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Architectural and Engineering Services for Engineering Site and Assessment, Conceptual Design and Related Services

PRELIMINARY STUDY OF ISLAND DEVELOPMENT AT THE PACIFIC ENTRANCE OF THE PANAMA CANAL

Final Report

December 2001

CENTRO DE RECURSOS TECNICOS
AUTORIDAD DEL CANAL DE PANAMA

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1 INTRODUCTION

The proposed Third Locks project and related expansion of the Panama Canal will generate significant quantities of excavated and dredged material. This study examines the commercial, technical and environmental issues related to the use of this material to create a new island at the Pacific entrance to the Panama Canal. Estimates of the volume of material vary from 55.0 to 85 million m3. It is expected that the excavation from the Locks will be made in the dry, with a significant percentage of rock. The remainder is expected to be silts and clays, typical of the formations in the area.

Up to 15.0 million m3 will be dredged to provide the access to the Locks. This material will again be silts or clays, and will convert to a semi-slurry format, depending on the class of dredge equipment used.

This preliminary report is presented in two volumes. This main volume includes the technical evaluation and recommended configuration, characteristics and cost estimates for the island. The second volume contains technical appendices used to support the analyses.

2 STUDY OBJECTIVES

The primary objective of this study is to examine the technical, environmental and capital cost aspects of the construction of the artificial island using the excavated material from the locks, at a pre-feasibility level of effort.

In order to provide a basis for the future studies that will examine of the financial viability of the project in greater detail, costs are also compared with estimates prepared earlier for the disposal of the excavated materials to Autoridad del Canal de Panamá (ACP) designated uplands sites.

This report represents a preliminary overview of the major project elements involved with the construction of the island, and is intended to provide the information that ACP will require in order to make a decision to proceed with a more detailed investigation. In the event that the project is approved for further evaluation, it is recognized that multiple, technical, financial, economic and environmental studies will be needed to expand on the issues presented in this pre-feasibility study.

3 SCOPE OF THE STUDY

As noted above, the primary objective of this study is to study the technical, environmental and capital cost aspects of an island development at the Pacific entrance to the Canal. Furthermore, the scope of work is limited to an evaluation of either:

- Container Terminal Facilities only
- A port Complex included Value added, distribution and other appropriate marine related services.

It is recognized that the island project does not represent the only option for use of the excavated materials from the Locks projects, and an internal ACP workshop was held in November 2000 to discuss possible options for beneficial use of the materials. Following the workshop, ACP staff recommended that the commercial potential for the Pacific Island concept should be evaluated at a preliminary level, before considering other alternatives.

As a result, the scope of this study is limited to the construction of an island due west of the Canal, located to effectively receive materials from the Locks excavation works, to offer minimum conflict with other existing or potential uses and environmental impacts of the shore side areas, and sited to avoid navigational or anchorage conflicts with existing and future Panama Canal operations.

4 COMMERCIAL DEVELOPMENT SCENARIOS

The Terms of Reference for this study require an examination of at least two scenarios for commercial development of the reclamation project. Development options for the island may include, but not necessarily be limited to:

A. Hub Container Terminal or terminals complex, as indicated in Figure 4-1

B. Pacific-Area Commerce. As shown in Figure 4-2, this would include:

- A container terminal or terminals
- Cargo Airport (not located on the island)
- Value-Added Distribution and Warehousing Center
- Manufacturing sites requiring close proximity to Port or Airport facilities
- Commercial services
- Regional access links, including highway, rail and sea-lane approach to Canal Entrance.

Figure 4-1: Schematic - Hub Container Complex.

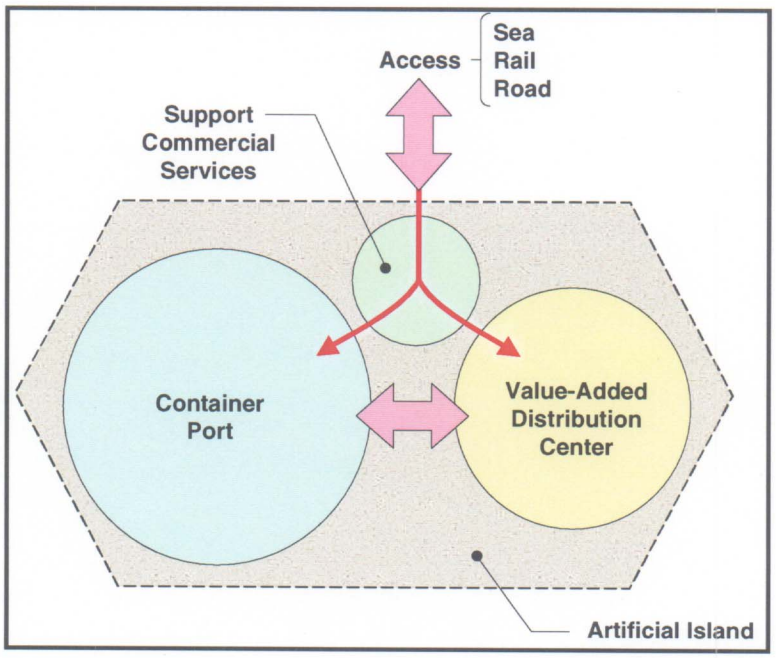
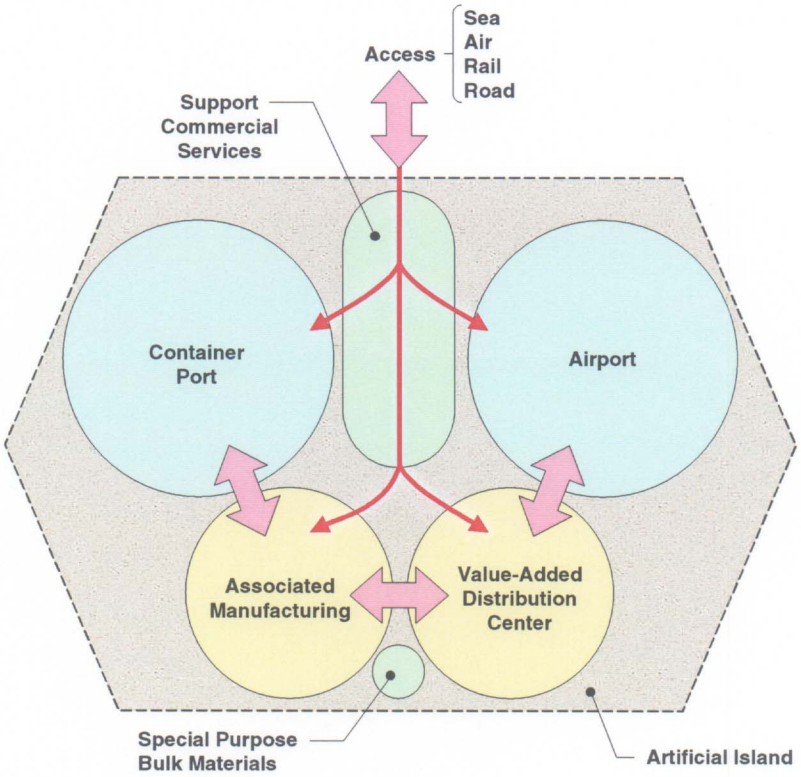


Figure 4-2: Schematic - Pacific Area Commerce Center



4.1 Panama Container Terminal Capacity

Existing and expected future handling capacity of the existing container terminals on the Pacific and Atlantic sides is shown in Table 4-1. It should be noted that expansion of container capacity of the Atlantic side could take place at a number of locations, such as Telfers Island, while mid-term expansion capability on the Pacific side is limited to Farfan and possibly Rodman, with both projects being within the high traffic area of the Canal. Conversion of both areas to container terminals also poses significant land use, environmental and engineering challenges.

Consequently, it is reasonable to assume that the required capacity to meet future demand can readily be installed on the Atlantic coast, whereas the current expansion of the Panama Ports/HIT terminal in Balboa represents the most probable limit of capacity for the Pacific Coast.

Table 4-1: Panama Container Terminals Capacity

Container Terminal	Imports	Exports	Loaded Total	Empties	TOTAL TEUs	Capacity	Utilization % of Cap.	Terminal Size (ha/ac) 2000	Terminal Size (ha/ac) Max.
Atlantic Side Terminals:									
MIT	501,743	522,222	1,023,965	307,189	1,331,154	1,500,000 [1]	89%	63/156	114/282
Colon	91,825	88,224	180,049	54,041	234,090	521,775 [1]	45%	25/62	72/178
Cristobal	84,299	80,994	165,293	49,588	214,881	1,500,000 [2]	14%	143/353	143/353
Sub-total	*677,867*	*691,440*	*1,369,307*	*410,818*	*1,780,125*	*3,521,775*	*51%*	*231/571*	*329/813*
Pacific Side Terminals:									
Balboa	90,499	96,951	177,450	76,050	253,500	253,500 [3]	100%	8.4/21	50/124
TOTAL	**768,366**	**788,391**	**1,546,757**	**486,868**	**2,033,625**	**3,775,275**	**54%**	**293/592**	**453/937**

Container Terminal	2000 Productivity / Acre (Lifts)	2000 Productivity / Acre (TEUs)	2000 Productivity / Hectare (Lifts)	2000 Productivity / Hectare (TEUs)	Maximum Productivity (TEUs/ha)	Maximum Capacity (TEUs)
Atlantic Side Terminals:						
MIT	5,079	8,533	12,577	21,129	20,871	2,379,294
Colon	2,234	3,775	5,541	9,364	20,871	1,502,712
Cristobal	360	609	779	1,503	10,435	1,492,205
Sub-total	--	--	--	--	--	*5,374,211*
Pacific Side Terminals:						
Balboa	7,143	12,071	17,857	30,178	20,871	1,043,550
TOTAL	--	--	--	--	--	**6,417,761**

Notes: 1) Capacity calculated at maximum productivity rate of 20,871 TEUs per hectare.
2) Capacity calculated at maximum productivity rate of 10,435 TEUs per hectare.
3) Capacity calculated at maximum productivity rate of 30,178 TEUs per hectare.

5 DEMAND FOR CONTAINERIZED CARGO BASED VALUE ADDED & DISTRIBUTION SERVICES

Asian exports of consumer product components and finished goods are increasingly facilitated by the accomplishment of value-added activities in route. These activities include:

- Logistic services;
- Bar Coding and Scanning;
- Sorting and Labeling;
- Preparation and Insertion of Marketing Materials;
- Repacking / "Pick & Pack";
- Kitting;
- Packaging Design & Manufacture;
- Manipulation;
- Repair;
- Internet Fulfillment;
- Special "Piece" Manipulation; and
- Storage.

Already Panama's Cristobal Free Zone fulfills some of these functions for Asian and European exports to South America. While it is recognized that the traditional role of the Free Zone has changed as the South American economies have opened, future activities will focus on Value added aspects of Atlantic-side transshipment containers. A second facility is required to handle the main volume of Asian exports to countries on the West Coast of Central and South America, on the East Coast of Central and South America, to Caribbean to be transshipped at Pacific-side container terminals.

Current experience of container based Value-added distribution in Panama can be used to indicate potential demand. At this time 73% imports to the Atlantic terminals are directly transshipped, 25% are drayed to the Cristobal Free Zone and 2% service local Panama demand. In this case the 25% applies only to Asia exports to Latin America, which are off-loaded from mainline ships prior to being transshipped or, once they have been processed through the Value-added distribution facility, re-exported.

It is likely that major international retail and wholesale distribution companies will take advantage of an opportunity to store, inventory, manipulate and distribute to outlets in South and Central America and the Caribbean. With interconnected marine terminals on both oceans Panama provides them with an attractive location for economically servicing markets on both the Atlantic and Pacific and also provides a single regional location from which the final destination of the contents of containerized cargo can be determined with a minimum of ensuing transportation time. This allows retailers to adjust deliveries as close as possible to real time sales, thus minimizing shelf time and inventory costs.

6 FACILITIES PLANNING

6.1 Container Terminals

6.1.1 Ship Size.

The completion of the Third Locks project will set a new Panama Canal standard for container and other ships. It therefore is reasonable to design the first phase of container facilities on the new island to that new size limit.

According to the Terms of Reference for the Third Locks Concept study, and preliminary dimensional criteria from the Harza and other studies used as a basis for this evaluation, the new locks will be designed to accommodate the following vessel dimensions:

Length – 385.7 m
Beam – 54.9 m
Draft 15.2 m
DWT – 105,000.

Table 6-1, presents a range of typical dimensions for existing, in building and potential future container ships. Using these parameters as general guidelines, the capacity of a container vessel, falling within the new Locks dimensional limits, will be on the order of 10,500 teu.

Table 6-1: Typical Dimensions of Existing and Future Container Vessels

Class of Vessel	*DWT*	*TEU Capacity*	*Containers across deck*	*Length (m)*	*Beam (m)*	*Draft (m)*
Line vessels						
1st generation		1,000		180	25	9
2nd generation		2,000		225	29	11.5
3rd generation		3,000	12	275	32	12.5
Panamax	70,000	4,000	13	294	32.6	12.5
Post-Panamax (1991)	75,000	4,400	16	275	39.4	12.5
Super Post Panamax	105,000	6,250 – 7,500	18	315	44	13.5 – 14.5
Mega - Ship1		9,200	19	346	46	14.5
Mega - Ship2	152,000	12,500	21	400	54.2	14.5
Malacca-max	242,000	14 - 18,000	24	400	60	21
Feeder vessels		300 -1,200		75 -130	13 -19	4.0 - 8.0
TOR - Locks Concept Study	105,000	10,500	21	385.7	54.9	15.2

6.1.2 Berth Dimensions

Based on the parameters above, the container terminal should be designed to accommodate a 386 m vessel, drawing 15.2 m fully loaded. Assuming a terminal module designed to receive one 9,200 and one 10,500 teu mainline vessels at one time, this then indicates a module berth length of approximately 850 m. This terminal would then be adequate to handle two or possibly three existing Panamax vessels or a combination of main line and feeder ships.

Draft at the berth would be 16.75 m, sufficient to accommodate the design vessel indicated in section 6.1.1.

6.1.3 Terminal Throughput.

Throughput will depend on the lesser of berth transfer or yard capacity. For the purposes of this evaluation, berth throughput can be assessed on a random arrival basis, using average crane productivity standards as a benchmark value. If it is assumed that a

maximum of five cranes will be used to work one of the Post Panamax vessels[1], with two feeder ships being handled at the same time, a total of eight cranes would seem reasonable for this class of transshipment module. Assuming a net productivity of 30 to 35 moves per hour, and an annual level of use of 2,500 hours, the target berth/crane capacity of the terminal will be on the order of 650,000 lifts, or approximately 950,000 teus[2], including empties.

Using the output from the M&N QuickTerm model shown in Appendix B, the container transshipment module will require a yard area of 29.10 ha, plus the berth area of some 3.00 ha, for a total of 32 ha per unit. Each terminal module will have a static holding capacity of 30,159 teus, necessitating 18,106 ground slots.

6.2 Value Added and Distribution services

For the purposes of this analysis, value-added, warehouse criteria have been based upon those used in Hong Kong, specifically from Sea-Land for its innovative facility there. In this view, a warehouse is composed of units, i.e., the smallest unit that may be leased to a single establishment. In terms on net spatial requirements, that is without truck access or parking or exterior equipment passageways, they constitute a space of 1,845 m^2 (equivalent to 19,859.4 sq. ft.). Table 6-2 gives the space/activity allocation accounted for by each unit.

Table 6-2: Space Allocation of a Unit

Activity	%	Sq. Meters Req'd
Distribution	10	184.5
Manipulation	10	184.5
Warehousing	75	1,383.8
Office	5	92.3
Total	**100**	**1,845.1**

A single building is composed of twenty units, i.e., 36,900 sq. m. or 397,198 sq.ft. of net leaseable area. Based on dwell time of 2 days for distribution and 8.5 days for warehousing, a single unit can be expected to handle a throughput of 2,336.1 teus per year. Based on the Sea-Land experience in Hong Kong, an average container throughput for a 36,900 sq m building is expected to be on the order of 50,000 teus per year.

1 At the Port of Singapore, up to five cranes regularly work Post Panamax vessels at this time.

2 Assumes 40% of all containers are 40 ft units

7 ISLAND LOCATION EVALUATION

7.1 Planning Criteria

7.1.1 Navigation Aspects

Controlling navigation criteria for the island location are:

- Location of Pacific and Explosives Cargo Anchorages west of Canal Entrance
- Presence of Taboga and Taboguilla Island
- Presence of various rock outcrops and islands in the area
- Volume of dredging required for access
- Proximity of island to Panama Canal Entrance

7.1.2 Land Use Compatibility (Howard AFB)

The Administración Regional Interoceanica (ARI) is still studying the potential use for the reverted Air Force Base at Howard. For the purposes of this study, it has been assumed that the future use will be developed around the runway and airside facilities. On this assumption, the island should be located outside the Obstacle Free Zone for the main runway, and also ensure that container cranes and other high level equipment are located outside the main aircraft approaches.

7.1.3 Land side Access

Materials transport options are discussed in more detail in Section 9.3. Clearly the access routes during the construction period should avoid areas of commercial activity and minimize conflicts with ecologically significant areas, existing highways or corridors and short- term development areas.

In terms of island location, the shoreline departure point is the only consideration of importance. Consequently, alternatives to the east and the west of the Howard AFB runways were evaluated, and are presented later in this report.

Finally, the level of investment required to provide the landside connection to the island is significant. Any connection that can then serve as a permanent multi-modal corridor linking the island to the former US bases and Panama City areas will offer significant economic advantages over the provision of a purely construction haul road.

7.1.4 Geotechnical Considerations

No detailed information is available at this time on geotechnical characteristics in the area of the proposed island. Based on other work in the area[3], it is expected that the island will be constructed over soft silts from 0 to 5.00 m deep, with weathered and dense basalt type formations located at varying depths below the seabed. There are also numerous rock outcrops in the area. Deeper water seabed conditions are likely to be mainly sand deposits, with rock at varying elevations.

It may be necessary to remove some or all of the silt materials in areas such as the container terminals, where significant settlement cannot be tolerated. Other future development zones can possibly be surcharged and allowed to settle over time, without removal of the soft materials.

For the purposes if this study, it has been assumed that the sea bed and sub bottom conditions are similar from the Canal Entrance to west of the Vacamonte Port, indicating that there are no favored locations for the island from a purely geotechnical point of view.

7.1.5 Recommendation

The recommended location of the island is indicated in Figure 7-1. It is seen that it will be located immediately due east of the flight path into HAFB, and west of the Explosives Cargo anchorage area. Navigation access to the marine facilities will be via a new channel, which would intersect the main Panama Canal approach some 2.00 km south of the limits of the Explosives Anchorage area.

Access to the island is via a causeway-trestle combination. At this stage of the evaluation, two open stretches are recommended along the causeway. As discussed in paragraph 9.3, later in this report, the shoreline section of the trestle will be an open piled structure, designed to permit movement of littoral material along the shoreline and offering a passage for marine life. At approximately the mid point of the causeway, and in sufficient water depth to permit the passage of small fishing vessels, it is recommended that a bridge be placed. This would also permit fish passage and permit small craft to navigate along the coastline without having to cross the navigation channel into the new island.

