	309.3	318.3	290.8	331.1	386.8	284.8	2,928.1
Chilibre	19.5	7.4	18.6	74.6	217.9	258.6	247.6	269.1	274.8	347.9	275.6	81.5	2,093.1
Caño	51.5	20.0	20.4	73.2	243.5	225.1	224.3	252.9	236.0	325.1	349.2	187.2	2,208.4
Los Cañones	111.4	46.1	37.2	110.8	309.7	280.8	285.4	295.4	374.8	362.3	340.1	204.7	2,758.7
El cacao	47.5	23.1	45.8	105.2	274.8	217.6	197.0	262.9	308.1	417.0	264.4	120.2	2,283.6
Cirí Grande	54.4	35.9	21.9	121.1	304.2	251.9	201.5	306.2	329.9	399.7	285.6	153.8	2,466.1
Zanguenga	46.2	21.1	14.5	75.2	210.2	215.2	172.0	231.7	254.6	338.3	233.7	140.1	1,952.8
Cascadas	21.8	11.1	26.2	88.3	239.9	254.6	204.3	237.6	258.5	315.7	253.1	93.3	2,004.4
Ave.	65.3	30.6	30.0	[illegible]	276.9	268.1	255.2	284.0	269.0	353.6	345.7	201.4	2,493.6

WATERSHED YIELD

(GATUN WATERSHED)

(UNIT : m^3/s)

River	Station	Period of Record	Drainage Area	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Trinidad	Chorro	1947~1983	173km²	4.28	2.23	1.34	1.58	4.00	6.48	6.70	8.24	9.99	13.81	14.25	9.47
①			100km²	2.47	1.29	0.77	0.91	2.31	3.75	3.87	4.76	5.77	7.98	8.24	5.47
Gatun	Ciento	1943~1983	122km²	4.62	2.59	1.66	2.24	4.38	5.95	7.54	7.91	7.15	11.48	16.05	11.35
②			100km²	3.79	2.12	1.36	1.84	3.59	4.88	6.18	6.48	5.86	9.41	13.16	9.30
Ciri Grande	Los Cañones	1947~1983	186km²	7.94	3.69	2.42	2.43	6.47	10.68	11.26	13.16	15.23	17.85	18.42	13.24
③			100km²	4.27	1.98	1.30	1.31	3.48	5.74	6.05	7.08	8.19	9.60	9.90	7.12
①+②+③/3	Specific Yield		100km²	3.51	1.80	1.14	1.35	3.13	4.79	5.37	6.11	6.61	9.00	10.43	7.30

(MADDEN WATERSHED)

(UNIT : m^3/s)

River	Station	Period of Record	Drainage Area	Jan	Feb.	Mar	Apr.	May	Jun	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
Chagres	Chico	1933~1986	414km²	25.90	15.33	10.99	15.72	27.09	29.21	32.72	34.78	33.34	38.83	49.16	48.46
①			100km²	6.26	3.70	2.65	3.80	6.54	7.06	7.90	8.40	8.05	9.38	11.87	11.71
Boquerón	Peluca	1933~1983	91km²	5.84	2.92	1.95	3.81	8.09	8.07	10.03	9.79	7.64	8.04	12.87	13.24
②			100km²	6.42	3.21	2.14	4.19	8.89	8.87	11.02	10.76	8.40	8.84	14.14	14.55
Pequeñi	Candelaria	1943~1983	135km²	12.25	6.48	4.56	7.65	15.23	16.40	18.64	18.29	16.30	17.23	22.14	25.40
③			100km²	9.07	4.80	3.38	5.67	11.28	12.15	13.81	13.55	12.07	12.76	16.40	18.81
①+②+③/3	Specific Yield		100km²	7.25	3.90	2.72	4.55	8.90	9.36	10.91	10.90	9.51	10.33	14.14	15.02