It is emphasized that this configuration has been based on the consultant's judgment, from experience at other locations. It is clear that a full evaluation of the local hydraulic and coastal regime would be needed to confirm these preliminary recommendations.

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3 Vacamonte Fishing Port, Punta Paitilla Islands project

FIG 7-1 - RECOMMENDED LOCATION FOR ISLAND

8 CIVIL ENGINEERING EVALUATION

8.1 Introduction

This section evaluates the engineering characteristics of the island and also compares the development costs with those that would arise from disposal of the excavated material to the ACP designated disposal sites examined in the Harza study.

The difference between the cost of the island and disposal of the material to the ACP sites then represents the opportunity cost of the commercial development of the island. Alternatively, it can be considered as a "raw land" cost.

8.2 Characteristics of Excavated Material

Information used for this evaluation was provided by ACP, using reports prepared by Harza together with the results of other in-house studies. For a listing of reference data, the reader is referred to Appendix E of the Technical Appendices to this report.

Borehole data from the P1 and P2 alignments was used to cross check materials quantities by characteristics. Table 8-1 indicates typical formations and classifications based on the site information.

Table 8-1: Borehole Log Information from ACP studies

Symbol	Formation	Description
Tb	*Basaltos*	Intrusive and extrusive basalt, middle locene
Tpa	*Pedro Miquel*	Pedro Miquel Formation, early Miocene hard, Fine to coarse-grained agglomerate
Tl	*La Boca*	La Boca Formation, early Miocene soft, Mudstone, siltstone, sandstone, tuff and limestone
Tca	*Cucaracha*	Cucaracha Formation, early Miocene, soft Bentonic clay shale, carbonaceous clay shale and in lower part, a thin ash flow tuff
Tcb	*Culebra*	Culebra Formation, early Miocene soft, Calcareous sandstone and siltstone.

ELEVATION = TOP OF STRATA IN METERS

GENERAL INFORMATION				WATER		SOIL								ROCK																
						SLIDE		PACIFIC MUCK		FILL		OVERBURDEN		BASALT				AGGLOM.		MUDSTONE/ SILTSTONE		SHALE		SANDSTONE/ SILTSTONE		CONGLOM.		ASHFLOW		BOH
BORING ID	NORTHING	EASTING	GROUND ELEV (m)	TOP	BOT	TOP	BOT	TOP	BOT	TOP	BOT	TOP	BOT	TOP	BOT	Depth to Top	Depth to Bot	TOP	BOT	TOP	BOT	TOP	BOT	TOP	BOT	TOP	BOT	TOP	BOT	
TP1-1	997107.7	651198.9	72.4							72.4	69.1	69.1	63.4					63.4	62.2			62.2	17.1	17.1	6.8					6.8
TP 1-3	995623.1	652394.5	92.0									92.0	91.4	91.4	88.9	0.6	3.1	88.9	9.5											9.5
TP 1-4	994720.5	653346.0	43.2			43.2	41.0					41.0	39.4	39.4	-11.4	3.8	54.6	-11.4	-14.7											-17.0
														-14.7	-17.0	14.7	17.0													
TP 1-5	993782.7	654377.7	18.7							18.7	7.6	7.6	2.2	2.2	-26.7	16.5	45.4													-26.7
TP 1-6	993269.3	654706.5	24.5									24.5	14.0	10.2	-16.5	14.3	41.0							14.0	13.1	13.1	12.5			-16.5
																								12.5	10.2					
TP 1-7	992903.0	655155.4	19.0							19.0	18.3	18.3	9.6	9.6	-26.5	9.4	45.5													-26.5
TP 1-8	992513.2	655358.6	5.4					1.1	-3.6	5.4	2.2	-3.6	-6.6	2.2	1.1	3.2	4.3							-6.6	-36.3					-36.3
TP 2-1	996026.0	653026.0	16.5	16.5	11.3			11.3	3.0			3.0	1.5											1.5	0.6	0.6	-0.3			-10.1
																								-0.3	-10.1					
TP 2-2	995940.0	653255.0	16.5	16.5	7.3			7.3	0.6					-20.1	-23.2	36.6	39.7							0.6	-2.4	-2.4	-20.1			-23.2
TP 2-3	995700.0	653379.0	16.5	16.5	7.3			7.3	4.3	4.3	3.4	3.4	3.0							-5.2	-6.4	-0.2	-5.2	-6.4	-6.7	3.0	-2.0			
																				-6.7	-7.0	-7.0	-14.2			-6.6	-7.0	-14.2	-19.1	-19.1
TP 2.4	995346.0	653750.0	16.5	16.5	5.2			5.2	2.1			1.2	0.2									0.2	-11.9	-11.9	-17.2	-17.2	-18.8			-25.9
																						-23.0	-25.9	-18.8	-23.0					
TP 2-5	995000.0	654100.0	16.5	16.5	7.3			7.3	3.3											3.3	0.5	0.5	-4.4	-4.4	-23.5					-23.5
TP 2-6	994658.0	654132.0	16.5	16.5	7.6			7.6	-1.6			-1.6	-3.7					-12.8	-13.4			-13.4	-17.9	-3.7	-5.0	-5.3	-6.5			-21.3
																								-6.5	-12.8					
																								-17.9	-21.3					
TP 2.8	994032.0	654683.6	20.2					4.1	3.8	20.2	4.1	2.0	1.4											1.4	-3.4					-3.4
								2.5	2.0	3.8	2.5																			
TP 2.9	993638.8	654670.2	19.9							19.9	11.3	11.3	9.1	9.1	-17.1	10.8	37.0													-17.1

8.3 Quantities

Materials quantities were taken from the Harza study, after being crosschecked against terrain models based on ACP topographic and bathymetric information. There were a number of areas where the computations might provide different results, such as interpretation of side slopes and intersection of these slopes with the existing terrain. However, as can be seen from Table 8-2, below, reasonable consistency of results was obtained through this process. The Harza excavation quantities were therefore accepted as a basis for concept development and the preliminary engineering work tasks.

Table 8-2: Correlation between Harza & MN quantity calculations

Channel Alignment	Channel Bottom El. (m)	M&N (m^3)	HARZA (m^3)	Approximate % Difference
P1	10.36	62,239,000	69,350,000	10.8
P2	10.36	34,116,000	37,410,000	9.2
P1	9.90	65,796,000	69,572,000	5.6
P2	9.90	35,420,063	36,924,000	4.2
P1	8.08	67,328,000	72,750,000	7.7
P2	8.08	38,854,000	40,000,000	2.9
P1	7.16	69,414,000	74,150,000	6.6
P2	7.16	40,799,000	41,070,000	0.7

It is understood that the Harza computations were based on a tentative lock width of 160 ft, compared with the 200 ft now accepted. However, it was decided that a recalculation of the quantities was not warranted at this level of evaluation. Based on the quantities evaluation and the examination of the boreholes, Table 8-3 shows the characteristics and quantities of materials that will be obtained from the excavation and dredging on the two Lock alignments.

Table 8-3: Materials Characteristics and Quantities, P1 and P2 alternatives

Phase	Lock Option	Volume (m3)				
		Overburden		Rock		Total
		Wet	Dry	Wet	Dry	
1	P1	1,450,000	12,420,000	5,820,000	49,660,000	69,350,000
	P2	2,050,000	5,430,000	8,200,000	21,730,000	37,410,000
Canal Deepening		2,400,000		3,266,851		5,666,851
2	P1	960,000	-	3,840,000	-	4,800,000
	P2	730,000	-	2,930,000	-	3,660,000
Canal Deepening				10,043,395		10,043,395
3	P1	680,000	-	2,720,000	-	3,400,000
	P2	520,000	-	2,070,000	-	2,590,000

For this study, only the Phase 1 lock excavation and Canal deepening quantities have been used to compute the initial island size. It is assumed that later excavation could be used to increase island area, or taken to other disposal sites, depending upon the economics of the transportation or land values at the time of undertaking the work.

It should be noted that the volumes indicated in Table 8-3 are in-place materials quantities. For the transportation cost analyses and island size computations, bulking factors of 25% and 30% are applied respectively to the volumes of overburden and rock to account for increases after excavation and consolidation of materials within the island. These coefficients would be revised with more detailed study, but are unlikely to increase to more than 30% or be less than 20%. dry

8.4 Construction Schedule

Clearly the construction schedule for the island must follow the excavation program for the Locks and Canal deepening projects. For this study, the following milestone dates have been assumed:

Locks Feasibility Studies complete by..... end of 2003

Engineering and Contract Awards..... end of 2005

Locks construction..... 2005 to 2010

8.5 Wave Protection

8.5.1 Coastal Design Conditions

Bathymetry

Hydrographic data were obtained from British Admiralty Charts 1401 and 1929. Vertical data are referenced to Chart Datum, which is approximately the level of Mean Low Water Springs (MLWS). Water depths within the proposed project area range from 0 to 13 meters at MLWS. Water depths in the island location range from 9 to 12 meters MLWS; the breakwater would be located in water depths of 12 to 13 meters MLWS.

Tidal Levels

Tidal range as reported on the British Admiralty Charts is about 5 meters. Tidal datum characteristics for Balboa, Panama at latitude 8°57' N and longitude 79° 34' W are presented in Table 8-4.

Table 8-4: Astronomical Tidal Datum Characteristics for Balboa

Tidal Datum	Height above Datum (m)
Mean High Water Springs (MHWS)	4.9
Mean High Water Neap (MHWN)	3.8
Mean Low Water Neap (MLWN)	1.1
Mean Low Water Springs (MLWS)	-0.1

Wave Conditions

Offshore wave data used to evaluate wave conditions at the proposed sites were obtained from the *U.S. Navy (USN) Marine Climatic Atlas of the World* (1979). The USN statistics of height and period are for shipboard observations in deep water in the South Pacific Ocean south of Punta Mariata. The nearest station is located southwest of the project site, at about latitude 6° N and longitude 81° W. The data provide both directional and period breakdowns of the wave height statistics; these original duration statistics were adjusted to add up to 100 percent. Analysis of the data indicates that the majority of waves originate from the southwest direction. The most common wave height and period are reported to be 1.5 meters and < 6 seconds (Table 8-5 and Table 8-6).

Table 8-5: Percentage of Wave Height per Direction

	Percentage of Wave from Given Direction									
Hs (m)	**Calm**	**N**	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**	**Total**
0.0	9.7%									9.7%
0.0 - 1.0		2.2%	2.4%	1.2%	1.0%	3.7%	5.7%	3.1%	1.4%	20.6%
1.0 - 2.0		4.1%	5.8%	2.3%	1.1%	13.2%	21.2%	6.5%	1.7%	55.8%
2.0 - 3.0		1.2%	1.4%	0.3%	0.1%	2.7%	4.7%	1.4%	0.2%	12.0%
3.0 - 4.0		0.1%	0.3%	0.0%	0.1%	0.4%	0.5%	0.1%	0.0%	1.5%
4.0 - 6.0		0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.4%
Totals	9.7%	7.7%	9.9%	3.9%	2.3%	20.0%	32.3%	11.1%	3.3%	100.0%

Table 8-6: Percentage of Wave Period per Wave Height

	Percentage of Wave Period (Seconds)							
Hs (m)	Calm	< 6	6 - 7	8 - 9	10 - 11	12 - 13	> 13	Total
0.0	9.7%							9.7%
0.0 - 0.5		17.7%	2.7%	0.8%	0.9%	0.0%	0.0%	22.2%
1.0 - 1.5		27.8%	16.8%	5.7%	1.6%	1.7%	0.8%	54.3%
2.0 - 2.5		3.4%	4.4%	2.5%	1.0%	0.4%	0.4%	12.0%
3.0 - 3.5		0.4%	0.5%	0.3%	0.1%	0.1%	0.0%	1.5%
3.5 - 5.0		0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.3%
Totals	9.7%	49.4%	24.5%	9.4%	3.6%	2.1%	1.3%	100.0%

Figure 8-1 presents a wave rose developed from the USN data that indicates the percentage of waves from each direction. This clearly shows the predominance of the 1.50 meter wave from the southwest direction. Point Mala in southern Panama and Cape San Lorenzo of Ecuador on the western shore of South America serve to create land barriers that only allow waves approaching from a small "window" (from about 190 through 200 degrees) to directly reach the project site. Figure 8-2 shows the percent occurrence of waves approaching the Bay of Panama from the south and southwest directions (from about 157.5 through 247.5 degrees). An extreme wave analysis of the above wave statistics was prepared and produced significant wave heights of 4.80 m and 5.00 m for the 50 year and 100 year return periods respectively.

Figure 8-1: Wave Rose

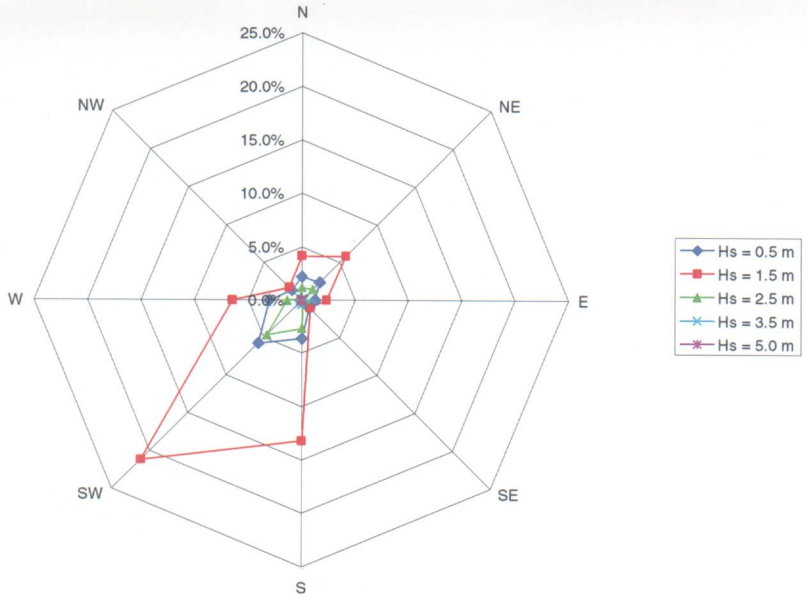
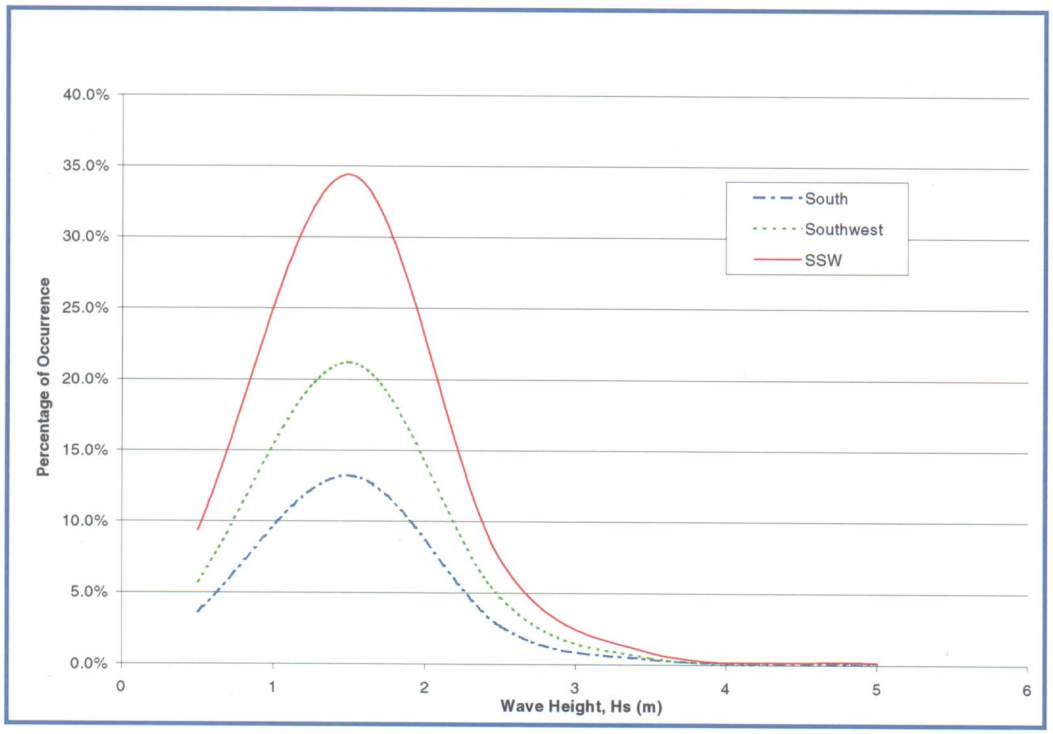


Figure X-1
Wave Rose

Figure 8-2: Percentage Occurrence of Waves from S and SW direction



As the project is primarily located in water depths of 12 to 13 meters, along with consideration of the 5.00 meter tidal range, it is evident that ocean waves approaching from the south and southwest will not be subject to breaking prior to reaching the project site. To be conservative, it is assumed that all waves from the south and southwest direction could reach the project site, and a design wave of 5.00 meters was used as a basis for the preliminary design and preparation of the cost estimate for the wave protection structures.

9 DEVELOPMENT CONCEPTS

9.1 Introduction

The materials quantities and characteristics presented in the Harza report indicate that 69.35 million m3 and 37.41 million m3 of excavation will be required for the P1 and P2 alternatives respectively. Island development concepts for each materials volume are developed to respond to the following alternatives:

Materials from P1 Lock Alignment

- Offshore Breakwater Option
- Revetment/Breakwater Option

Materials from P2 Lock Alignment

- Offshore Breakwater Option
- Revetment/Breakwater Option

The fundamental difference between the P1 and P2 alternatives is the volume of materials to be incorporated, and its impact on the size of the island. The two sub options examine the size, and cost of the island assuming construction with and without an offshore breakwater to protect the main and future berth areas.

9.2 Construction Considerations

As can be seen from Table 8-1, a considerable portion of the excavated material will be rock. While this should provide armor stone for the revetment and breakwater, it raises issues related to building foundations, utility corridors, construction sequencing and long term settlement.

Taking these considerations into account, the following construction sequence is suggested:

1. Remove sufficient overburden materials to expose rock and also complete access road or rail grading.
2. Place rock over full island area, bringing elevation to approximately +4.00 MLWS.
3. Construct rock retaining dikes and cells on placed rock fill
4. Select or crush rock to provide a filter layer between large material and upper layers
5. Place overburden and non-rock material as a final layer.

6. Place a layer of crushed stone over island to provide base material for development.

In this way, the larger rock, with high void ratio will be placed in the lower layers of the island and can also displace the silts, if geotechnical studies indicate that this is acceptable. The upper layers of the island would be placed in the dry, with areas also designed to receive dredged materials if necessary. However, it is unlikely that Channel expansion material removed by cutter suction or trailer hopper dredge equipment could be economically incorporated in the island construction.

9.3 Materials Transportation Alternatives

The original report prepared by Harza[4] in August 2000 provided cost estimates for the removal and transportation of Locks material to a number of designated disposal sites located within some 10 km of the work site. Due to the number of sites and proximity to the excavation areas, the transportation cost computations were based on a trucked operation, using large volume off road dump trucks.

Since the island is a single point of materials placement, and located some 20 km from the excavation site, it was necessary to extend the transportation cost studies to other methods of materials handling. Consequently, the following options are evaluated in this report:

- Truck Haul
- Dedicated Rail line
- Conveyor system.

9.3.1 Methodology for Computation of Transportation Costs

Transportation cost models were constructed for each system indicated above. The estimated costs include the following major work categories:

- Mobilization
- Construction of Haul roads, conveyor or rail system
- Maintenance of access corridors
- Equipment rental/operating and maintenance costs based on cycle times, materials characteristics and volumes

---

[4] Evaluation of Lock Channel Alignments, Harza, August 2000

- Contractor's profit and overhead

At this stage, contingency allowances have not been applied to the alternative transportation cost models, since they will be equally applicable to all options and the intent of the exercise is the selection of the preferred transportation mode. They are applied to the full estimates presented later in this report.

The reader is reminded that the following estimates only include the cost of haulage of the materials to the island location, in order that the preferred system can be selected and the island designed to accommodate the recommended option. While allowances are included for the civil works needed to support the transportation system, the estimates do not include the cost of construction of the island or any of the infrastructure needed for development. The complete construction cost estimates are provided in Section 11 of this report

9.3.2 Truck Haul Option

Unit rates for truck haul and productivity indices were extracted from the Harza estimates, which also included materials excavation, and input to a transportation cost model that takes into account:

- Equipment Classification and capacity
- Haul distance
- Average speeds
- Load unload times
- Maintenance and down time
- Acceptable truck headway
- Materials Characteristics

Table 9-1 indicates the materials transportation component of the island construction, using large 200 tonne dump trucks over a purpose built haul road. It should be noted that this cost only applies to materials transportation, and includes the cost of construction and maintenance of a dedicated haul road. Additional detail on the cost estimates is presented in Appendix D1 of Volume 2 of this Report.

The transportation productivity models also indicate a time constraint for the truck transportation option. According to the model output, it could take almost ten years to build the island using the truck haul system, primarily caused by congestion at the dumping sites if additional trucks are input to the system. While this could probably be resolved once the island was under construction, productivity would be low during the early phases of the work.

Table 9-1: Estimated Transportation costs using Truck Haul

Costs Using Material Quantities from Channel Alignment P1				
General				
Mobilization and Demobilization	1	LS	$2,500,000	$2,500,000
Truck Haulage				
Equipment Cost	87,381,000	m^3	$12.27	$1,071,869,876
Haul Roads				
Construction and Maintenance	87,381,000	m^3	$0.05	$4,697,025
Total Haulage Cost				***$1,079,067,701***

Costs Using Material Quantities from Channel Alignment P2				
General				
Mobilization and Demobilization	1	LS	$2,500,000	$2,500,000
Truck Haulage				
Equipment Cost	47,136,500	m^3	$12.27	$578,205,617
Haul Roads				
Construction and Maintenance	47,136,500	m^3	$0.10	$4,697,025
Total Haulage Cost				***$585,192,642***

9.3.3 Rail Transportation System

A major portion of the original Canal excavation was moved by rail, and the use of rail for this project offers some distinct advantages:

- The system is independent of the existing highway network
- Rail is normally more economical for high volumes being moved over extended haul distances
- The existence of a rail connection to the existing Panama Canal Railroad system would offer an effective interface between the Pacific and Atlantic coast transshipment terminals
- Air pollution from a rail system should be less than that for truck haulage.

Three alternative routes were initially assessed for the rail access and presented to ACP staff during technical work sessions and meetings with ARI held on October 24 and 25. Based on these discussions, the route indicated in Figure 9-1 was selected.

The selected alignment does conflict with a number of general development recommendations provided by consultants to ARI for the future use of the Howard AFB. However, it was agreed during the meetings that the location of the rail link within the former base would enhance the attraction of the property to future developers. It was also considered that none of the apparent land use conflicts represented fatal flaws in either the island or HAFB development proposals.

The horizontal and vertical alignments shown optimize the cut and fill along the route and a maximum grade of 1% is indicated. This is considered to be the optimum for balanced locomotive power. Overburden material from the initial phases of the locks excavation would also be used to build embankments for the rail line, where required.

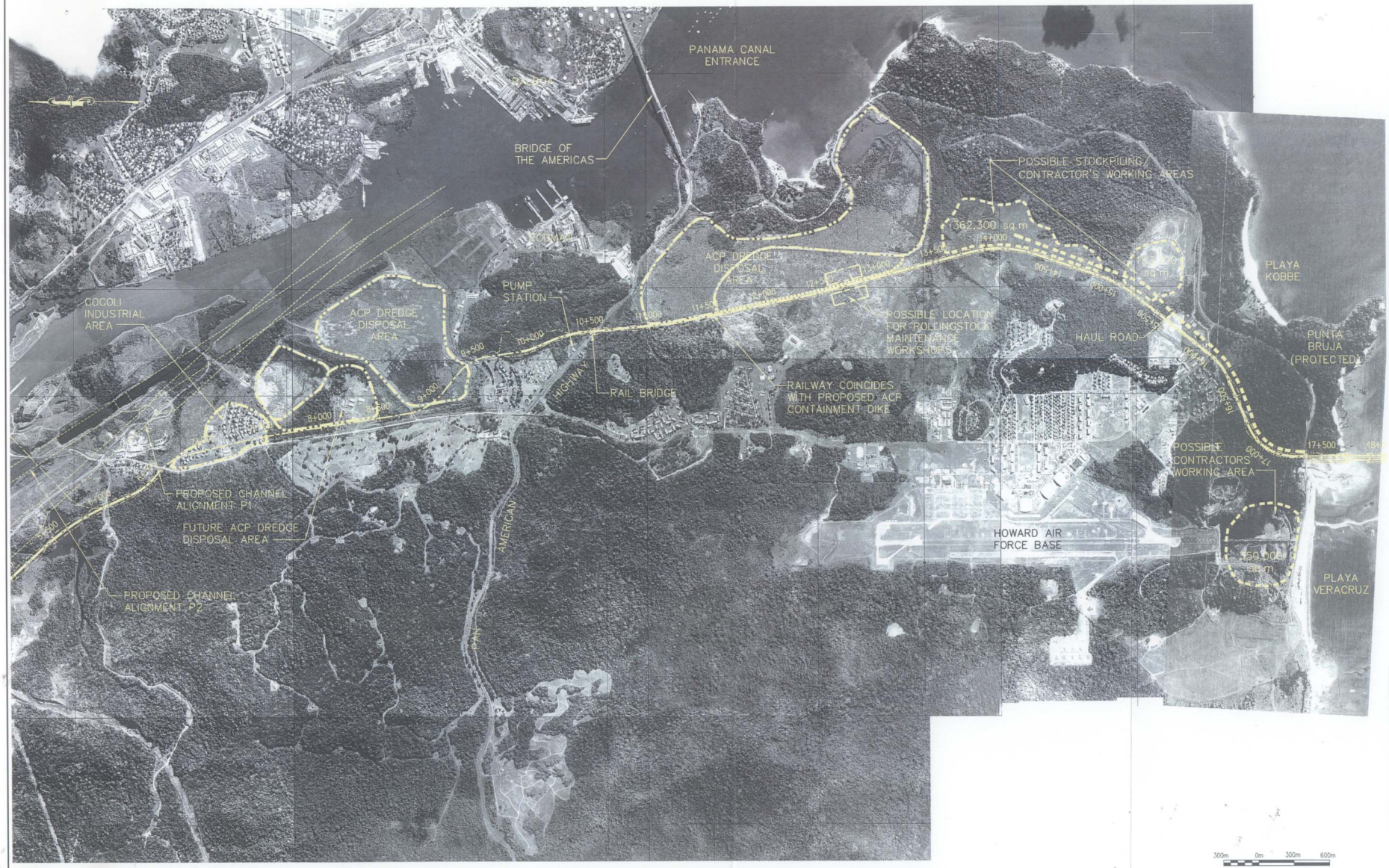
Unlike the truck haul option, no studies have been undertaken for ACP on the costs of rail transport of excavated materials for the Locks Project. The consultants therefore constructed a transportation model to develop equipment requirements for the project, and then developed a capital, operations and maintenance cost model to provide the unit rates for the rail option. No residual value was allocated to locomotives and rolling stock, although it was considered that the provision of rehabilitated or used locomotives would be a more probable option than new purchases for the primary traction units. Based on these analyses, Table 9-2 then indicates the estimated transportation cost using a rail based transportation system. Additional detail on the cost estimates is presented in Appendix D3 of Volume 2 of this Report.

Table 9-2: Estimated Transportation Costs using Rail System

Costs Using Material Quantities from Channel Alignment P1				
General				
Mobilization and Demobilization	1	LS	$2,500,000	$2,500,000
Materials Haulage				
New Railway on Formation	34.90	Km	$813,600	$28,394,640
New Railway on Trestle	0.40	Km	$413,700	$165,480
New Railway on Causeway/island	12.1	Km	$415,500	$5,044,170
Railway Structures	1.0	LS	$5,172,405	$5,172,405
Materials Transportation	87,831,000	m3	$2.48	$216,295,862
Total Haulage Cost				***$257,572,557***

Costs Using Material Quantities from Channel Alignment P2				
General				
Mobilization and Demobilization	1	LS	$2,500,000	$2,500,000
Materials Haulage				
New Railway on Formation	34.90	Km	$813,600	$28,394,640
New Railway on Trestle	0.40	Km	$413,700	$165,480
New Railway on Causeway/island	11.2	Km	$415,500	$4,632,825
Railway Structures	1.0	LS	$5,172,405	$5,172,405
Materials Transportation[5]	43,352,500	m3	$2.38	$103,511,280
Total Haulage Cost				***$144,376,630***

[5] Unit haul rates for each alternative will vary according to mean haul distance, equipment allocations and cycle time. Average haul distance to Option P2 is 1.00 km less than for P1.



MOFFATT & NICHOL ENGINEERS

SKIDMORE, OWINGS AND MERRILL LLP

LOUIS BERGER INTERNATIONAL

ACP AUTORIDAD DEL CANAL DE PANAMA

Designed by D.J.Mac.	Date NOV. 2001		Rev.
Dwn by D.J.Mac.	Ckd by M.G.H.	Design file no.	
Reviewed by T.J.S.		Drawing Scale AS SHOWN	
Submitted by M.G.H.		Plot scale 1 = 1	

PRE-FEASIBILITY STUDY FOR ARTIFICIAL ISLAND DEVELOPMENT

PROPSOED ROUTE FOR RAIL LINE – AERIAL

FIG 9–1

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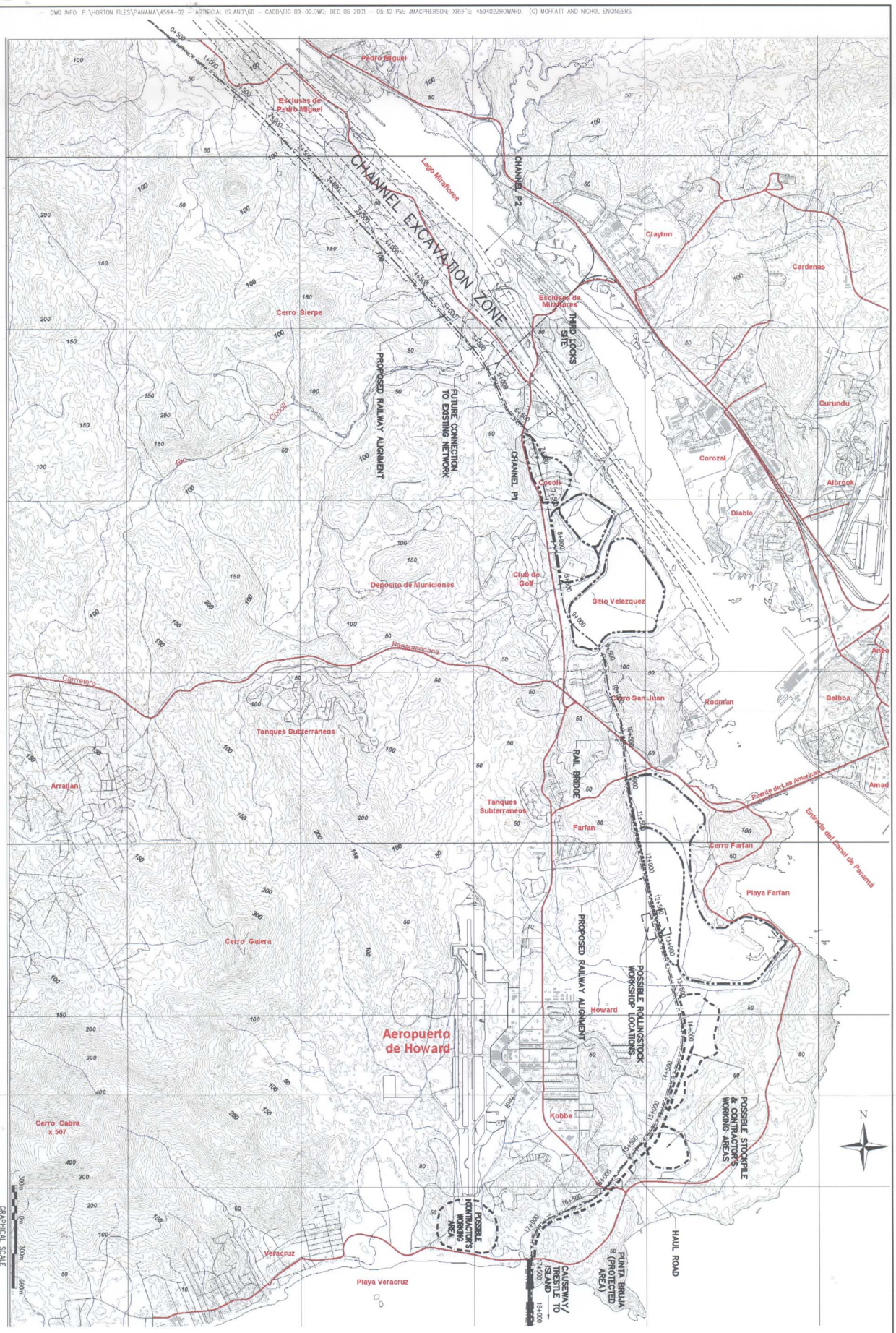

FIG 9-2

PRE-FEASIBILITY STUDY FOR ARTIFICIAL ISLAND DEVELOPMENT

PROPOSED ROUTE FOR RAIL LINE - TOPOGRAPHICAL

ACP AUTORIDAD DEL CANAL DE PANAMÁ

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Designed by: D.J.Mac		Date: NOV. 2001	Rev.
Dwn by: D.J.Mac	Ckd by: M.G.H.	Design file no.	
Reviewed by: T.J.S.			
Submitted by: M.G.H.		Drawing Scale: AS SHOWN	
		Plot scale: 1 = 1	

9.3.4 Conveyor system

In practical terms, the use of conveyors for this project seems to be an unlikely option, since almost 80% of the material to be transported will be rock, and much of this is likely to exceed 0.5 m in diameter or side.

According to opinions expressed by various bulk handling specialists and equipment manufacturers, rock of a greater diameter than 15 cm is likely to cause significant damage or accelerated wear on the idler systems and belt transfer points. For this reason, it was assumed that all material outside the acceptable parameters for a conveyor system would be moved by truck.

The conveyor system would be a low level installation to facilitate maintenance and access and generally follow the alignment selected for the rail line, shown in Figure 9-1, above. Access to the conveyor would be from a service road, which would also be the haul road for the truck transportation system.

As for the rail system, ACP did not have any study information on the costs of materials handling by a conveyor system. The consultants therefore constructed a cost model using industry prices for conveyor systems for heavy bulk materials, primarily drawing from experience based on the planning and design of coal terminals. Table 9-3 indicates the estimated transportation costs using a conveyor system, supplemented by truck haul for the larger sized materials. For additional detail on the cost estimates used to produce the summary cost table, the reader is referred to Appendix D2 of Volume 2 of this Report.

Table 9-3: Estimated Transportation Costs using Conveyor System

Costs Using Material Quantities from Channel Alignment P1				
General				
Mobilization and Demobilization	1	LS	$2,500,000	$2,500,000
Truck Haulage				
Equipment and Haulage Roads	34,675,000	m^3	$10.77	$373,617,565
Conveyor Haulage				
Equipment Cost	50,206,000	m3	$2.86	$143,363,072
Total Haulage Cost				***$519,480,637***

Costs Using Material Quantities from Channel Alignment P2				
General				
Mobilization and Demobilization	1	LS	$2,500,000	$2,500,000
Truck Haulage				
Equipment & Haulage Roads	18,706,250	m^3	$10.88	$203,584,535
Conveyor Haulage				
Equipment Cost	27,183,967	m3	4.54	$125,908,228
Total Haulage Cost				***$326,590,088***

9.3.5 Preferred Materials Transportation System

Table 9-4 shows the comparison of transportation costs for the three systems analyzed. It should be noted that each system will lead to slight differences in the configuration of the links to the island and the island size itself. However, these have not been taken into account at this preliminary level of evaluation, since they do not impact the selection of the preferred system.

Table 9-4: Cost Summary for Alternative Materials Transportation Systems

Alignment P1	
Truck Haul	$1,079,066,701
Rail Haul	**$257,572,557**
Conveyor Haul	$519,480,637

Alignment P2	
Truck Haul	$585,192,642
Rail Haul	**$144,376,630**
Conveyor Haul	$326,590,088

As a practical matter, only the truck haul and rail systems are considered to be technical viable alternatives, since there are considerable doubts as to whether the conveyor system could handle the irregular rock size expected to be produced by this project.

However, from the evaluation of costs and productivity criteria to meet the construction schedule, it is clear that a rail based system will offer the most economical transport system to move the rock and other materials from the excavation sites to the island. It also offers considerable residual value, which in turn will enhance the future commercial viability of the island as container traffic is developed and interaction between terminals on the two coasts is developed.

9.4 Access Recommendations

9.4.1 Landside

Access to the island will be via a causeway, constructed from the shoreline to support the rail system recommended in the previous paragraph. An added benefit of the rail system is that it can later serve as a connection to the existing Panama Canal Railroad if provision

is made to cross the Locks[6]. Given that the causeway will interrupt the local littoral regime, it is expected that an open trestle section will be required at the shoreline to preserve the local sand beaches and the materials around the discharge of the river at the eastern end of the Veracruz beach area.

A bridge will probably be needed at the approximate mid point of the causeway to permit passage of small fishing and recreational vessels. The bridge should be located at a point where water depth is on the order of 5.00 m, to avoid need for dredging or maintenance of the channel. It should be also noted that the height of the bridge will necessitate a ramped section for rail and highway access. Combining the need for water depth and an economic and acceptable rail grade may necessitate a degree of design trade-off as the project develops. From the information available, it would seem that a 2.00% grade on the northbound ramp would provide a workable response to the design criteria for an empty or lightly loaded train, with a 1.00% grade on the southbound of the ramp, where the materials trains will be running with a full load.