DISCHARGE TABLE

Gatun Watershed

Trinidad Chorro 173km²

(UNIT: m^3/s)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE.
1947	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	16.20	6.67	11.44
1948	*******	1.87	1.03	.58	1.55	2.03	6.29	7.62	6.72	7.26	16.60	5.70	5.20
1949	2.26	1.05	.56	.55	1.84	10.30	9.65	10.50	15.90	13.00	22.90	17.00	8.79
1950	4.45	2.63	1.42	.69	6.24	9.83	10.10	13.50	8.62	13.30	19.20	15.80	8.81
1951	5.02	3.37	1.70	1.23	6.31	*******	7.13	9.21	*******	9.68	12.00	7.78	6.34
1952	3.17	1.95	1.01	.78	1.99	5.45	4.93	5.77	9.93	14.10	9.74	18.80	6.47
1953	7.49	6.43	1.67	1.17	6.72	6.22	5.69	4.16	5.85	11.50	11.90	6.36	6.26
1954	3.01	1.74	1.02	.90	8.20	7.11	17.80	*******	14.30	13.90	21.50	9.75	9.02
1955	10.10	3.22	1.58	1.12	2.13	8.25	6.96	11.00	13.00	15.20	22.00	10.80	8.78
1956	9.18	3.15	1.97	1.53	5.00	8.34	10.20	6.35	11.70	20.50	11.60	6.00	7.96
1957	2.65	1.46	.89	.50	2.25	2.83	*******	*******	5.17	13.70	9.95	5.37	4.48
1958	3.54	3.31	1.57	1.02	3.64	4.35	6.45	9.43	9.15	10.50	8.02	4.48	5.45
1959	2.36	1.32	.74	.61	1.09	2.70	2.78	3.59	4.26	13.40	9.16	11.70	4.48
1960	5.45	2.19	2.27	2.83	6.93	7.80	*******	*******	*******	*******	15.00	25.60	8.51
1961	4.03	2.03	1.14	1.17	2.07	5.39	4.72	5.26	8.57	13.60	11.80	9.50	5.77
1962	3.26	1.76	1.01	.92	1.41	2.19	3.04	7.83	6.70	9.12	9.50	7.14	4.49
1963	2.78	1.85	1.00	2.06	4.61	5.58	6.76	8.85	8.99	12.90	14.60	4.63	6.22
1964	2.27	1.18	.75	.89	3.38	11.40	11.30	11.50	13.70	15.00	17.70	5.25	7.86
1965	3.99	1.92	1.07	.61	.97	2.00	1.78	4.19	3.32	7.01	8.79	9.35	3.75
1966	3.18	1.52	1.00	1.08	6.65	9.09	7.25	*******	*******	14.20	19.20	14.60	7.78
1967	4.49	2.15	1.10	1.75	5.53	13.40	9.64	11.30	14.80	17.20	11.30	5.17	8.15
1968	2.38	1.71	1.07	.96	2.73	7.96	5.92	8.43	8.86	15.20	14.70	6.92	6.40
1969	2.86	1.65	.82	1.28	2.67	5.58	*******	*******	13.80	11.70	12.80	7.66	6.08
1970	6.22	2.70	2.28	2.39	7.46	4.94	5.55	12.40	10.40	15.80	12.60	26.30	9.09
1971	11.10	3.80	2.16	1.55	6.50	9.11	8.27	11.40	11.20	14.40	18.10	4.40	8.50
1972	2.87	1.85	1.43	3.84	2.72	5.21	2.09	3.39	8.56	8.28	7.83	3.11	4.26
1973	1.75	1.40	1.10	1.12	2.57	9.93	11.20	8.82	16.00	17.70	20.80	11.00	8.62
1974	4.36	2.01	1.60	1.24	2.22	4.77	5.96	7.54	8.60	24.10	14.60	7.61	7.05
1975	2.48	1.52	1.26	1.05	1.92	4.27	6.07	12.10	17.30	18.80	28.00	15.90	9.22
1976	5.97	2.34	1.50	1.48	3.33	2.96	1.49	1.93	6.41	15.70	11.20	3.77	4.84
1977	1.85	1.41	1.14	1.04	2.15	2.78	2.67	6.98	7.93	15.70	12.10	6.25	5.17
1978	2.31	1.58	1.28	6.30	6.18	9.53	8.94	14.40	13.00	17.10	18.70	9.51	9.07
1979	2.65	1.39	.87	1.66	3.54	6.52	7.02	10.20	11.50	14.00	8.33	7.06	6.23
1980	6.22	2.74	1.47	.99	3.62	7.27	5.23	8.91	6.78	13.90	13.80	8.94	6.66
1981	5.76	3.95	3.13	7.53	12.80	14.30	13.40	13.20	11.60	15.90	18.90	14.20	11.22
1982	6.69	3.15	2.04	2.11	2.63	4.03	2.69	2.75	6.40	11.70	8.51	2.34	4.59
1983	1.65	1.08	.67	.50	2.28	3.28	2.04	2.93	10.70	8.29	7.80	8.11	4.11
AVE.	4.28	2.23	1.34	1.58	4.00	6.48	6.70	8.24	9.99	13.81	14.25	9.47	6.95

Gatun Watershed

Gatun Ciento 122km2

DISCHARGE TABLE

(UNIT: m^3/s)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE.
1943	*******	*******	*******	*******	5.56	*******	*******	7.21	7.03	10.60	13.00	19.50	10.48
1944	4.65	2.32	1.19	2.79	9.05	5.04	7.46	12.10	5.97	20.40	15.40	20.20	8.88
1945	5.68	3.26	1.54	.91	2.68	3.19	*******	*******	*******	*******	*******	*******	2.88
1946	*******	*******	*******	1.24	2.57	3.34	9.06	6.31	8.95	6.89	7.83	16.00	6.91
1947	4.74	2.52	1.36	*******	2.11	5.73	*******	8.28	7.76	8.99	10.80	9.37	6.17
1948	4.17	2.42	1.50	.85	2.67	3.19	6.57	4.92	4.77	5.69	9.93	3.85	4.21
1949	1.28	1.28	.96	.91	2.57	6.28	6.80	6.99	7.13	*******	*******	9.81	4.40
1950	3.01	2.28	1.71	1.82	3.75	5.91	8.54	7.22	6.17	6.19	17.30	20.90	7.07
1951	3.60	4.70	2.40	2.06	4.16	3.95	*******	*******	7.42	9.98	10.30	6.98	5.55
1952	3.06	2.31	1.92	1.47	2.45	5.11	8.04	7.39	7.29	*******	*******	*******	4.34
1953	*******	5.32	2.64	2.38	4.93	*******	8.76	7.95	9.25	17.00	18.80	9.02	8.61
1954	3.89	2.82	1.45	1.55	5.96	5.87	11.40	9.49	9.11	8.84	15.40	10.10	7.16
1955	8.41	2.82	1.61	1.11	1.72	3.94	4.85	9.20	5.56	8.21	14.40	8.09	5.83
1956	6.48	2.43	1.76	1.13	*******	*******	9.12	*******	6.22	10.50	15.80	5.29	6.53
1957	.88	.49	.36	*******	*******	.51	.46	.57	1.28	5.17	11.50	4.18	2.54
1958	*******	3.07	2.43	1.49	3.20	4.48	4.82	3.68	6.50	6.10	*******	5.78	4.15
1959	2.65	1.62	1.13	1.01	1.88	3.45	3.31	4.14	7.98	9.85	16.80	26.00	6.65
1960	4.69	.94	.91	3.49	6.07	5.69	4.58	5.87	3.94	8.24	11.40	19.20	6.25
1961	2.77	1.57	1.14	1.10	2.47	8.90	7.16	6.85	8.20	12.70	15.70	8.05	6.38
1962	3.52	2.23	1.53	1.04	13.40	10.80	15.40	13.30	11.20	12.00	13.20	9.53	8.93
1963	9.70	2.86	1.65	1.32	7.49	13.30	12.20	19.60	15.30	18.80	34.10	6.17	11.87
1964	3.06	1.43	1.05	1.57	7.43	15.80	26.60	17.60	*******	26.40	30.80	10.70	12.95
1965	4.65	3.25	2.03	1.12	5.54	*******	*******	11.10	*******	35.50	56.30	25.50	16.11
1971	7.09	3.20	2.73	2.02	2.53	3.78	8.43	9.06	6.20	9.65	11.80	4.27	5.90
1972	10.10	3.18	1.99	3.29	4.09	8.47	4.96	3.71	7.76	9.12	8.57	10.10	6.28
1973	2.64	1.88	*******	.93	2.32	6.02	6.34	7.03	7.91	5.71	15.20	5.91	5.63
1974	4.85	2.70	.67	.42	.69	1.71	2.29	2.79	3.17	8.46	13.20	5.52	3.87
1975	3.03	1.97	*******	*******	.78	4.24	9.60	10.40	7.13	13.70	18.50	16.50	8.58
1976	4.32	2.18	1.47	1.64	2.10	2.60	1.29	2.13	6.81	9.82	14.10	4.98	4.45
1977	3.36	1.94	1.26	1.10	1.60	2.61	3.76	9.64	8.90	10.50	11.00	9.19	5.41
1978	4.33	3.66	2.66	6.03	6.60	8.03	11.10	12.90	10.10	8.95	18.00	9.68	8.50
1979	4.54	2.11	1.77	2.65	4.44	7.03	6.01	9.39	7.73	15.20	15.20	8.44	7.04
1980	7.39	3.69	2.19	1.69	4.97	8.15	3.70	5.06	4.58	8.05	9.32	8.47	5.60
1981	4.77	3.06	2.22	18.10	16.70	14.20	12.00	8.94	6.23	10.70	24.30	28.00	12.44
1982	8.86	5.57	3.25	2.61	2.36	6.12	6.43	3.98	5.37	11.20	6.80	2.57	5.43
1983	1.67	.90	.50	.74	2.00	2.84	2.80	6.35	6.91	9.58	9.00	17.90	5.10
AVE.	4.62	2.59	1.66	2.24	4.38	5.95	7.54	7.91	7.15	11.48	16.05	11.35	6.92