If construction of the bridge was postponed until the end of the island project, the ramp could be delayed and rail productivity improved.

Figure 9-3 shows a typical cross section of the proposed causeway. It includes provision for a four- lane highway, rail access and service road, a utility corridor, pedestrian access and separation areas.

Figure 9-4 shows a typical section of the open piled trestle section of the access. It is approximately 40 m wide, and carries all of the features noted above for the causeway, except for the landscaping elements.

[6] Provision for rail lines has been incorporated into the approaches and swing bridge at Miraflores locks but the link has not been completed.

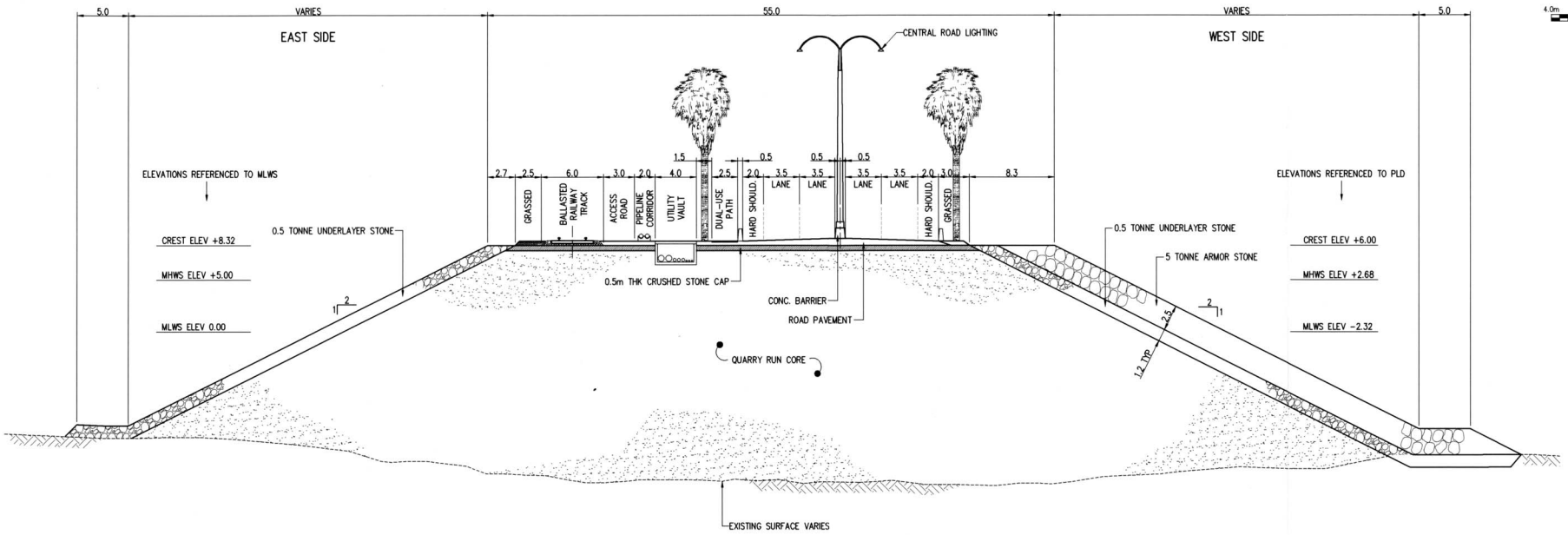

FIG 9-3: CROSS SECTION OF ACCESS CAUSEWAY

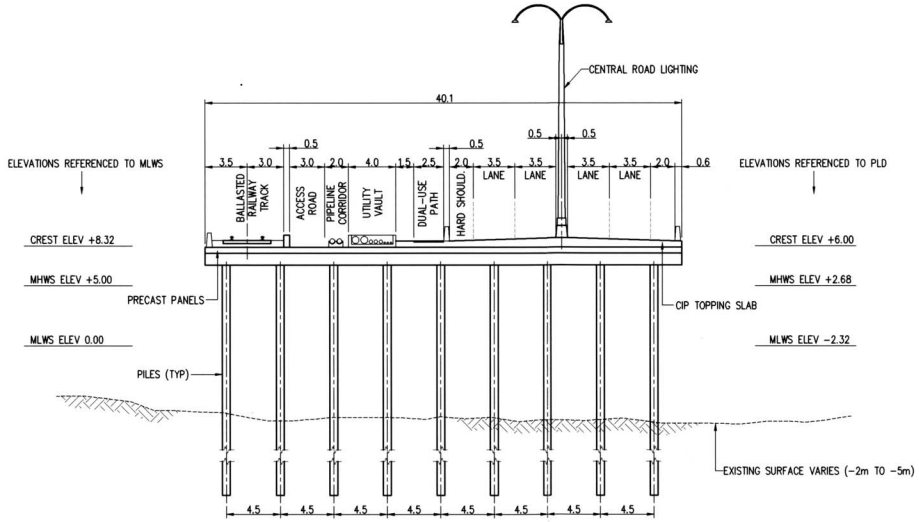

FIG 9-4: CROSS SECTION OF ACCESS TRESTLE

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PRE-FEASIBILITY STUDY FOR ARTIFICIAL ISLAND DEVELOPMENT
TYPICAL CAUSEWAY AND TRESTLE CROSS SECTIONS

DWG INFO: P:\HORTON FILES\PANAMA\4594-02 - ARTIFICIAL ISLAND\60 - CADD\FIG 09-03.DWG, NOV 09 2001 - 10:24 AM, JMACPHERSON, XREF'S, 4594002BORDER, (C) MOFFATT AND NICHOL ENGINEERS

9.5 Navigation Access

9.5.1 Operational Criteria

In order to offer a high level of service to port users, the following navigation and channel operational criteria are considered essential to the efficient management of port traffic:

- Two way vessel traffic capability
- Unrestricted, 24 hour transit for all but the largest cargo vessels
- State of the art vessel traffic control system.

Along with the above, the following criteria were also assumed for the preliminary sizing of the navigation channel:

- Tug assistance will be provided for all vessel berthing operations
- Pilotage will be required for all vessels

9.5.2 Design Standards

The approach taken for the navigation channel analyses is based on a synthesis of the following publications:

- Permanent International Association of Navigation Congresses (PIANC), International Commission for the Reception of Large Ships (ICORELS), "Optimal Layout and Dimensions for the Adjustment to Large Ships of Maritime Fairways," Report of Working Group IV, 1980.
- National Ports Council (NPC), "Port Approach Design- A Survey of Ship Behaviour Studies," London, U.K, 1975.
- US Army Corps of Engineers, "Hydraulic Design of Deep-Draft Navigation Projects, " EM 1110-2-1613, 1983.
- TERMPOL - Canadian Coast Guard (1977)
- US Navy, Naval Facilities Engineering Command, Design Manual DM-26.1 "Harbors," 1981.

Other pertinent publications are referenced in subsequent paragraphs where appropriate, however, the above references provide the basis for channel depth, channel width, and turning basin requirements.

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9.5.3 Channel Depth Requirements

Channel depth requirements are taken from the above referenced U.S. Army Corps of Engineers document. The required channel depth relative to a referenced water level must be based on:

- Loaded vessel draft including trim
- Squat
- Wave induced motions
- Safety Clearance
- Dredging Tolerance
- Advanced Maintenance Dredging

For the purposes of this study, all dredging depths and drafts are referred to Mean Lower Water Spring tidal elevations (MLWS) which is equivalent to 2.32 m below Precise Level Datum (PLD) as defined in the Panama Canal Clearance Diagram.[7]

Loaded Draft

For the purposes of this report, a fully loaded draft of 15.20 m, as noted in section 6.1.1, has been used for preliminary planning purposes.

Squat

The position of a vessel's keel relative to the channel bottom will lower as the vessel speed increases. This phenomenon results when increased water velocities flowing past a moving ship hull produce a localized lowering of the water surface. In general, squat is a function of the vessel speed, under-keel clearance, channel width, channel depth and vessel dimensions.

Wave-Induced Motions

Wave hindcast analyses will be needed to determine the effect of wave-induced motions on the main navigation channel. Given the protection of the channel by Taboga and Taboguilla islands, wave induced motion is unlikely to exceed 1.0 m.

Safety Clearance

For a channel bed consisting of sand or silts, as expected at the project locations, a slight touch between vessel and bed is acceptable. For this study, a safety clearance of 0.6 m has been adopted.

---

[7] Panama Canal Clearance Diagram, Drawing Ref 6120-30C, Panama Canal Authority July 1999

Once again, a more detailed subsurface investigation program is necessary to determine the extents of the rock layer(s) and potential hard spots within the channel area.

Dredging Tolerance

An additional tolerance depth of 0.5 m has been allowed (beyond the design dredge depth) as a dredging pay item. There are inherent difficulties in dredging a uniform and highly accurate depth and the assumed tolerance is a widely accepted standard.

Advanced Maintenance Dredging (AMD)

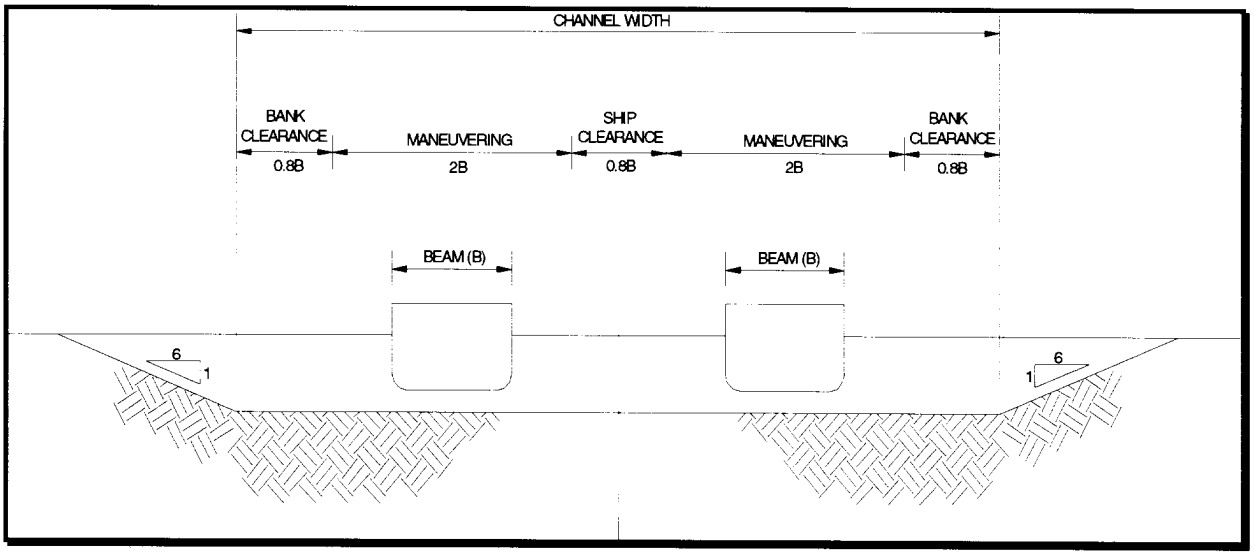
In areas prone to siltation, an additional depth can be added to the channel in order to allow for storage of accumulated sediment between maintenance dredging events. This approach prevents the premature loss of project depth and increases the length of time between dredging events.

Given the apparent stability of the bottom contours in the area and in the absence of any supporting data to the contrary, it is suggested that an allowance for AMD is not required at this stage.

9.5.4 Channel Width

The minimum width of a straight channel depends on the size and maneuverability of the vessel navigating the channel, the type of channel bank, the effect of other vessels in the channel and the effects of wind and currents. The width required takes into account space for a maneuvering lane, ship clearance and bank clearance.

Figure 9-5: Typical Width Dimensions of a Straight Dredged Channel



The Maneuvering Lane

The maneuvering lane must allow for the oscillating track of a maneuvering vessel. Generally, the width of the maneuvering lane will vary from 1.6 to 2.0 times the beam of the vessel depending on its controllability.

The Ship Clearance Lane

In a multiple lane channel, ship clearance lanes are normally taken as 80 percent of the design vessel beam.

Bank Clearance

A bank clearance width of 80% of the vessel beam is added to both sides of a channel.

9.5.5 Recommendations

Navigation access to the island is routed south of the existing Pacific and Explosives anchorages and north of Taboga Island. If it is assumed that passage of two mainline Post Panamax vessels is required, the channel would be 300 to 330 m wide to meet the various design standards.

However, there are a number of vessel passing or navigation options that would reduce channel width and still provide a high level of service. As a port designed to handle both main line and feeder ships, it is suggested that one way traffic would be appropriate for mainline vessels, with two way traffic for ships below a given size limitation. Under these conditions, the channel width could be reduced to approximately 225 m.

It is therefore suggested that the initial channel width should be set at 225 m, with potential for expansion later as traffic and financial resources permit. The initial depth is set at 16.75 m to accommodate a loaded vessel draft of 15.20 m, as indicated in the preliminary design parameters for the Third Locks project.

A 600 m turning basin is provided at the entrance to the container berths on the east face of the island. This is adequate to handle the largest general cargo vessels expected to use the new Locks and port facilities.

Future expansion could include widening and deepening of the canal to accommodate VLCC or ULCC vessels in the event that oil or bunker fuel consolidation/distribution facilities were developed on the island.

Given the existence of a number of small islands and rock outcrops in the area of the proposed channel, a substantial proportion of the dredging may be rock. During the capital dredging work for the Vacamonte port, some 10 km west of the proposed island, a dense andesite/basalt layer was encountered at depths of approximately 7.00 to 10.00 m below MLWS. This hard layer was overlain by approximately 2.00 m of highly weathered to partially weathered rock, with very soft silts above this layer.

For the purpose of preliminary cost estimating, it has been assumed that 5.0%of the dredging will be in dense rock and 15% would be in weathered hard material. It is emphasized that these allowances are not supported by any site investigation data, and simply reflects the experience of the consultant in Panama and other similar areas.

9.6 Wave Protection

9.6.1 Protection Requirements

Although the wave climate in the area of the island is typically mild, long period waves are frequently generated by storms in the Pacific, and can cause considerable movement of a vessel at an unprotected berth. Similarly, container transfer operations are vulnerable to vessel movement, particularly from long period swells which cause " ranging" of the ship at the berth face. Liquid and dry bulk operations are less impacted by wave action, and would not necessarily require protection at the project location.

9.6.2 Breakwater Alternatives

Given the need to offer maximum flexibility for future development, and taking into account the large volume of rock that will be derived from the Locks excavation, two breakwater configurations are suggested.

The offshore breakwater concept would give full protection to berths on the east, south and west face of the island, enabling container operations to be extended to all three areas. It is located some 500 m from the south face of the island, to facilitate access by large container ships, oil tankers and bulk vessels at some time in the future.

In the event that the cost of the offshore breakwater adversely impacts the financial viability of the project, adequate protection to the east face of the berths could be provided by the construction of a "stub" breakwater some 1,000 m in length, extending from the south east corner of the island. However, there is some doubt as to the degree of extent of wave motion that vessels would experience at berths located on the south face of the island. Based on experience at other locations subject to long period waves from the Pacific, it would seem likely that unprotected berths on the south face would not be operationally acceptable for container ships, but might work for bulk carriers.

9.6.3 Preliminary Design Basis

Figure 9-6 indicates a typical cross section of the offshore berm breakwater concept. The graded armor layer is placed on a slope of 1:1.25, and the breakwater has a crest elevation of approximately 11.25 m above MLWS. Armor to the causeway section of the access would consist of 5.00 tonne placed stone. In the event that the shorter breakwater option is selected, protection and section configuration will be as for the offshore structure.

Given the intention to use as much material as possible from the locks excavation, and based on the output from local quarries, it would seem reasonable to expect that armor stone up to 10 tonnes will be available, with occasional pieces of 15 tonnes.

A 5.0 meter, 11 second wave was used as the design wave condition to size the armor stone. Several breakwater types can be considered for this project, with the final selection heavily dependent on the type and size of rock that could be removed economically from the Locks excavation site.

At this level of evaluation, a berm breakwater is suggested, since it can largely be constructed by dumping graded rock material without a significant amount of rock sorting or re-handling. These structures exhibit a high level of stability in relatively high wave conditions and are also flexible where settlement is likely to occur. Computations were made using recent PIANC guidance for design of berm breakwaters, which indicates that a 3.5 m berm width would be appropriate. This was computed for an armor rock having W_{14}, W_{50}, W_{85} and percentage exceedance values of 3, 10 and 14 tonnes respectively.

The berm breakwater is designed to match the characteristics of the available rock. Under this assumption, all stone larger than 3.00 tonnes would be used as armor material, whereas all smaller rock would be used in the breakwater core.

The primary armor stone size fits within the design parameters for wave protection at the island and would enable the breakwater or island revetment to be built with an outer slope of 1V to 2H.