DISCHARGE TABLE

Gatun Watershed
Ciri Grande Los Cañones 186km2

(UNIT: m^3/s)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE.
1947	*******	*******	*******	*******	*******	21.90	25.60	21.10	*******	*******	19.80	9.21	19.52
1948	4.29	1.64	1.15	.85	1.88	2.69	10.50	12.30	11.70	10.80	22.10	5.98	7.16
1949	2.39	1.43	.92	.83	2.57	14.20	10.40	13.10	21.30	17.60	*******	24.50	9.93
1950	4.01	2.20	1.31	.92	7.00	*******	*******	20.20	13.30	18.20	23.90	24.00	11.50
1951	7.33	3.98	2.20	1.44	7.20	8.85	8.20	8.95	15.50	13.10	19.90	11.30	9.00
1952	4.80	2.24	1.17	1.03	4.03	10.60	8.13	8.63	14.80	21.40	13.30	19.00	9.09
1953	14.00	5.27	2.75	1.92	8.56	7.64	7.42	6.12	7.61	16.90	*******	13.30	8.32
1954	5.98	2.75	1.70	1.37	6.78	7.16	17.50	13.10	18.00	15.20	29.30	*******	10.80
1955	18.60	4.93	2.39	1.86	3.83	15.30	10.80	18.00	22.20	19.10	29.50	16.80	13.61
1956	17.20	4.53	2.87	2.67	10.60	15.40	14.40	10.70	17.40	*******	18.50	10.40	11.33
1957	1.05	2.04	1.29	.93	4.18	4.19	4.15	8.29	9.09	21.40	13.80	11.10	6.79
1958	6.81	5.21	2.73	1.92	6.22	7.51	10.50	*******	13.80	18.20	14.60	7.60	8.65
1959	*******	1.99	1.38	1.22	1.86	4.02	6.89	*******	*******	*******	*******	*******	2.89
1978	*******	*******	*******	*******	*******	*******	13.90	18.60	19.40	22.10	19.00	11.70	17.45
1979	8.24	6.59	6.08	6.67	9.93	15.40	15.70	21.30	25.60	25.10	9.86	8.77	13.27
1980	10.70	3.68	2.01	1.45	5.36	10.70	7.95	18.60	8.95	15.20	15.50	12.60	9.39
1981	11.40	9.23	8.02	13.00	21.00	22.80	20.20	14.70	14.50	21.70	20.70	19.60	16.40
1982	7.92	3.45	2.30	2.65	4.55	7.51	6.30	4.69	8.67	17.00	12.60	3.80	6.79
1983	2.39	1.49	.88	.54	4.41	5.67	4.13	5.28	17.10	12.60	12.30	15.50	6.86
AVE.	7.94	3.69	2.42	2.43	6.47	10.68	11.26	13.16	15.23	17.85	18.42	13.24	10.46

DISCHARGE TABLE

Madden Watershed

Chagres Chico 414km2

(UNIT : m^3/s)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE.
1933	*******	*******	11.40	9.05	19.50	21.30	20.40	24.30	30.90	19.20	42.10	67.60	26.58
1934	24.90	11.00	8.23	12.20	31.90	32.80	*******	*******	*******	51.50	62.90	41.80	30.80
1935	39.50	17.70	11.70	8.48	26.80	25.40	64.60	43.40	34.90	30.40	178.00	104.00	48.74
1936	15.90	9.53	7.76	9.40	38.20	24.40	30.50	33.50	40.20	38.80	42.60	24.80	26.30
1937	38.50	20.30	11.20	9.87	20.00	22.10	24.50	28.60	34.10	44.40	54.50	81.70	32.48
1938	20.40	14.50	11.00	*******	53.60	41.20	37.20	67.80	41.10	41.50	51.00	107.00	44.21
1939	25.80	12.10	9.30	8.88	10.00	19.70	15.00	23.10	23.90	23.40	49.30	41.10	21.80
1940	22.00	16.00	14.20	11.90	15.50	18.10	15.60	26.90	22.40	35.60	31.80	21.40	20.95
1941	15.00	22.10	17.50	11.90	22.20	37.30	28.10	37.50	40.40	75.60	67.00	43.40	34.83
1942	21.20	15.90	16.00	24.70	17.90	29.70	33.10	32.20	39.20	51.30	40.90	34.60	29.72
1943	28.80	20.50	15.80	17.00	33.60	35.40	27.30	31.90	31.60	45.40	41.20	76.60	33.76
1944	26.70	20.20	10.70	17.80	37.70	31.10	42.00	42.90	37.40	56.30	53.50	89.10	38.78
1945	29.40	17.80	11.20	11.30	25.30	28.90	30.70	40.20	36.10	34.80	31.40	65.70	30.23
1946	19.80	14.40	9.81	12.70	24.10	27.70	39.60	42.80	34.90	30.80	25.50	58.70	28.40
1947	19.90	13.60	8.59	9.55	13.90	22.90	32.20	33.70	28.50	32.10	35.60	39.30	24.15