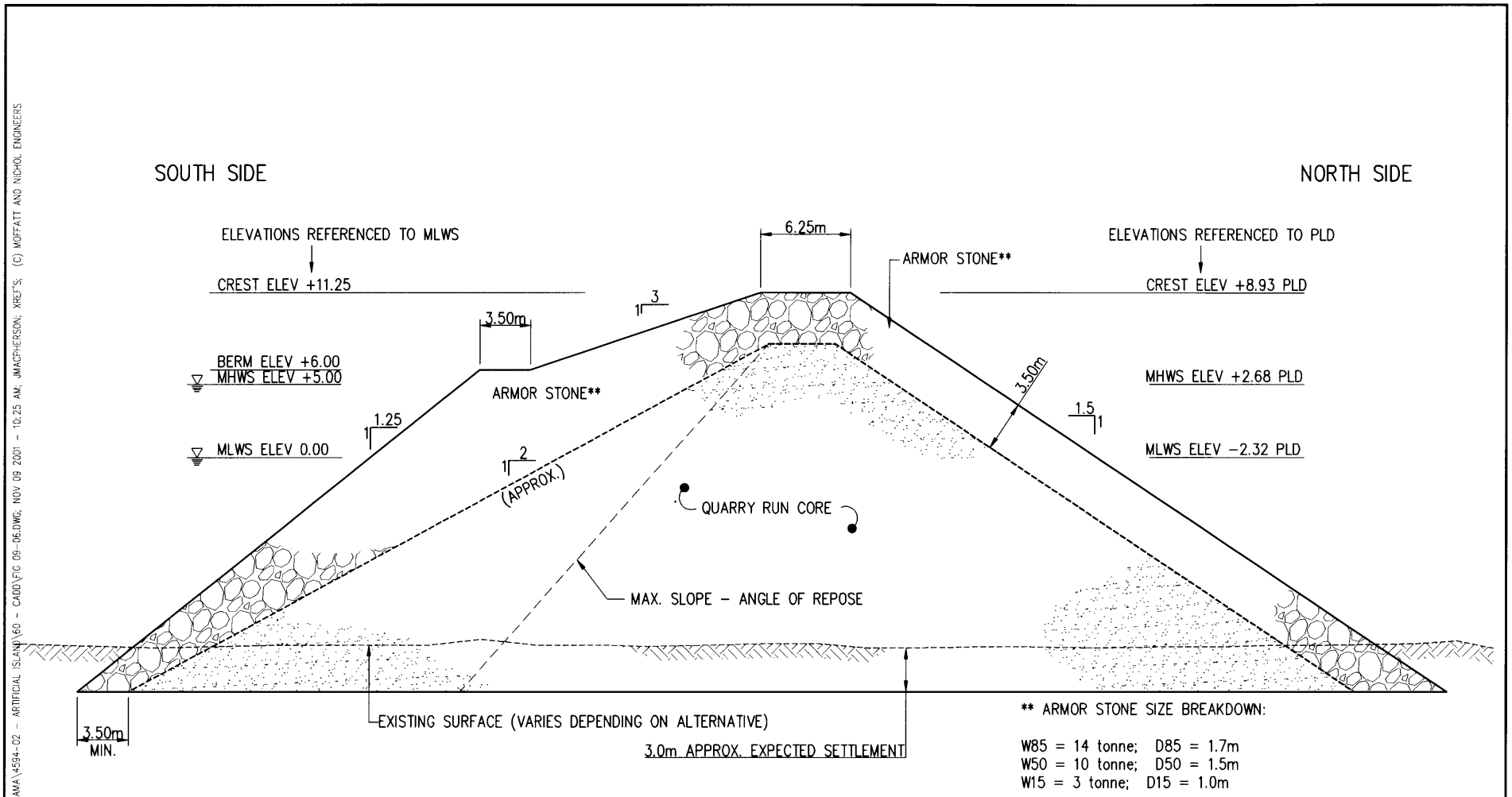


FIG 9-6: TYPICAL CROSS SECTION OF OFFSHORE BREAKWATER

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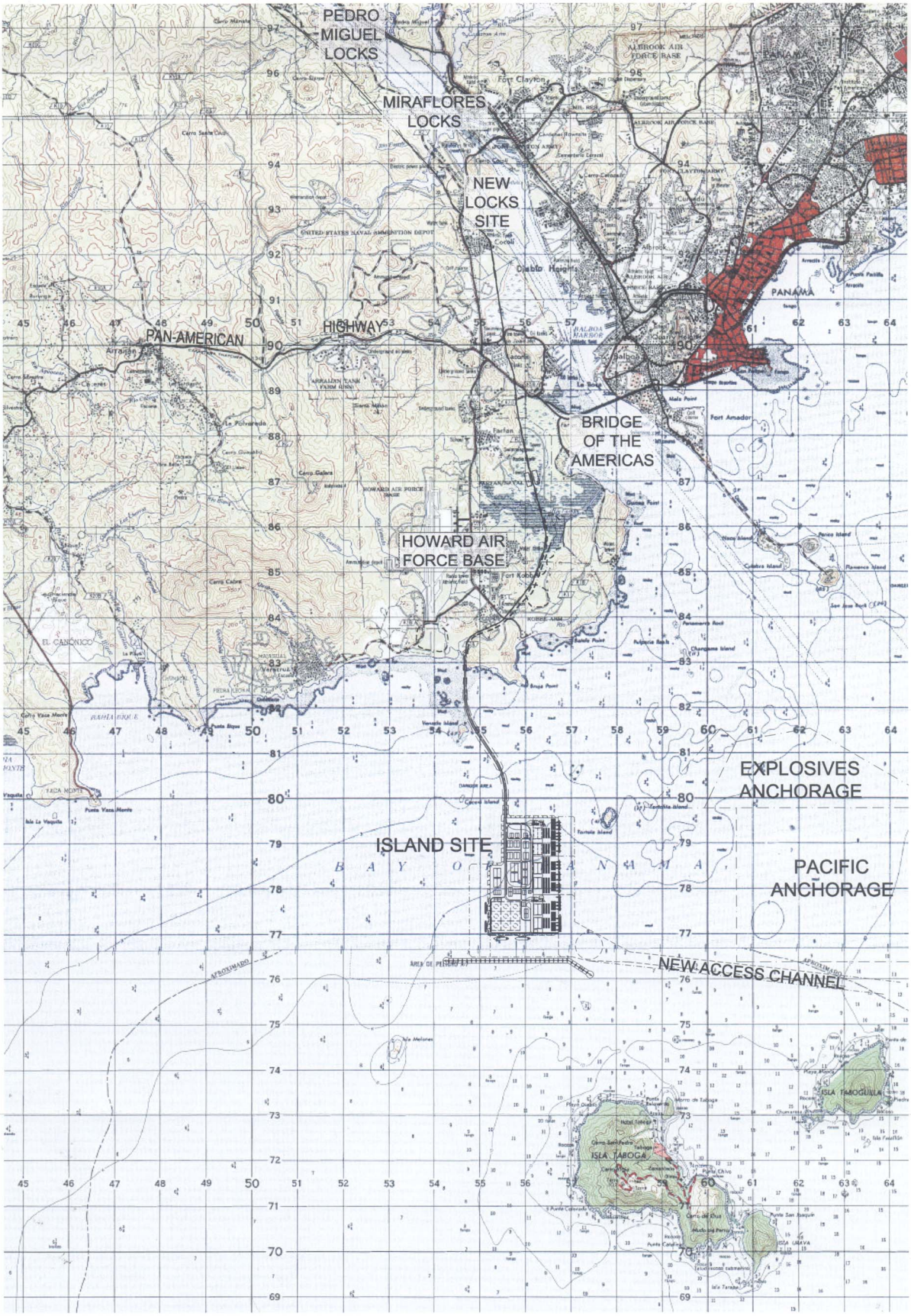
9.7 Development Concepts

Figure 9-7 shows a general concept for the island, causeway connection, approach channel and land links, based on the recommended rail access system. Figure 9-8 to Figure 9-11 show a series of concepts, based on the volume of materials derived from the P1 and P2 Lock alignment alternatives and the navigation and wave protection considerations discussed earlier. Sub-options are also indicated for each island alternative, whereby the offshore breakwater is eliminated in order to reduce costs.

DWG INFO: P:\HORTON FILES\PANAMA\4594-02 - ARTIFICIAL ISLAND\60 - CADD\FIG 09-07.DWG; NOV 09 2001 - 10:26 AM; JMACPHERSON; XREF'S; 459402ZLOCALITY, ISLA-1A, 459402ZBORDER, 459402ZBATHYM, (C) MOFFATT AND NICHOL ENGINEERS



800.0m 0m 800.0m 1600.0m

SCALE: 1 : 40000

FIG 9-7

PRE-FEASIBILITY STUDY FOR ARTIFICIAL ISLAND DEVELOPMENT

GENERAL PLAN OF ISLAND AND ACCESS CONNECTIONS (SHOWING ALTERNATIVE P1-A)

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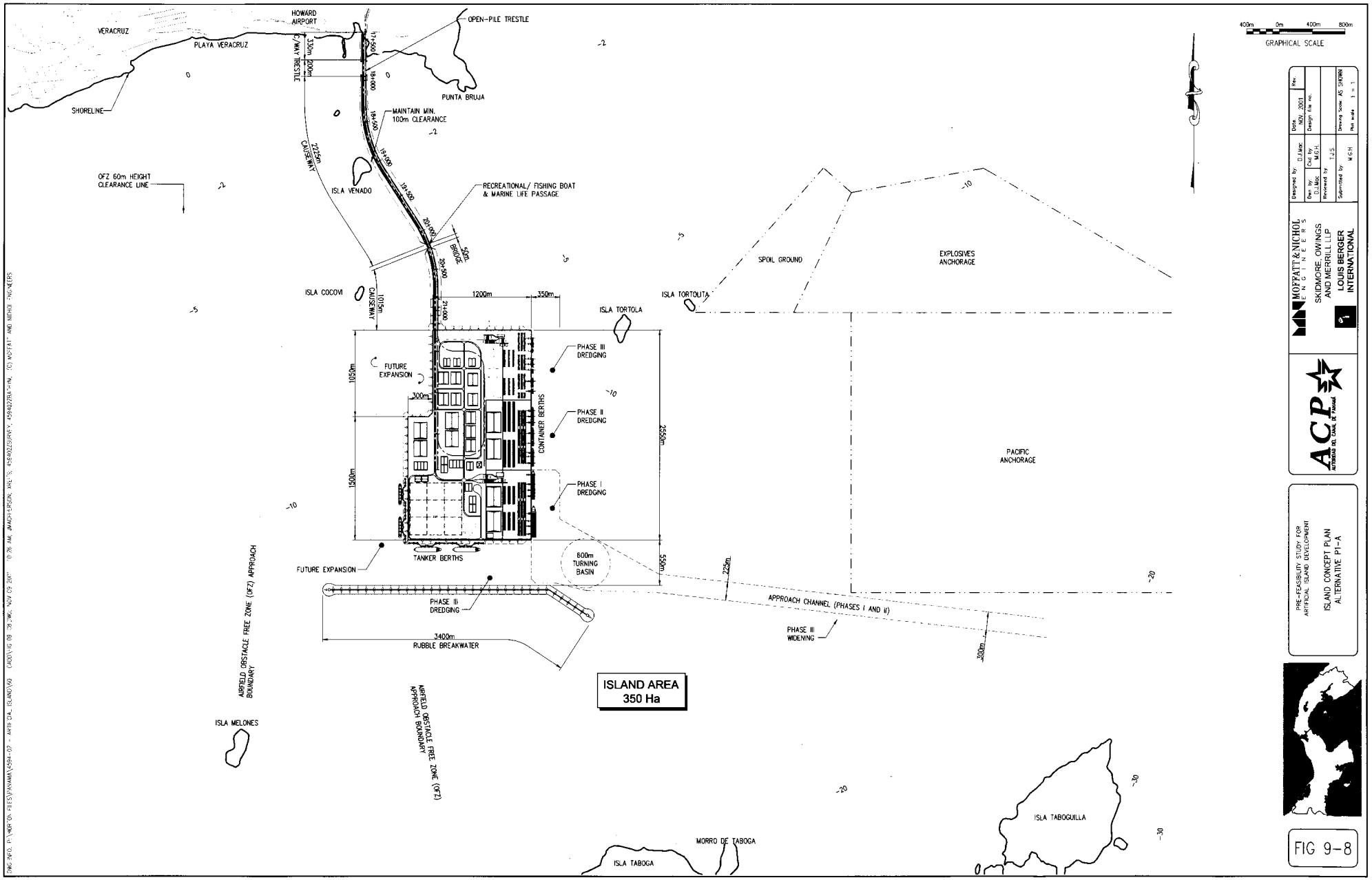
Reviewed by: T.J.S.			
Submitted by: M.G.H.		Drawing Scale: AS SHOWN	
		Plot scale: 1 = 1	


VERACRUZ
PLAYA VERACRUZ
SHORELINE
HOWARD AIRPORT
OPEN-PILE TRESTLE
PUNTA BRUJA
C/WAY TRESTLE
330m
200m
2215m CAUSEWAY
MAINTAIN MIN. 100m CLEARANCE
OFZ 60m HEIGHT CLEARANCE LINE
ISLA VENADO
RECREATIONAL/ FISHING BOAT & MARINE LIFE PASSAGE
50m BRIDGE
ISLA COCOVI
1015m CAUSEWAY
1200m
350m
ISLA TORTOLA
ISLA TORTOLITA
SPOIL GROUND
EXPLOSIVES ANCHORAGE
PACIFIC ANCHORAGE
FUTURE EXPANSION
1050m
300m
1500m
PHASE III DREDGING
PHASE II DREDGING
PHASE I DREDGING
CONTAINER BERTHS
2550m
TANKER BERTHS
600m TURNING BASIN
500m
225m
APPROACH CHANNEL (PHASES I AND II)
PHASE III WIDENING
300m
3400m RUBBLE BREAKWATER
ISLAND AREA 350 Ha
AIRFIELD OBSTACLE FREE ZONE (OFZ) APPROACH BOUNDARY
ISLA MELONES
ISLA TABOGUILLA
MORRO DE TABOGA
ISLA TABOGA
400m 0m 400m 800m
GRAPHICAL SCALE
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SKIDMORE, OWINGS AND MERRILL LLP
LOUIS BERGER INTERNATIONAL
ACP AUTORIDAD DEL CANAL DE PANAMA
PRE-FEASIBILITY STUDY FOR ARTIFICIAL ISLAND DEVELOPMENT
ISLAND CONCEPT PLAN ALTERNATIVE P1-A
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Drn by D.J.Mac
Chd by M.G.H.
Reviewed by T.J.S.
Submitted by M.G.H.
Date NOV. 2001
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FIG 9-8

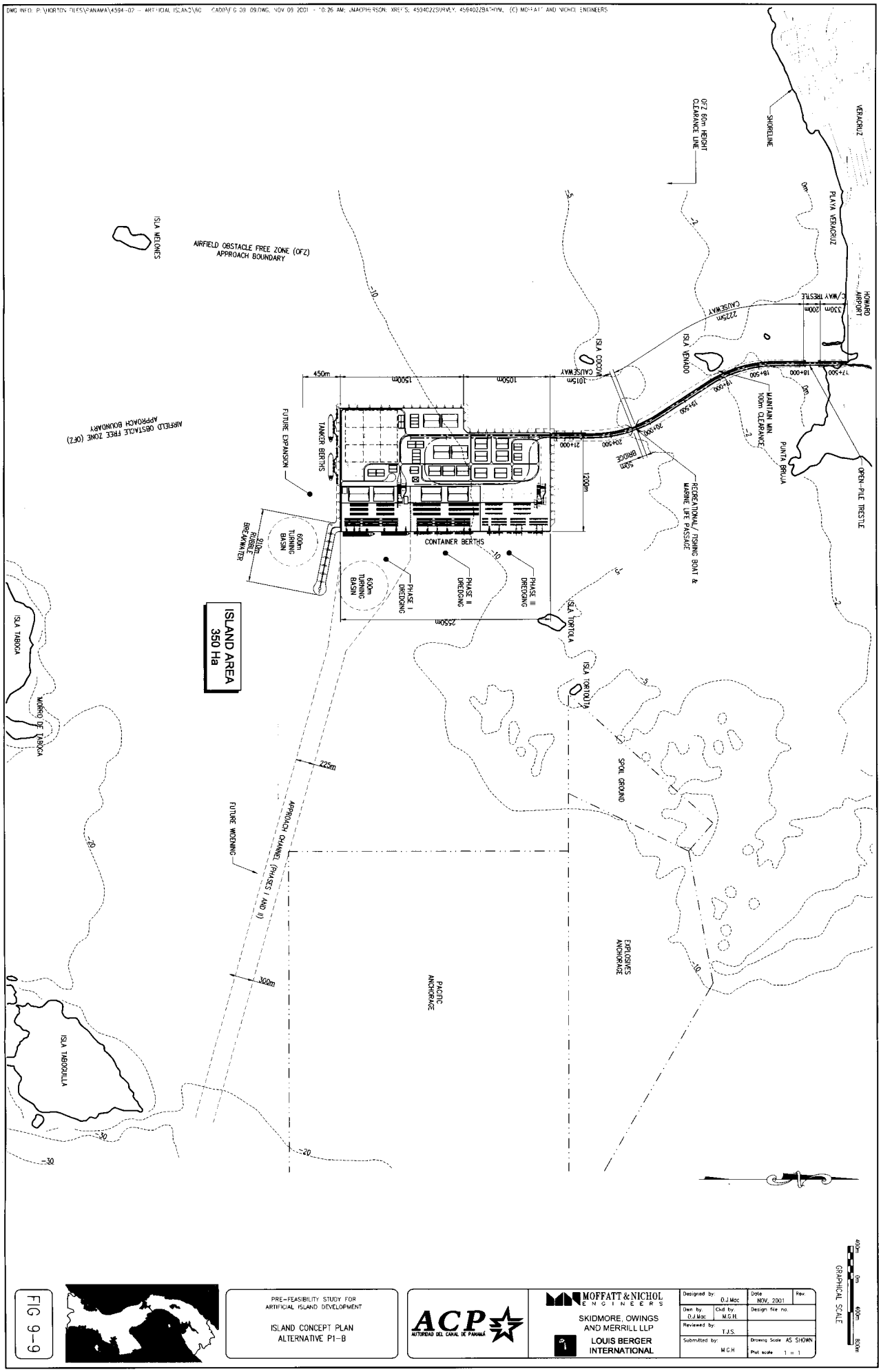

FIG 9-9

PRE-FEASIBILITY STUDY FOR ARTIFICIAL ISLAND DEVELOPMENT

ISLAND CONCEPT PLAN
ALTERNATIVE P1-B

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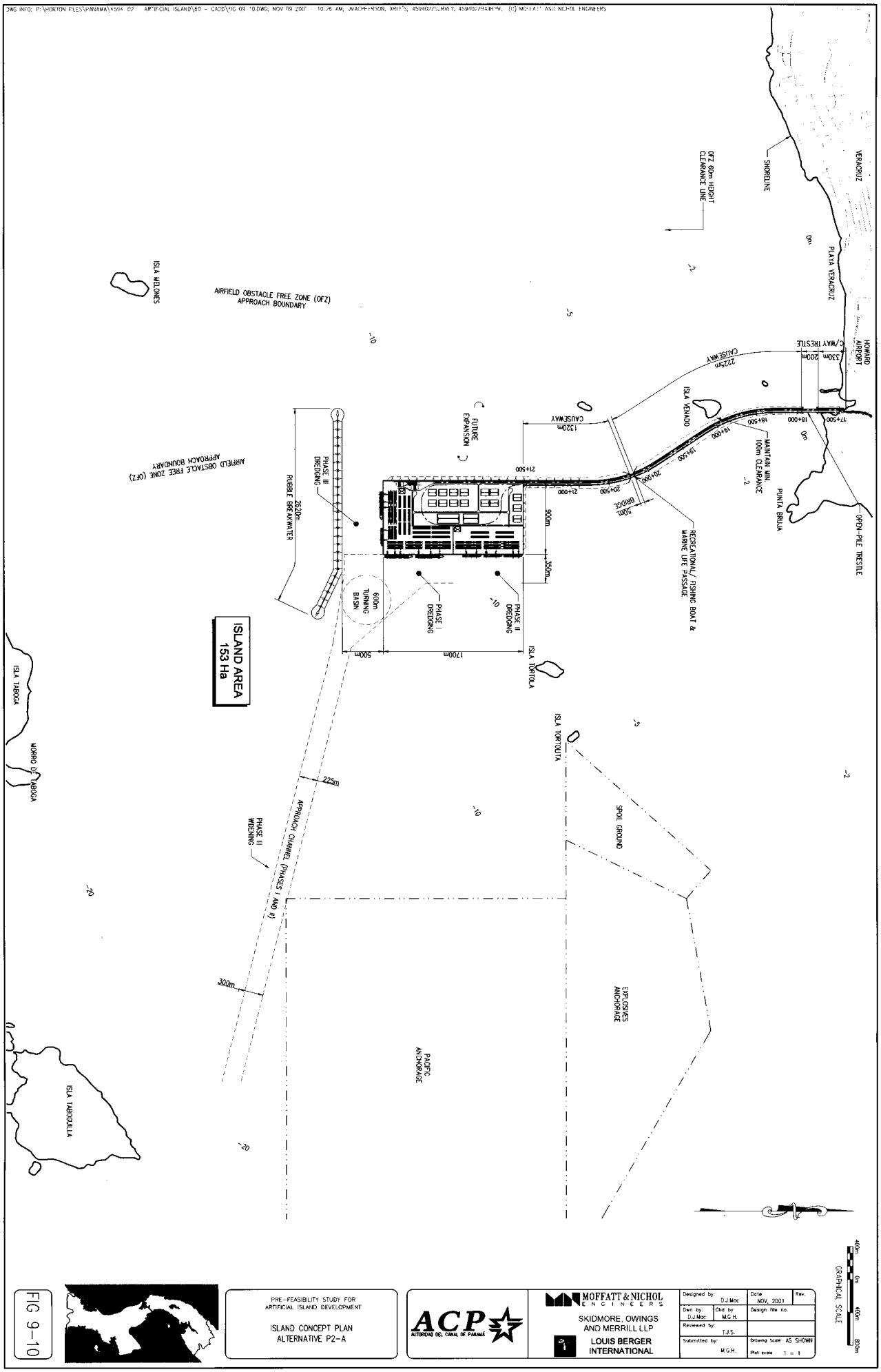