1948	16.50	8.99	6.32	6.06	14.20	23.70	40.00	31.50	26.60	38.90	45.80	29.50	24.01
1949	15.00	9.36	6.86	7.15	23.50	39.10	51.00	48.30	38.30	45.00	61.20	53.60	33.20
1950	20.60	17.10	10.70	20.00	40.40	30.10	53.90	45.80	32.90	26.20	50.80	60.10	34.05
1951	19.70	43.20	23.30	19.40	25.80	30.50	33.20	24.80	28.70	24.80	28.90	28.20	27.54
1952	18.40	12.40	9.02	10.60	24.10	23.90	31.50	38.20	35.00	49.40	31.50	53.20	28.10
1953	41.40	27.00	14.00	12.50	37.60	27.60	32.70	31.40	28.10	33.60	39.60	34.30	29.98
1954	18.30	13.70	12.40	12.80	21.70	34.60	34.70	39.10	38.20	25.00	64.20	63.20	31.49
1955	64.80	18.40	12.70	10.20	15.30	17.50	28.30	48.70	31.40	28.40	77.00	44.00	33.06
1956	62.40	21.70	19.20	19.80	43.40	37.20	63.90	34.10	35.80	44.60	86.30	41.50	42.49
1957	17.50	11.50	8.19	6.90	13.10	12.70	11.90	13.90	17.90	30.60	49.00	33.00	18.85
1958	32.90	14.80	10.70	7.32	17.60	21.30	22.10	25.20	27.00	27.70	33.30	27.20	22.26
1959	12.70	8.58	6.69	9.73	17.90	17.50	16.40	18.40	32.10	33.20	55.00	89.50	26.48
1960	53.90	12.30	8.95	21.40	27.40	29.60	30.80	29.10	30.10	34.30	35.30	94.00	33.93
1961	18.40	10.10	8.17	11.90	18.50	43.10	26.80	33.40	31.50	37.80	45.00	28.40	26.09
1962	17.60	11.20	9.03	9.48	27.60	20.20	33.00	44.10	38.10	36.40	40.60	31.80	26.59
1963	37.80	19.30	12.90	27.30	39.00	41.30	47.70	45.70	49.40	37.70	43.90	25.40	35.62
1964	15.40	12.10	9.92	16.90	26.90	45.50	28.00	26.40	31.70	27.90	39.20	22.20	25.18
1965	18.20	14.10	11.90	10.70	23.70	33.10	23.30	30.70	40.30	50.80	50.10	51.40	29.86
1966	25.90	16.80	12.60	34.70	41.00	32.70	34.00	30.40	38.10	42.30	*******	77.10	35.05
1967	33.90	19.80	16.40	31.20	43.00	49.50	44.80	33.90	35.30	30.50	36.10	37.10	34.29
1971	31.10	16.30	*******	10.40	31.00	31.90	43.00	37.20	31.20	29.60	37.70	20.70	29.10
1972	51.10	19.20	11.10	22.50	40.70	21.80	14.90	11.40	19.20	30.80	32.90	20.50	24.68
1973	12.90	9.07	6.19	5.51	16.00	27.60	28.10	31.40	27.90	34.60	54.60	43.00	24.74
1974	27.30	14.20	10.40	8.15	13.50	17.30	21.70	30.30	30.40	40.30	38.00	15.80	22.28
1975	11.60	7.12	4.82	*******	*******	29.80	48.20	53.60	34.30	46.40	58.60	59.00	35.34
1976	25.30	13.50	10.80	12.50	*******	*******	*******	*******	*******	*******	*******	*******	15.52
1977	15.40	10.50	7.80	7.84	14.50	16.70	23.10	28.70	26.30	57.00	46.50	33.20	23.96
1978	13.40	11.30	8.10	28.80	27.70	42.00	47.60	49.20	32.00	34.50	42.90	23.10	30.05
1979	12.30	9.14	7.18	17.90	17.20	23.60	27.10	36.40	31.50	28.30	42.30	40.60	24.46
1980	30.70	18.50	10.30	11.00	22.20	29.10	18.00	21.20	23.50	30.50	43.10	39.20	24.77
1981	27.50	21.20	17.50	103.00	50.10	39.00	41.80	40.60	28.60	34.40	42.90	66.10	42.72
1982	33.50	14.10	8.90	12.20	22.30	19.20	33.60	31.90	30.30	48.50	33.30	20.20	25.67
1983	14.90	8.27	5.84	5.51	37.60	22.20	19.50	21.60	28.40	35.40	42.10	75.20	26.38
1984	32.50	18.30	9.39	6.72	21.50	37.30	49.20	81.00	60.90	68.20	70.30	44.40	41.64
1985	23.60	14.50	14.50	9.94	22.80	41.20	32.50	25.90	47.10	39.70	37.80	66.90	31.37
1986	22.60	13.00	12.50	27.30	58.40	33.30	26.20	21.70	40.00	66.90	65.50	33.70	35.09
AVE.	25.90	15.33	10.99	15.72	27.09	29.21	32.72	34.78	33.34	38.83	49.16	48.46	29.95