FIG 9-10

PRE-FEASIBILITY STUDY FOR
ARTIFICIAL ISLAND DEVELOPMENT

ISLAND CONCEPT PLAN
ALTERNATIVE P2-A

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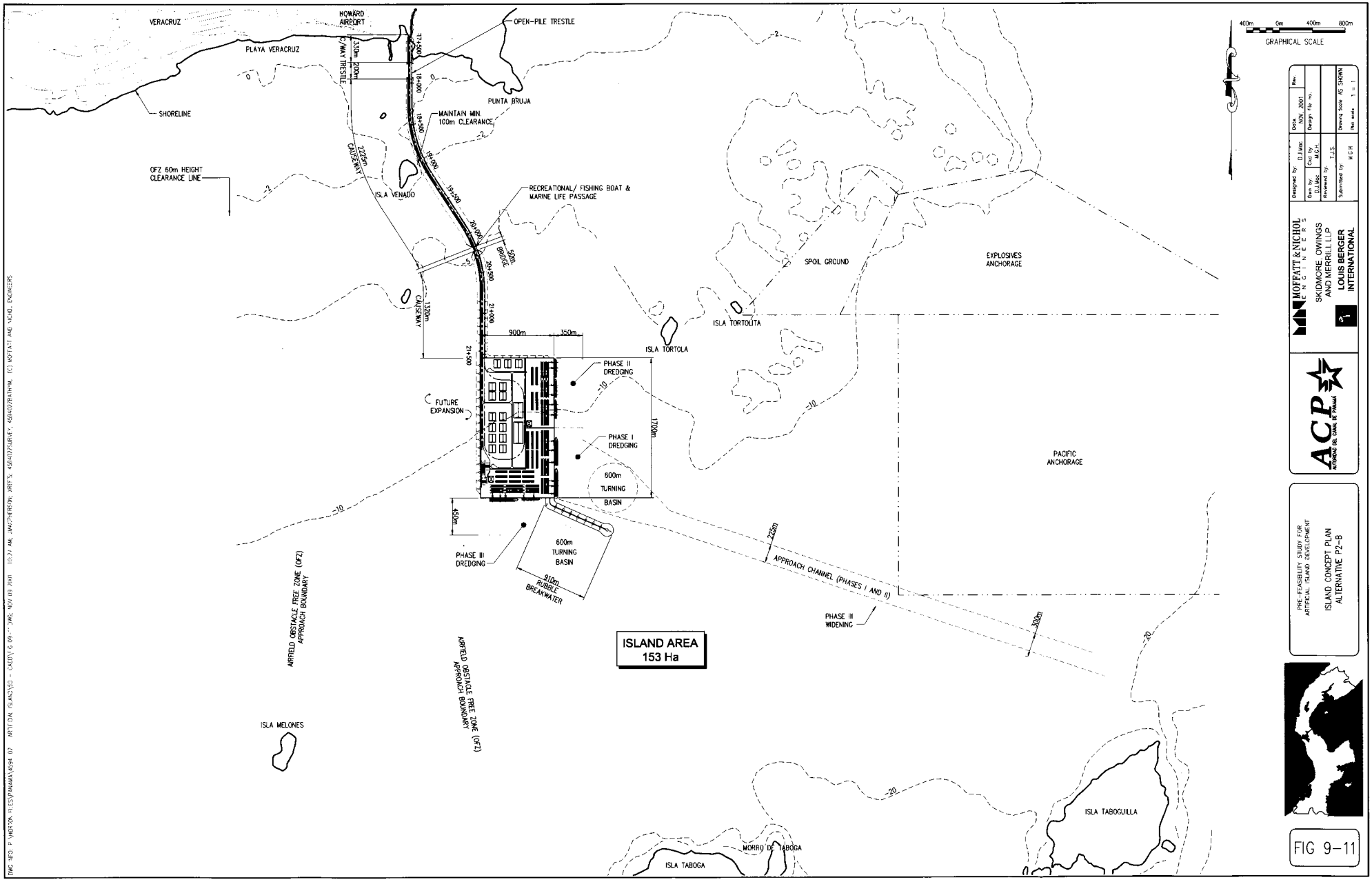
VERACRUZ
HOWARD AIRPORT
OPEN-PILE TRESTLE
PLAYA VERACRUZ
C/WAY TRESTLE
330m
200m
17+500
18+000
18+500
19+000
19+500
20+000
20+500
21+000
21+500
PUNTA BRUJA
SHORELINE
MAINTAIN MIN. 100m CLEARANCE
OFZ 60m HEIGHT CLEARANCE LINE
2225m CAUSEWAY
ISLA VENADO
RECREATIONAL/ FISHING BOAT & MARINE LIFE PASSAGE
50m BRIDGE
1320m CAUSEWAY
900m
350m
ISLA TORTOLA
ISLA TORTOLITA
SPOIL GROUND
EXPLOSIVES ANCHORAGE
PHASE II DREDGING
FUTURE EXPANSION
PHASE I DREDGING
1700m
600m TURNING BASIN
450m
PHASE III DREDGING
600m TURNING BASIN
910m RUBBLE BREAKWATER
225m
APPROACH CHANNEL (PHASES I AND II)
PHASE III WIDENING
300m
PACIFIC ANCHORAGE
AIRFIELD OBSTACLE FREE ZONE (OFZ) APPROACH BOUNDARY
AIRFIELD OBSTACLE FREE ZONE (OFZ) APPROACH BOUNDARY
ISLAND AREA
153 Ha
ISLA MELONES
ISLA TABOGUILLA
MORRO DE TABOGA
ISLA TABOGA
GRAPHICAL SCALE
400m 0m 400m 800m
MOFFATT & NICHOL ENGINEERS
SKIDMORE, OWINGS AND MERRILL LLP
LOUIS BERGER INTERNATIONAL
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PRE-FEASIBILITY STUDY FOR ARTIFICIAL ISLAND DEVELOPMENT
ISLAND CONCEPT PLAN
ALTERNATIVE P2-B
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Rev.
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FIG 9-11

9.8 Land use Plan

9.8.1 Marine Terminals

A preliminary land use plan is presented in the following figures for the two Lock alternatives. It can be seen that the main focus of the development is container terminals, with the intention to provide at least three container modules for each island alternative.

Future development of marine facilities would depend very much on demand at the time, but could include a fourth container terminal for the larger island (P1), bunkering or bulk materials transfer facilities. However, it should be noted that any future development or terminals on the island to accommodate vessels having greater draft than the future Panama Canal will require significant dredging and may not be financially viable.

9.8.2 Value added and Distribution Facilities

The concept plan indicates that the main distribution facilities will be located close to or even within the container terminal area. This reflects the recent trend to consolidation of distribution activities at the point of arrival of the cargo. This is particularly the case for US terminals such as those at the Port of Savannah, and may or may not be applicable to Panama. It should also be noted that heavy demand for waterfront dependent activities on the island could trigger the displacement of Trade related but non water dependent uses to the Howard area, to the possible benefit of both developments.

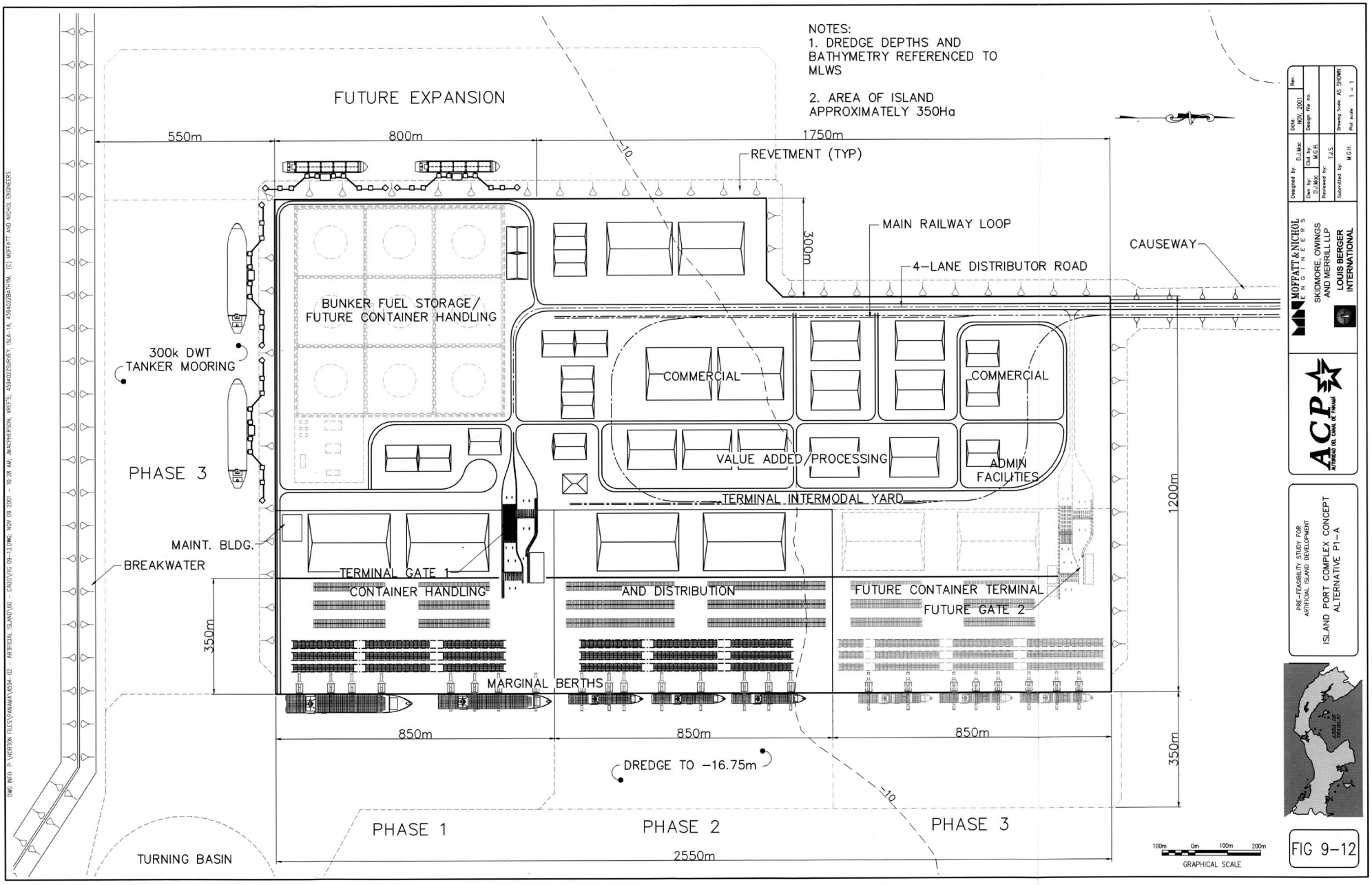
9.8.3 Commercial and Support services

The economic, trade and commercial activity on the island will generate a need for banking, services and support facilities. At this preliminary stage, it is sufficient to acknowledge this need, but it is too early to discuss specifics.

9.8.4 Public Access Areas

As a major new development, the island will almost certainly attract public attention. It will also be the base for a significant number of employees, who will require access to open spaces, exercise areas and other public facilities. The popularity of the Amador causeway is an indication of what might happen in terms of public access and this project offers a special opportunity to offer a pleasant environment for island workers and visitors.

Public access areas might include parks, public concert sites, recreational areas, a fishing pier, sports fields, cycle paths, exercise areas and viewing areas. These again can be incorporated at a later date, but should be given a high priority during the planning phases.


NOTES:
1. DREDGE DEPTHS AND BATHYMETRY REFERENCED TO MLWS
2. AREA OF ISLAND APPROXIMATELY 350Ha
FUTURE EXPANSION
550m
800m
1750m
REVETMENT (TYP)
MAIN RAILWAY LOOP
4-LANE DISTRIBUTOR ROAD
CAUSEWAY
300m
BUNKER FUEL STORAGE/ FUTURE CONTAINER HANDLING
300k DWT TANKER MOORING
COMMERCIAL
COMMERCIAL
VALUE ADDED/PROCESSING
ADMIN FACILITIES
TERMINAL INTERMODAL YARD
PHASE 3
MAINT. BLDG.
BREAKWATER
TERMINAL GATE 1
CONTAINER HANDLING
AND DISTRIBUTION
FUTURE CONTAINER TERMINAL
FUTURE GATE 2
1200m
350m
MARGINAL BERTHS
850m
850m
850m
DREDGE TO -16.75m
PHASE 1
PHASE 2
PHASE 3
2550m
350m
TURNING BASIN
GRAPHICAL SCALE
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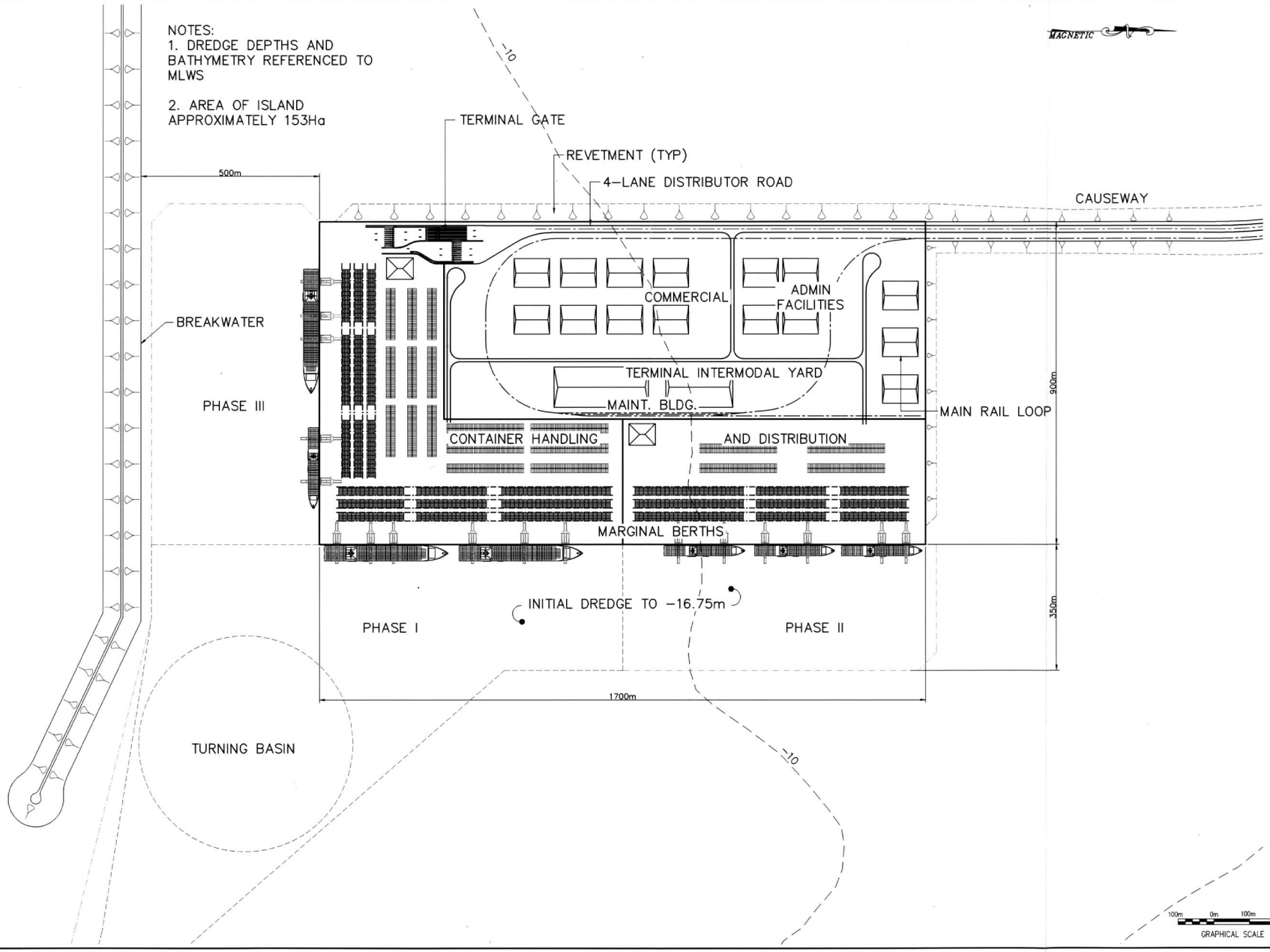
PRE-FEASIBILITY STUDY FOR ARTIFICIAL ISLAND DEVELOPMENT
ISLAND PORT COMPLEX CONCEPT ALTERNATIVE P1-A
FIG 9-12



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PRE-FEASIBILITY STUDY FOR ARTIFICIAL ISLAND DEVELOPMENT

ISLAND PORT COMPLEX CONCEPT ALTERNATIVE P2-A

FIG 9-13

10 ENVIRONMENTAL ISSUES

10.1 Objective of the Evaluation

The objectives of the environmental assessment are:

- Define the environmental baseline, describing in advance the initial characteristics of the area directly influenced by the project. This should include physical, biotic and socioeconomic components.
- Identify and evaluate the environmental impacts, negative and positive, in the area directly and indirectly influenced by the project's construction and operation, in terms of the different baseline elements. These impacts should qualify as significant or insignificant, permanent or temporary, repairable or non-repairable and reversible or irreversible. Similarly, it should be determined if accumulative impacts will occur and the alternative of not going through with the construction of the project should be evaluated.
- Identify potential interest groups, agencies or stakeholders to be included in the public awareness and participation initiatives.
- Develop an Environmental Management and Action Plan (PAMA) that will involve a series of specific programs aimed to guarantee the security of people working on the project and the quality of the environment.
- Recommend a specific Monitoring Plan for resources that are subject to environmental risk and/or present some form of health risk. This Monitoring Plan should include stages of construction, occupancy and operation.

10.2 Basis for Analysis

The area influenced by the project varies according to resources that will be impacted. For the most part, impacts will be local. Some impacts will be felt along the coastline.

The most important impacts fall within the following general categories:

- Air Quality and Noise
- Geology and Geotechnical Properties
- Water Quality
- Biological Environment
- Socioeconomic and Cultural Environment

10.3 Legal Framework

It is necessary in all environmental assessments to take into account the legal framework. At the very least, in developing the project one must consider the laws, decrees and norms that are applied to development projects in agreement with the environmental legislation of the Republic of Panama.

Furthermore, direct communication should be established with all responsible entities such as the Ministry of Public Works, the Autoridad Nacional de Ambiente (ANAM), the Autoridad de la Región Interoceánica (ARI), the Ministry of Health and the Autoridad Marítima de Panamá (AMP).

10.4 Scope of Required Environmental Studies

In order to determine the studies that should be developed in later phases, a clear objective must be defined. The following issues should be considered in developing a more detailed environmental assessment, taking into account the objectives and needs of ANAM.

10.4.1 Categorization

Considering the type and magnitude of this project, with certainty it should be classified in Category III, which involves, among other aspects, an intense process of public consultation that includes a town meeting regarding the project.

10.4.2 Framework

The project can be presented to the permitting agencies and interested parties in one or two ways:

- The placement of excavated material to support the Third Locks project.
- A new development with a specific commercial or defined purpose.

10.4.3 Area Influenced by the Project

Depending upon the framework of the project, the area of indirect influence should be determined. It is possible that impacts could be limited to the area impacted by hydrodynamic effects; however, impacts could be felt on a global scale. This highlights the importance of clearly outlining an approach and the magnitude of the studies to be achieved.

10.5 Critical Factors for consideration

The following factors will be considered during the permitting and environmental evaluation process. The key issues are summarized in Table 10-1.

10.5.1 Background and Identification of the Sponsor

Legal matters of interference and jurisdiction determined during the process of identification should be resolved. Initially, the ACP and AMP should be principal actors. ARI and ANAM should also be participants.

10.5.2 Site Selection & Construction

The impacts caused by access to the island support a coastal placement of the surplus material; the option of having the deepest access for ships would justify an offshore location. Other factors include:

- Identification of works to make up the project
- Lifespan and Description of Stages

10.5.3 Evaluation of Long Term Activities

The environmental review should cover the potential land use of the island, in order to eliminate dirty industries or conflicts with surrounding areas. Part of the Final report should address the classifications of activities that will be permitted on the island to ensure compliance with long-term air quality and water quality goals and other factors discussed in this report. This evaluation will include solid and waste water treatment issues, air emissions, noise pollution and long term shoreline or water quality issues.

10.5.4 Types of Inputs and Generation of Waste

The basic input is made up of an estimated 70 million cubic meters of surplus material from the excavation process at the third group of canal locks. The transport and disposal of this material are key aspects in the environmental assessment and should be carefully evaluated once the detailed construction processes are known. Generation of waste will be associated with the operation. If the prospect of a container management terminal is developed, it would be considered, among the port alternatives, as the "cleanest" and most compatible with other types of developments (for example, tourism). Nevertheless, the waste generated for such an activity, enhanced by the magnitude of the service to be developed, will be considerable and the process of disposing of this material should be carefully analyzed.

10.5.5 Amount of Investment

The amount of investment into the project will presumably be in the billions of dollars if it is calculated up to the operational phase. The magnitude of the project will equally generate a demand for many types of studies, including environmental, of grand scope and reach. The process of finding answers to some of the basic questions could delay the process considerably.

10.6 Steps to Obtain Field Data

The collection of field data will make oceanographic and land studies necessary. A course of action that should be anticipated includes various biological collections, water and soil sampling and examination, finding hydrometric information, geotechnical testing, bathometric drilling and topographical surveys, aerial photography and interpretation, as well as finding diverse biological and physical information. From a social point of view, the communities affected by sector (fisherman, operators and various beneficiaries of the tourism industry, beachfront proprietors, ship operators, etc.) should be interviewed. Likewise, all of the instances of citizen participation identified in the bylaw of ANAM and those that emerge from a more detailed analysis of the impacts should be outlined early on.

The act of "creating" new lands in the sea does not have a strong history in Panama. In that sense, the Punta Pacifica Islands Project should be considered as a guide. Nevertheless, the legal context could result very differently as Pacific Point is a private development. Legal and administrative aspects should be analyzed in detail and conclusions should form part of the Environmental Impact Assessment in a clear and concise manner.

10.7 Baseline Studies

10.7.1 Soil Use

Applies to land areas and the marine environment that will be impacted by the construction works. In the first case, existing information should be collected in the areas of extraction, transport and disposal (temporary and definite) of the material. It is necessary to define the project layout to refine the scope of this task. The scope should include the natural environment (vegetative covering, productive uses) as well as the urban environment (zoning, infrastructure, services). In this sense, information obtained from ARI will be essential.

10.7.2 Flora and Fauna

Given the importance of the project, field studies should be brought forward to fill or complement the base information. The studies conducted by the US military before transfer and the more recent ARI studies may be of value in this respect.

10.7.3 Hydraulic and Coastal Regimes

In addition to section 5.9, the mathematic modeling of the hydrodynamic standard is considered essential in simulating the existing situation as well as the hydraulic dynamic and contamination. The existing models developed by Dames & Moore and Delft Hydraulics offer an excellent background that contemplates the global hydraulic dynamic (ANAM, 1999). Likewise, there exists a history of studies completed by the CESOC Consortium (MEF, 2000) for the sanitation study in the Bay. Border and specific site conditions should be noted in the general model of the bay.

10.7.4 Population and Socio-economic Indicators

This is a key aspect of the baseline studies. ACP's recent experience in the western region of the canal's watershed can serve as a basis for the environmental characterization studies.

The community involvement in all aspects of the process and their participation from the onset are basic safeguards for the project to be socially viable. Later on, the instances of public participation envisioned by ANAM for these types of projects will be described. Of particular concern will be the popularity of Veracruz and Kobe beaches as local recreational destinations and potential resort development projects in the Kobe beach area.

10.7.5 Description of Sites of Unique Landscape

If the off-shore solution is chosen, the island, its lighting and, fundamentally, its accesses will consist of new unique landscapes. The landscape of the area, with existing islands and specifically the island of Taboga represent the same visual impact. It should be taken into consideration that the island, with 300 hectares of envisioned surface area, is approximately half the size of Taboga. The access could cause a negative distortion to the landscape; thus, this should be taken into consideration during the design phase. The causeway and the Southern Corridor give valid precedence. Consulting with the public, the beachfront proprietors at Veracruz and the potential developers of a Kobe Beach resort and hotel, will serve as a basis for the preliminary impact assessment.

10.8 Identification, Analysis, Valuation and Hierarchy of Impacts

This is a traditional aspect of the Environmental Impact Assessment, for which there exists sufficient experience on the part of ANAM. This process requires multidisciplinary interaction for the EIA, of which it is recommended that only one firm develop.

10.8.1 Previous environmental situation

This will emerge from the baseline and identify the most important intersections between action and elements impacted.

10.8.2 Forecast of Direct, Indirect, Cumulative and synergetic impacts

Relationships between actions and affected elements should be established for the construction and operations stages.

10.9 Summary of Potential Impacts

Based on the discussions held in Panama in early August, and experience of the consultant in Panama and at other locations, the expected issues or impacts that may arise from this project are summarized in Table 10-1 below.

Table 10-1: Preliminary Identification Of Environmental Impacts

Impact	Description	Recommendations
Interference in artisan & other fishing activities	The access to the island (viaduct) will interfere with the movement of small fishing boats and ships that move along the littoral. This will probably produce a negative reaction by those directly affected that could start a wave of negative opinion.	Early on, initiate the process of consulting with citizens. Evaluate traffic and operational characteristics.
Disruption of Hydrodynamic Movement In the bay	Interference caused by the island access complex in the main hydrodynamic complex of the Bay of Panama could affect sediments (erosion – local and zone deposits). Undoubtedly, this will be one of the first arguments presented by the reactionary groups.	Develop a tri-dimensional hydrodynamic model that addresses issues of sediment and contamination. Calibrate according to the existing studies and conclusions made in the field. This aspect is of fundamental importance.
Effects to soil use and potential interference with plans and tourist activities	The potential development of the Howard Canal corridor could affect the use of soils in that area. In particular, the protected areas identified on the coast and the development of the tourist area of Veracruz, for which plans are currently being formulated by the IPAT, could be affected.	The interests of the tourist sector should be analyzed through surveys, workshops and other forms of citizen participation relating to the development of the island. Following other projects in the world, port and tourist aspects should be integrated.
Loss of marine habitat	The covering of the marine base by excavated material will signify a loss of approximately 400 hectares of marine habitat. This has been, on a much smaller scale, one of the most significant impacts identified by the development of the Pacific Point Islands. A reaction from the ecological groups is expected.	Irreversible impact. It does not presume a direct effect upon habitats at high risk or high representation. This can be mitigated by some form of compensation.
Effects to coastal resources (Coral in Otoque and other areas)	Depending upon effects to the hydrodynamic, the disturbance could reach the coral resources in front of Punta Chame. This aspect should be summarized beforehand from claims made by ecological groups.	The hydrodynamic model should be used correctly in order to make a decision regarding this sensitive aspect. It should be attempted to not affect this fragile and scarce resource, although in principle and according to records consulted, a complete avoidance is unlikely.
Contamination at beaches and western coastline	Also depending upon interference to hydrodynamics (currents), some sectors of the pacific coastline west of the canal could suffer from an increase in the concentration of contaminants caused by the island-	Similar to the previous case, the hydrodynamic model should be sufficiently "robust" in order to answer to these interrogations. It is necessary to use information developed in the context of the Punta Pacifica project

	viaduct complex. A reaction could arise from groups interested in beachfront development in Veracruz.	to minimize efforts. Conversely, the records consulted seem to indicate that this effect will be minimal.
Effects to landscape and visual impacts	The creation of a new island and access to that island will create a visual disruption in some directions currently heading toward the open sea. This could jeopardize some hedonic price of the immobile coastal developments. This effect could be exacerbated by the nighttime illumination of developments proposed on the island. This illumination could also affect the habitats of nocturnal animals in the area.	As mentioned in 6.5, the survey process is fundamental in this sense. A hedonic price should be attributed to this impact for its internalization.
Increase of dredging in the canal	Depending upon the position and shape of the island and its accesses, dredging of the canal could increase.	Depending upon the position of the island and its access, and later on the protection of the causeway, sedimentation of the canal and consequently dredging could increase. The mathematic model should be capable of responding to this question.
Interference with maritime traffic and disruption during construction	The conformation of the island and its access, that may include marine equipment, could cause an interference with maritime movement west of the canal, in particular concerning the movement of ships in transit to and from the canal.	The movement of work vessels and barges to and from the island could increase the risk of accidents and slow access to the canal. This effect can be mitigated but will require a specific study and formulation of detailed processes.
Association of the island with the extension of the canal; increase in adverse opinions from certain groups related to the global process of extending the canal.	Currently, the ACP suffers from a deterioration of its credibility in certain national sectors as a result of actions in the western region of the canal watershed. The development of the island could produce a synergic effect in this sense, which could produce a current of opposition.	Similar to other aspects, benefits are foreseen in advancing the community consultation process and supporting it with the maximum amount of methods and elements of decision possible (details, models).

10.10 Methodology for Impact Analyses

Among the diverse possibilities, ANAM has recommended using the Vicente Conesa Fernández – Vitora methodology, in which impacts are qualified in order to assign importance according to character, degree of distress, risk of occurrence, extension, duration, reversibility,

10.10.1 Representative Environmental Variables

Will be decided, following classic methodology, utilizing the Leopold Matrix.

10.10.2 Applicable Norms

Water quality, zoning, protected areas, among others to be determined as a function of the analysis.

10.11 Plan for Environmental Management

The elaboration of an Environmental Management Plan is a basic requirement for this project. From this Plan, studies would be developed from the elements contributed by Citizen Participation. This would involve a dynamic process of evaluating impacts and elaborating the methods of mitigation, making use of the suggestions from the community with technical and economic validity. It is important that the costs for this process be established early in the environmental evaluation process. In addition to the Mitigation Plan, a Monitoring and Control Program, a plan to prevent risk of accidents, a contingency plan and a Citizen Participation Plan must also be included:

10.12 Citizen Participation Plan

This is one of the most critical aspects of the permitting and environmental process. Early attention should be given to the key element of current events. Mechanisms of inducement should be developed early on in the project to encourage participation from the community level (bottom-up approach). For this process, all forms of participation should be defined and developed (surveys, interviews, workshops, work meetings). Furthermore, informative mechanisms should be developed for the individual sectors as well as mechanisms for potential conflict resolution.

The Citizen Participation Plan should include mechanisms for the public to request information, in particular from environmental and similar groups.

Other aspects of citizen participation include Formal and Open Consulting and the Public Forum, for which consultants and authorities should prepare appropriately.

10.13 Costs of Environmental Studies

On the basis of experience at other locations, it is estimated that basic and formal studies will demand at a minimum $2 million, excluding field studies. The process of citizen participation, depending upon difficulties that could arise, could require $500,000; however this figure is even more uncertain. Finally, it is almost impossible in this stage to estimate the costs associated with mitigating impacts and execution of the Environmental Management Plan. For other projects of a similar nature, these costs will vary between 1.0 and 3.5% of the development cost.

11 COST ESTIMATES

11.1 Introduction

This section presents the estimated cost of construction of the island, its infrastructure and the port facilities to be located on the island. Cost estimates are also presented for disposal of the material to a number of ACP designated sites located within some 10 km of the Locks construction area.

In Section 9.3.5, the rail transportation system was recommended on the basis of cost and future residual value to the development. All of the following estimates therefore assume that materials will be moved to the island by rail.

For ease of allocation of costs, the estimates are broken into the following categories

1. **Island construction using the preferred rail transportation system, including:**
    - Cost of provision of rail system from Locks site to island and associated civil works
    - Materials transportation and placement
    - Construction of breakwater and island wave protection
    - Island fill
    - Trestle and bridge within the causeway

2. **Basic Infrastructure, including:**
    - Roadway on causeway and connection from shore
    - Primary internal roadways within the island
    - Extension of rail loop within island
    - Power, water and other utilities
    - Parks and green areas
    - Illumination and public access areas
    - Main navigation channel to island
    - Dredging at berths and maneuvering areas

3. **Container Terminal Module, including:**
    - 850 m Berths
    - Paving
    - Utilities within terminal area

- Buildings
- Gantry cranes to service terminal at full capacity
- Fencing and security

Cost estimates are not provided for Value added installations, since it is assumed that land parcels will be leased or sold, with the lessee being responsible for construction of its own buildings and site improvements.

The estimates include an allowance for engineering studies, preparation of contract documents and construction administration. This is expressed as a simple percentage at this time. For more information on the engineering, field investigations and design studies required to support the project, the reader is referred to Section 13.2 of this report. A contingency allowance of 20% has also been added to all estimates to accommodate potential cost or construction quantity variations due to limited availability of site information at this time.

11.2 Island Construction

Construction cost estimates for the unimproved island are presented in Table 11-1 to Table 11-4 for the following concepts. All assume a rail transportation system, as recommended earlier in Section 9.3.5.

- **P1 – Alternative**
  - A. Offshore Breakwater Option
  - B. Revetment/Breakwater
- **P2 – Alternative**
  - A. Offshore Breakwater Option
  - B. Revetment/Breakwater

Table 11-1: Estimated Unimproved Island Construction Cost – Locks Option P1-A

Item	Quantity	Units	Unit Cost	Total
Construction Costs Using Material Quantities from Channel Alignment P1				
Alternative P1-A, Full-length Breakwater				
General				
Mobilization and Demobilization	1	LS	$2,500,000.00	$2,500,000
Material Haulage				
New Railway on Formation	34.9	km	$813,600.00	$28,394,640
New Railway on Trestle	0.4	km	$413,700.00	$165,480
New Railway on Causeway/Island	12.1	km	$415,500.00	$5,044,170
Railway Structures	1.0	LS	$5,172,405.06	$5,172,405
Material Transportation	87,381,000	m^3	$2.48	$216,295,862
Island Construction				
Trestle	8,020	m^2	$1,350.00	$10,827,000
Causeway	6,214,942	m^3	$8.34	$51,842,020
Causeway Bridge	2,005	m^2	$1,500.00	$3,007,500
Island Fill	75,122,158	m^3	$0.39	$29,633,300
Island Revetment Construction	960,900	m^3	$15.00	$14,413,499
Offshore Breakwater	5,083,000	m^3	$12.96	$65,858,000
Rock Crushing/Sorting Plant	1	LS	$1,000,000.00	$1,000,000
Total Cost - Island Construction				***$434,153,876***
Engineering and Construction Administration			4.00%	$17,366,155
Contingencies			20.00%	$90,304,006
Grand Total Cost				***$541,824,037***
Cost per sq. metre for Island Construction				***$155***

Table 11-2: Estimated Unimproved Island Construction Cost - Alt P1-B

Item	Quantity	Units	Unit Cost	Total
Construction Costs Using Material Quantities from Channel Alignment P1				
Alternative P1-B, Short Breakwater				
General				
Mobilization and Demobilization	1	LS	$2,500,000	$2,500,000
Material Haulage				
New Railway on Formation	34.9	km	$813,600	$28,394,640
New Railway on Trestle	0.4	km	$413,700	$165,480
New Railway on Causeway/Island	12.1	km	$415,500	$5,044,170
Railway Structures	1.0	LS	$5,172,405	$5,172,405
Material Transportation	87,381,000	m^3	$2.48	$216,682,203
Island Construction				
Trestle	8,020	m^2	$1,350.00	$10,827,000
Causeway	6,214,942	m^3	$8.34	$51,842,020
Causeway Bridge	2,005	m^2	$1,500.00	$3,007,500
Island Fill	78,844,708	m^3	$0.38	$29,580,787
Island Revetment Construction	960,900	m^3	$15.00	$14,413,499
Offshore Breakwater	1,360,450	m^3	$12.96	$17,626,700
Rock Crushing/Sorting Plant	1	LS	$1,000,000	$1,000,000
Sub Total - Island Construction				***$386,256,404***
Engineering and Construction Administration			**4.00%**	$15,450,256
Contingencies			**20.00%**	$80,341,332
Grand Total Cost				***$482,047,992***
Cost per sq. metre for Island Construction				***$131***