DISCHARGE TABLE

Madden Watershed

Boquerón Peluca 91km^2 (UNIT: m^3/s)

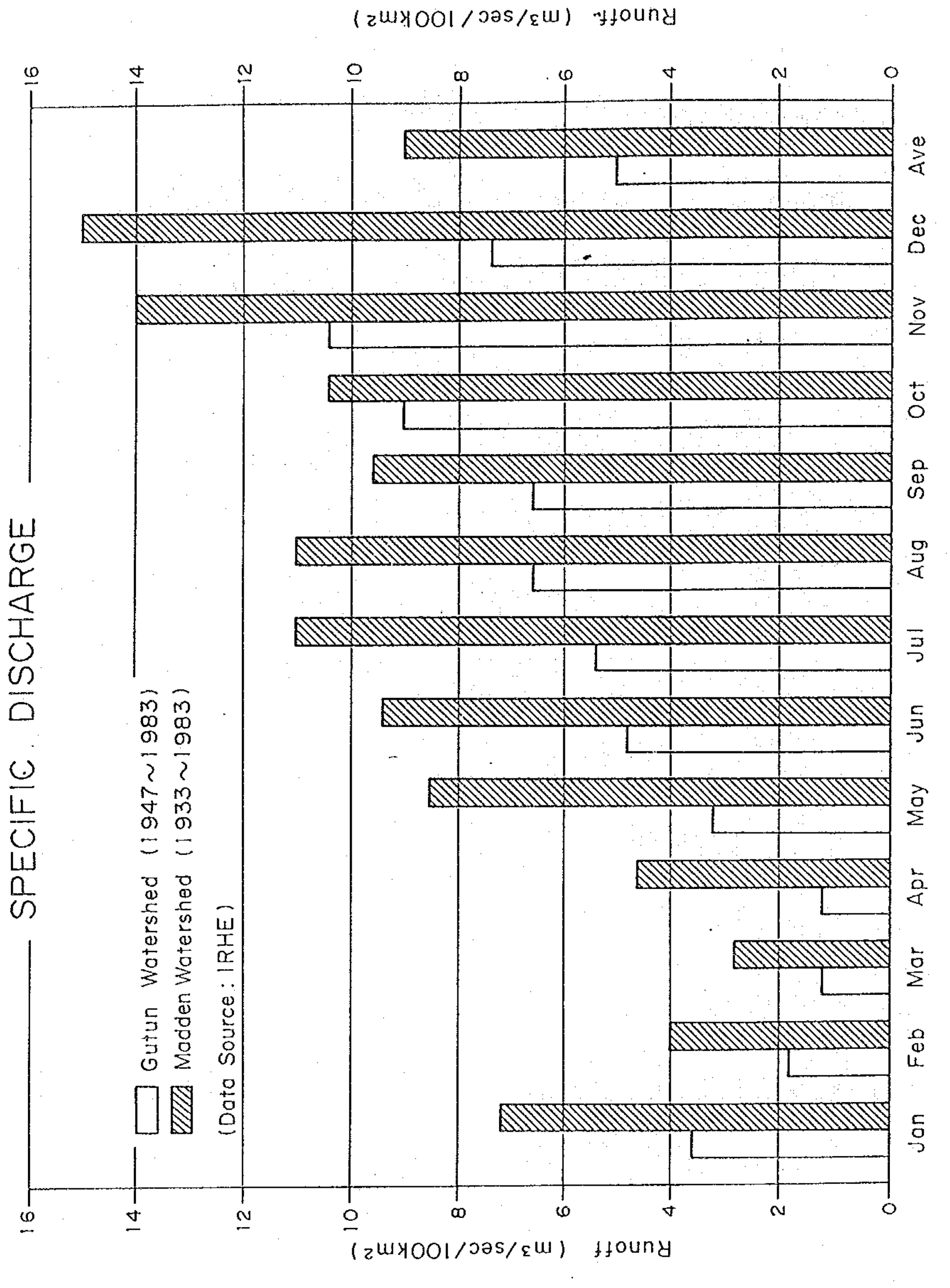
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE.
1933	*	*	*	*	*	*	*	*	6.78	3.59	15.50	19.50	11.34
1934	4.94	1.68	.91	1.38	10.00	7.72	7.09	7.36	8.57	8.55	15.90	9.54	6.97
1935	7.51	3.25	2.29	2.19	9.50	5.60	15.00	9.60	5.74	5.60	39.60	20.70	10.55
1936	3.06	1.32	.75	1.80	8.77	4.80	10.40	8.68	9.91	9.53	12.60	4.85	6.37
1937	9.50	3.50	1.54	1.59	7.25	6.77	9.24	10.40	7.18	9.60	12.20	20.90	8.31
1938	4.07	2.66	1.31	5.30	15.20	18.30	6.91	12.10	*	*	10.70	*	8.51
1939	4.88	1.77	2.02	2.32	2.32	7.37	7.98	15.20	8.53	6.58	19.60	14.10	7.72
1940	6.60	3.82	2.42	1.72	4.65	7.25	7.52	15.70	8.36	6.61	9.31	4.93	6.57
1941	2.95	*	2.82	1.87	7.36	*	10.70	12.00	6.94	19.20	15.80	8.19	8.78
1942	3.00	2.55	3.03	5.96	5.39	13.70	10.20	11.40	10.90	12.20	8.35	5.42	7.67
1943	4.17	3.67	2.63	2.92	9.01	11.10	8.39	12.40	11.20	8.75	9.22	*	7.59
1944	4.07	3.61	2.05	4.41	16.00	8.81	11.30	15.40	10.20	19.20	22.60	38.40	13.00
1945	5.17	2.52	1.60	1.38	8.13	7.03	11.90	13.20	*	*	8.37	11.80	7.11
1946	3.81	1.80	1.16	1.54	4.84	6.62	12.60	6.39	5.84	3.57	*	*	4.92
1947	2.49	2.21	1.24	1.46	*	8.42	15.80	11.70	5.51	4.94	5.03	8.27	6.10
1948	2.94	1.72	*	1.32	3.58	5.17	12.90	*	*	*	*	*	4.61
1949	2.38	1.60	1.32	*	*	11.60	15.00	11.70	8.81	10.40	13.20	13.80	8.98
1950	3.10	3.64	1.92	4.32	9.14	7.48	24.00	9.49	5.65	5.54	10.90	19.20	8.70
1951	3.89	9.70	4.68	5.80	7.47	7.38	5.02	8.11	*	8.15	8.01	8.68	6.99
1952	3.68	2.17	1.39	2.67	4.43	6.38	11.70	13.90	8.98	11.20	5.91	16.30	7.39
1953	11.60	9.56	2.28	2.21	8.88	6.87	8.88	8.21	6.32	6.87	13.20	9.53	7.87
1954	3.38	2.63	1.82	3.89	7.48	10.50	13.30	15.10	7.45	6.14	19.20	22.00	9.41
1955	15.50	2.95	1.92	1.64	4.54	4.48	7.69	14.60	5.83	3.87	15.20	*	7.11
1956	13.50	4.67	4.90	4.08	14.40	9.03	12.90	6.68	7.31	5.11	16.90	13.60	9.42
1957	2.91	1.60	1.17	1.01	4.69	3.20	2.24	4.17	4.85	6.57	16.90	11.40	5.06
1962	5.58	*	1.22	1.38	5.70	5.39	10.10	11.20	6.90	7.78	9.89	6.92	6.55
1963	8.11	2.39	1.50	2.32	13.50	9.75	9.69	10.50	8.73	5.43	8.89	4.30	7.09
1964	2.13	1.19	1.13	1.39	6.72	13.00	10.40	7.92	*	6.54	9.35	3.94	5.79
1965	3.77	1.78	1.60	1.50	5.08	*	*	4.96	7.06	10.60	14.70	13.20	6.43
1966	5.72	2.91	2.33	7.87	10.10	5.72	5.23	5.23	8.43	6.68	26.00	14.50	8.39
1967	5.12	3.01	2.40	6.48	9.94	8.98	14.90	6.60	6.18	4.21	10.60	9.48	7.32
1968	2.23	1.97	3.11	8.77	6.79	4.46	8.91	8.28	8.22	8.40	3.30	6.23	5.89
1969	2.66	2.29	2.00	2.24	6.06	3.33	5.39	8.53	6.38	6.84	7.31	22.50	6.29
1970	19.70	2.86	1.99	8.26	14.30	7.71	8.63	9.66	7.40	6.83	13.30	29.10	10.81
1971	4.66	1.96	2.75	1.08	3.98	8.28	14.20	8.72	6.37	6.46	8.35	3.78	5.88
1972	31.90	6.54	2.46	5.32	18.20	9.75	7.95	6.95	13.70	9.50	10.70	8.93	10.99
1973	3.37	2.11	1.03	.95	5.42	6.87	10.30	7.95	6.07	6.14	20.20	15.30	7.14
1974	6.00	2.48	1.87	1.67	3.50	7.61	10.40	8.79	6.04	7.72	19.00	6.71	6.82
1975	2.48	1.72	.96	.77	10.70	15.60	19.20	20.70	12.80	9.98	11.80	20.70	10.62
1976	5.81	3.31	2.57	5.29	5.10	6.85	4.76	4.52	7.65	7.37	15.30	3.66	6.02
1977	3.65	2.08	1.44	1.69	2.86	3.79	6.88	8.35	9.22	13.70	10.80	13.30	6.48
1978	2.24	3.20	2.27	10.10	18.20	12.80	4.66	10.40	8.22	5.89	8.91	4.98	7.66
1979	3.01	1.60	1.06	5.92	5.38	8.11	5.93	6.33	5.31	6.57	10.10	18.90	6.52
1980	5.71	2.42	1.21	1.40	6.11	11.40	4.84	4.10	4.28	8.14	8.51	12.10	5.85
1981	6.12	3.39	3.15	29.00	13.90	8.62	13.40	7.75	4.76	6.38	11.80	20.50	10.73
1982	6.54	2.92	1.52	2.71	2.55	3.63	8.39	11.60	7.38	11.70	6.00	3.70	5.72
1983	2.84	1.53	.87	2.67	9.03	7.78	8.55	8.20	7.89	9.32	9.93	32.40	8.42
AVE.	5.84	2.92	1.95	3.81	8.09	8.07	10.03	9.79	7.64	8.04	12.87	13.24	7.67

DISCHARGE TABLE

Madden Watershed
Pequeñi Candelaria 135km2

(UNIT: m^3/s)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE.
1943	-99.00	7.82	4.87	7.25	14.90	22.50	15.80	20.30	17.60	16.10	15.50	37.40	16.37
1944	9.29	9.20	3.83	5.72	20.90	15.00	20.90	24.40	16.40	24.60	26.40	54.10	19.23
1945	11.20	5.70	3.83	3.41	13.30	16.80	17.60	20.40	15.80	14.00	13.20	28.90	13.68
1946	5.35	3.79	2.62	3.75	12.90	17.20	27.50	16.10	16.00	15.40	11.70	34.50	13.90
1947	9.60	5.56	3.05	4.98	8.37	18.30	22.40	21.30	17.20	14.90	14.80	20.40	13.40
1948	6.61	3.50	2.26	2.29	7.26	11.80	20.40	15.10	17.10	15.90	17.90	10.10	10.85
1949	5.62	3.24	2.03	2.70	10.80	22.60	24.30	21.10	19.50	21.40	22.10	25.00	15.03
1950	7.54	7.42	4.18	8.79	22.30	16.20	38.10	25.90	16.60	13.00	21.90	31.40	17.78
1951	9.02	21.20	10.90	8.75	15.20	15.30	13.90	14.60	15.50	14.40	12.60	18.60	14.16
1952	7.95	4.75	2.69	3.54	12.10	11.60	19.20	24.30	18.00	23.00	14.80	23.70	13.80
1953	17.50	10.40	4.63	4.45	19.30	11.50	13.30	13.10	11.90	12.40	19.30	14.40	12.68
1954	6.70	4.80	4.45	6.39	13.60	16.50	17.80	19.20	15.00	10.80	30.70	29.20	14.60
1955	24.20	6.31	5.23	4.17	9.07	7.36	19.60	26.60	13.30	9.27	35.20	16.80	14.76
1956	23.50	9.41	9.23	9.34	25.10	17.80	23.50	15.10	14.90	13.00	28.00	22.00	17.57
1957	6.31	4.50	3.51	3.00	7.07	8.49	7.30	9.62	9.01	14.30	27.10	19.70	9.99
1958	19.70	7.52	5.98	4.14	8.94	9.50	16.30	12.80	18.30	14.30	19.30	13.50	12.52
1959	6.09	4.11	3.12	4.66	10.60	14.00	13.80	14.20	24.50	17.00	34.00	42.10	15.68
1960	19.00	5.62	4.63	15.90	17.40	16.80	15.80	12.90	11.80	12.70	19.40	38.70	15.89
1961	6.63	4.39	3.29	5.21	9.85	30.70	14.30	16.10	11.70	18.30	14.90	12.40	12.31
1962	5.67	4.28	3.25	3.98	12.90	11.80	22.70	21.60	16.30	15.80	18.00	13.50	12.48
1963	17.10	6.77	4.31	8.31	23.50	19.00	19.70	21.80	-99.00	-99.00	-99.00	-99.00	15.06
1964	4.73	3.39	3.04	5.81	14.30	22.20	17.10	15.90	13.50	12.30	17.10	8.80	11.51
1965	7.52	4.76	3.65	3.00	10.50	21.80	15.90	11.90	18.00	17.70	24.50	23.10	13.53
1966	11.10	5.78	4.28	15.70	19.00	15.10	13.60	13.90	17.60	15.60	44.60	35.30	17.63
1967	11.40	6.10	5.47	13.80	23.10	20.00	22.90	15.40	15.00	12.00	23.50	21.60	15.86
1968	5.90	4.80	5.39	6.56	17.70	15.30	17.80	17.20	17.40	16.00	14.60	11.30	12.50
1969	6.72	5.00	4.19	7.18	14.50	8.36	13.60	17.50	15.00	10.10	13.40	41.70	13.10
1970	36.80	11.60	8.33	20.80	24.70	12.90	14.80	18.00	17.10	19.40	20.20	41.80	20.54
1971	13.30	6.81	8.13	-99.00	10.40	18.30	25.10	14.40	11.00	13.00	12.70	8.70	12.89
1972	42.90	7.40	4.44	7.31	16.70	15.40	12.80	10.90	19.80	17.40	16.80	12.80	15.39
1973	6.27	3.78	1.79	1.36	10.80	11.80	18.20	18.10	12.40	12.40	27.20	18.80	11.91
1974	10.00	3.40	3.28	2.08	6.20	9.95	13.90	14.40	10.80	13.80	20.50	12.80	10.09
1975	4.87	3.20	2.61	1.93	14.80	18.40	21.60	30.60	19.20	18.10	22.60	29.10	15.58
1976	9.60	5.57	4.46	6.91	10.50	10.60	7.99	7.72	11.00	15.50	24.20	6.62	10.06
1977	6.19	4.18	3.04	3.32	5.45	7.14	11.50	18.00	14.20	25.40	19.60	21.20	11.60
1978	7.32	6.12	4.62	13.50	26.20	17.90	15.70	20.70	14.90	13.80	16.40	9.44	13.88
1979	4.04	3.50	2.43	10.90	10.10	15.10	11.70	13.40	10.10	13.70	18.10	26.50	11.63
1980	15.70	9.62	4.70	4.37	13.40	21.00	10.80	11.10	11.20	14.00	14.40	18.50	12.40
1981	12.70	8.07	6.48	43.10	20.90	39.00	41.80	40.60	28.60	34.40	43.00	66.10	32.06
1982	33.50	14.10	8.90	12.20	22.30	19.20	33.60	31.90	30.30	48.50	33.30	20.20	25.67
1983	14.90	8.27	5.84	5.54	37.60	22.20	19.50	21.60	28.40	35.40	42.10	75.20	26.38
AVE.	12.25	6.48	4.56	7.65	15.23	16.40	18.64	18.29	16.30	17.23	22.14	25.40	15.02


SPECIFIC DISCHARGE
Gutun Watershed (1947~1983)
Madden Watershed (1933~1983)
(Data Source : IRHE)
Runoff (m3/sec/100km2)
0
2
4
6
8
10
12
14
16
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Ave

EVAPORATION RATIO

(UNIT : %)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Note
10.09	10.73	12.02	11.30	7.88	6.74	6.40	6.85	6.52	6.80	6.40	8.27	100.00	

MONTHLY EVAPORATION

(UNIT : *mm*)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Gatun	140	149	166	156	109	93	89	95	90	94	89	114	1,384
Madden	137	145	162	153	107	91	87	93	88	92	87	112	1,354

Data Source : IOCS MEMORANDUM JAX - 50