Table 11-3: Estimated Unimproved Island Construction Cost - Alt P2-A

Item	Quantity	Units	Unit Cost	Total
Construction Costs Using Material Quantities from Channel Alignment P2				
Alternative P2-A, Full-length Breakwater				
General				
Mobilization and Demobilization (6%)	1	LS	$2,500,000.00	$2,500,000
Material Haulage				
New Railway on Formation	34.9	km	$813,600.00	$28,394,640
New Railway on Trestle	0.4	km	$413,700.00	$165,480
New Railway on Causeway/Island	11.2	km	$415,500.00	$4,632,825
Railway Structures	1.0	LS	$5,172,405.06	$5,172,405
Material Transportation	43,532,500	m^3	$2.38	$103,511,280
Civil Works				
Trestle	8,020	m^2	$1,350.00	$10,827,000
Causeway	6,745,910	m^3	$7.71	$52,004,760
Causeway Bridge	2,005	m^2	$1,500.00	$3,007,500
Island Fill	30,754,162	m^3	$0.42	$12,785,979
Island Revetment Construction	619,167	m^3	$15.00	$9,287,508
Offshore Breakwater	3,673,240	m^3	$13.07	$48,024,600
Rock Crushing/Sorting Plant	1	LS	$1,000,000.00	$1,000,000
Sub Total - Island Construction				***$281,313,977***
Engineering and Construction Administration			4.00%	$11,252,559
Contingencies			20.00%	$58,513,307
Grand Total Cost				***$351,079,843***
Cost per sq. metre for Island Construction				***$204***

Table 11-4: Estimated Unimproved Island Construction Cost - Alt P2-B

Item	Quantity	Units	Unit Cost	Total
Construction Costs Using Material Quantities from Channel Alignment P2				
Alternative P2-B, Short Breakwater				
General				
Mobilization and Demobilization (6%)	1	LS	$2,500,000.00	$2,500,000
Material Haulage				
New Railway on Formation	34.9	km	$813,600.00	$28,394,640
New Railway on Trestle	0.4	km	$413,700.00	$165,480
New Railway on Causeway/Island	11.2	km	$415,500.00	$4,632,825
Railway Structures	1.0	LS	$5,172,405.06	$5,172,405
Material Transportation	43,532,500	m^3	$2.34	$102,083,159
Island Construction				
Trestle	8,020	m^2	$1,350.00	$10,827,000
Causeway	6,745,910	m^3	$8.40	$56,665,170
Causeway Bridge	2,005	m^2	$1,500.00	$3,007,500
Island Fill	33,172,512	m^3	$0.39	$12,854,924
Island Revetment Construction	619,167	m^3	$15.00	$9,287,508
Offshore Breakwater	1,254,890	m^3	$13.10	$16,443,700
Rock Crushing/Sorting Plant	1	LS	$1,000,000.00	$1,000,000
Sub Total - Island Construction				***$253,034,312***
Engineering and Construction Administration			**4.00%**	$10,121,372
Contingencies			**20.00%**	$52,631,137
Grand Total Cost				***$315,786,821***
Cost per sq. metre for Island Construction				***$173***

11.3 Basic Island Infrastructure

Prior to the commercial exploitation of the island, basic infrastructure elements will be required. These include:

- Completion of Highway Access (pavement along causeway sections)
- Utilities
- Dredging (Channel and Turning Basin) for access to marine facilities
- Landscaping/Mitigation
- Public Access areas
- Security Installations and fencing

It has been assumed that the rail line installed for materials haulage will later be used to link the island with the Panama Canal Railroad yard in Balboa. For this to happen, rail bridges will be required at the existing Miraflores and the new Locks. The cost of these links have not been included in the infrastructure cost estimates at this time, pending a decision on the viability of the bridge links and its potential impact on Panama Canal operations.

Infrastructure costs have been divided into three Phases, to support incremental demand scenario. The three phases of Infrastructure Development include:

- **Phase 1** – Completion of access road on causeway, main lighting, power, water and utilities to island, first level of internal road systems, public access areas, parks and landscaping, dredging of 225 m wide channel to first container module.

- **Phase 2** – Extension of highway and utility networks, expansion of dredged area to accommodate second container terminal

- **Phase 3** - Extension of highway and utility networks, expansion of dredged area to accommodate third container terminal, widen approach channel to 300 m.

Table 11-5 and Table 11-6 show the estimated costs necessary to provide the infrastructure required to enable commercial development of each of the P1 and P2 alternative island concepts. For details of the estimates, the reader is referred to Appendix D5 of Volume 2 of this report.

Table 11-5: Estimated Basic Infrastructure Costs - P1 Locks Option

Infrastructure Costs	Phase 1	Phase 2	Phase 3	Total
Mobilization & Demob	750,000	500,000	500,000	$1,750,000
Dredging	39,546,958	15,477,772	27,409,246	$82,433,976
Roads and Paved Areas	3,976,875	843,750	562,500	$5,383,125
Utilities	21,000,000	1,500,000	2,650,000	$25,150,000
Public Access Areas	4,312,500	187,500	150,000	$4,650,000
Security and Fencing	657,500	657,500	243,750	$1,558,750
Engineering & Const. Admin	3,512,192	1,120,826	1,575,775	$6,208,793
Contingencies	14,751,205	4,707,470	6,618,254	$26,076,929
Total Cost	**$88,507,230**	**$24,994,818**	**$39,709,525**	**$153,211,572**

Table 11-6: Estimated Basic Infrastructure Costs – P2 Locks Option

Infrastructure Costs	Phase 1	Phase 2	Phase 3	Total
Mobilization & Demob	750,000	500,000	500,000	$1,750,000
Dredging	39,546,958	15,477,772	20,600,000	$75,624,730
Roads and Paved Areas	3,058,875	281,250	225,000	$3,565,125
Utilities	18,700,000	3,700,000	1,950,000	$24,350,000
Public Access Areas	2,975,000	90,000	45,000	$3,110,000
Security and Fencing	472,500	252,500	122,750	$847,750
Engineering & Const. Admin	3,275,167	1,015,076	1,172,138	$5,462,380
Contingencies	13,755,700	4,263,320	4,922,978	$22,941,997
Total Cost	**$82,534,200**	**$25,579,918**	**$29,537,865**	**$137,651,982**

11.4 Marine Related Facilities

11.4.1 Container Terminal Module

Using recent construction projects as a guideline, the estimated cost of a typical 32 ha terminal module is seen in Table 11-7 to be $149 million, which includes the cost of eight gantry cranes. Yard equipment is not included in this estimate, since it is common practice for the terminal operator to provide its own equipment and inventory control systems.

Table 11-7: Preliminary Cost Estimate for 32 ha Container Terminal Module

Item	Cost
Mobilization	$5,000,000
Site Work	$21,788,000
Entrance Complex	$1,120,000
Buildings	$4,437,500
Marine Structures	$47,850,000
Gantry Cranes	$40,000,000
SUBTOTAL	*$120,195,500*
Engineering & Const. Admin. /1	$4,811,730
Contingency /1	$24,039,100
Total Estimated Cost /2	*$149,046,330*

/1 – Does not apply to gantry cranes

/2 – Excludes Yard equipment and inventory control systems (provided by operator)

11.5 Summary of Capital Costs

The capital costs for each sub option of the P1 and P2 alternatives presented in the previous paragraphs are summarized in Table 11-8 and Table 11-9.

Table 11-8: Summary of Investment Costs – Lock Option - P1

Island with Full Breakwater

Development Component	Phase 1	Phase 2	Phase 3	Total
Island Construction (unimproved)	541,824,037			**$541,824,037**
Infrastructure	88,507,230	$24,994,818	$39,709,525	**$153,211,572**
Container Terminal(s)	149,046,330	$149,046,330	$149,046,330	**$447,138,990**
Total Cost	**$779,377,597**	**$174,041,148**	**$188,755,855**	**$1,142,174,599**

Island with Short Breakwater

Development Component	Phase 1	Phase 2	Phase 3	Total
Island Construction (unimproved)	482,047,992			**$482,047,992**
Infrastructure	88,507,230	$24,994,818	$39,709,525	**$153,211,572**
Container Terminal(s)	149,046,330	$149,046,330	$149,046,330	**$447,138,990**
Total Cost	**$719,601,552**	**$174,041,148**	**$188,755,855**	**$1,082,398,554**

Table 11-9: Summary of Investment Costs – Lock Option - P2

Island with Full Breakwater

Development Component	Phase 1	Phase 2	Phase 3	Total
Island Construction (unimproved)	351,079,843			**$351,079,843**
Infrastructure	82,534,200	$25,579,918	$29,537,865	**$137,651,982**
Container Terminal(s)	149,046,330	$149,046,330	$149,046,330	**$447,138,990**
Total Cost	**$582,660,373**	**$174,626,248**	**$178,584,195**	**$935,870,816**

Island with Short Breakwater

Development Component	Phase 1	Phase 2	Phase 3	Total
Island Construction (unimproved)	315,786,821			$315,786,821
Infrastructure	82,534,200	$25,579,918	$29,537,865	$137,651,982
Container Terminal(s)	149,046,330	$149,046,330	$149,046,330	$447,138,990
Total Cost	**$547,367,351**	**$174,626,248**	**$178,584,195**	**$900,577,793**

11.6 Use of Designated Disposal Sites

In order to test the commercial viability of the island project, it is necessary to compute the costs of transportation and island construction against other disposal alternatives. The incremental cost between the two options can then be viewed as the opportunity cost for the commercial exploitation of the island, assuming that no other cost effective locations exist for marine terminals development.

The designated ACP disposal sites and their capacity are indicated in Figure 11-1. Receiving locations are on both the east and west sides of the Canal, which could imply potential interference with Canal operations when the east side sites are being used.

According to the information on the drawing, the total capacity of the ACP sites is 59.60 million m3, which is considerably less than the bulked volume of the P1 materials. However, it is possible that the stockpile heights could be increased to meet the project needs. Given the naturally hilly terrain in the area, it would not be difficult to construct artificial hills to maintain a natural look to the area after filling.

To ensure compatibility with the costs of the island project, cost estimates developed by Harza for the movement of material to the disposal sites have been extended to include site restoration. Contingencies and engineering costs have also been added, again to maintain consistency with the island creation options.

Table 11-10 indicates the estimated cost of disposal of the material to the ACP sites shown in Figure 11-1. The estimate also includes costs for construction of access roads, site restoration and contingencies, in order to provide a valid comparison with the cost of construction of the island.

Table 11-10: Estimated Costs - Disposal to ACP Sites

Item	Quantity	Units	Unit Cost	Total
Costs Using Material Quantities from Channel Alignment P1				
General				
Mobilization and Demobilization	1	LS	$1,250,000	$1,250,000
Material Haulage				
Truck Transportation	87,381,000	m^3	$4.19	$366,102,640
Site Rehabilitation and Erosion Control				
Site Preparation & Restoration	87,381,000	m^3	$0.21	$18,332,944
Total Cost - Haulage & Site Restoration				***$385,685,584***
Engineering & Disposal Site Administration			1.50%	$5,785,284
Contingencies			12.50%	$48,933,858
Grand Total - P1				***$434,619,442***
Cost per cu. metre for Disposal				***$5.00***

Item	Quantity	Units	Unit Cost	Total
Costs Using Material Quantities from Channel Alignment P2				
General				
Mobilization and Demobilization	1	LS	$1,250,000	$1,250,000
Material Haulage				
Truck Transportation	47,136,500	m^3	$4.18	$197,260,790
Site Rehabilitation and Erosion Control				
Site Preparation & Restoration	47,136,500	m^3	$0.39	$18,332,944
Total Cost - Haulage & Site Restoration				***$216,843,734***
Engineering & Disposal Site Administration			1.50%	$3,252,656
Contingencies			12.50%	$27,512,049
Grand Total - P2				***$244,355,783***
Cost per cu. metre for Disposal				***$5.20***

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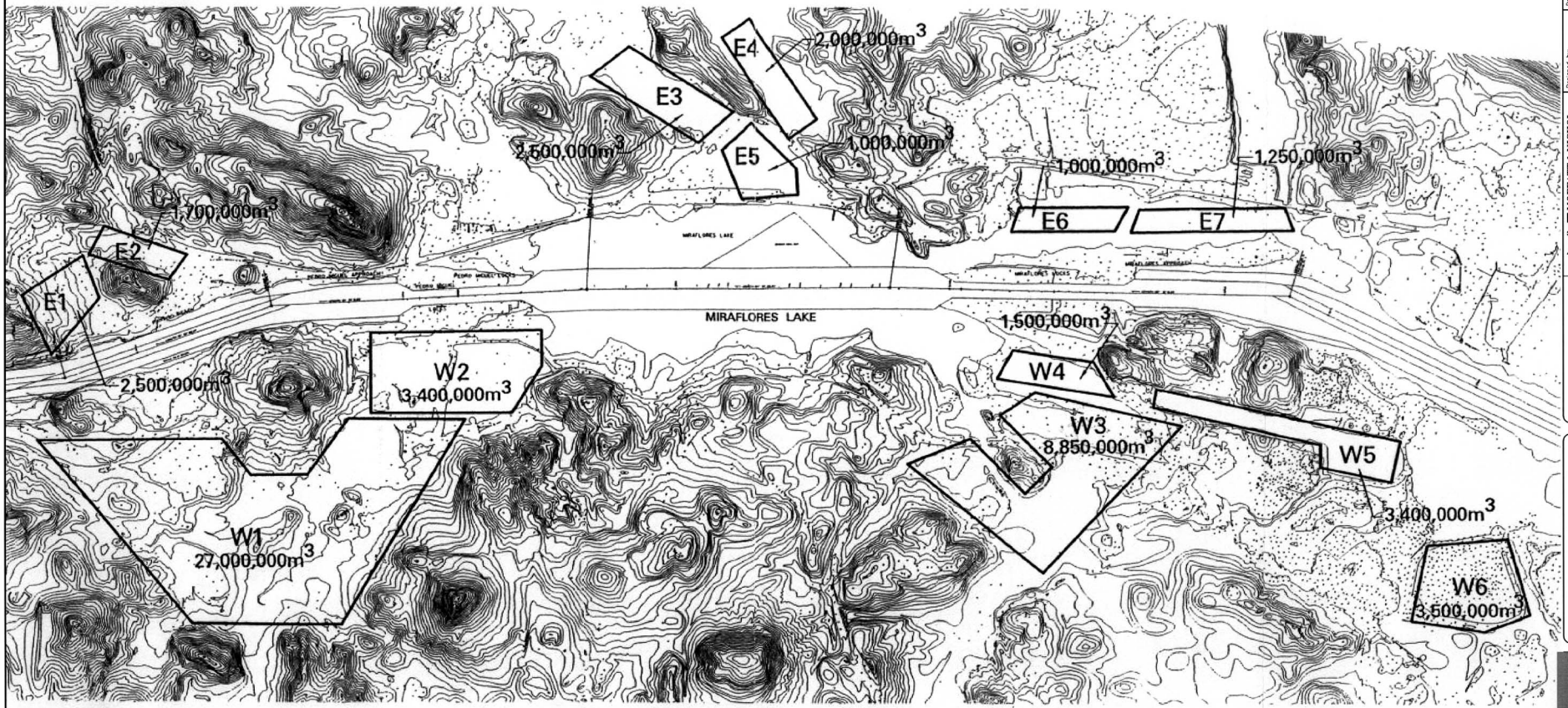


FIG 11-1

MOFFATT & NICHOL ENGINEERS

SKIDMORE, OWINGS AND MERRILL LLP

LOUIS BERGER INTERNATIONAL

ACP AUTORIDAD DEL CANAL DE PANAMÁ

PRE-FEASIBILITY STUDY FOR ARTIFICIAL ISLAND DEVELOPMENT

ACP DESIGNATED MATERIAL DISPOSAL SITES

Designed by: D.J.Mac | Date: NOV. 2001 | Rev.
Dwn by: D.J.Mac | Ckd by: M.G.H. | Design file no.
Reviewed by: T.J.S. | Drawing Scale: AS SHOWN
Submitted by: M.G.H. | Plot scale: 1 = 1

DWG INFO: P:\HORTON FILES\PANAMA\4594-02 - ARTIFICIAL ISLAND\60 - CADD\FIG 11-01.DWG; NOV 09 2001 - 10:43 AM; JMACPHERSON; XREF'S; 459402ZDIS_AREAS, (C) MOFFATT AND NICHOL ENGINEERS

12 FINANCIAL INDICATORS

12.1 Capital cost Evaluation

12.1.1 Island Construction

The foregoing sections clearly indicate that the construction of the island and its intermodal access system is technically viable. Section 10 also indicates that there do not appear to be any environmental issues that cannot be resolved by mitigation or an effective public awareness campaign.

Based on the cost estimates presented in Section 11.6 , the expected costs of island construction for the P1 and P2 alternatives are summarized in Table 12-1. The table also indicates the expected cost of placement of the same quantities of material at the ACP designated disposal sites, since the difference between the two costs may be considered as the opportunity cost for creation of the raw unimproved land for commercial development of the island itself.

As indicated in the table, the full development cost of the island, without container or value added installations, will vary from a low of $274.01/m2 to a high of $451.03/m2 depending on the Locks and breakwater options selected. If the cost of disposal to the ACP sites is discounted from the development costs, the range of values falls to a low of $86.54/m2 and a high of $225.52/m2.

Table 12-1: Summary of Island Investment Costs

	Locks Alternative			
	P1		P2	
	Long BW	Short BW	Long BW	Short BW
Land Base				
Island Area from Locks Excavation (ha)	350	368	172	183
Marketable Land Area (ha)	**221**	**232**	**108**	**115**
Development Costs ($millions)				
Unimproved island Construction	$541.82	$482.05	$351.08	$315.79
Infrastructure (3 phases)	$153.21	$153.21	$137.65	$137.65
Total Development Cost for the Island /1	***$695.04***	***$635.26***	***$488.73***	***$453.44***
Cost of Using ACP Disposal sites	**$434.62**	**$434.62**	**$244.36**	**$244.36**
Discounted Island Cost	***$260.42***	***$200.64***	***$244.38***	***$209.08***
Equivalent Development Costs ($/m2)				
Full Cost	**$315.21**	**$274.01**	**$451.03**	**$393.30**
Discounted (ACP disposal) Cost	**$118.10**	**$86.54**	**$225.52**	**$181.35**

12.2 Facilities Development

12.2.1 Container Terminals

There are essentially three approaches to container terminal development. Each has varying degrees of risk for the concession holder and owner, with consequent variations in investment costs and revenue.

- Build, operate and transfer (BOT) Full concession, where the concession holder builds and operates the terminal for a specific period, usually on the order of 25 to 35 years, with the facility ownership returning to the landlord on completion of the concession term.
- Operating Concession – The landlord builds the permanent installations, and possibly provides gantry cranes. The concession holder operates the terminal using its own yard equipment and personnel. Duration of agreement can be five to 20 years.
- Owner Operation. The project sponsor builds and operates the terminal, often with concessions for special services, such as stevedoring, tugs etc.

The most common system in the US is the landlord/lease system, whereby the container terminal will be constructed by the port agency or public entity. This is mainly the result of significant public financing and funding for port projects.

In South America and Asia, the BOT approach is far more common, as governments move away from public support for infrastructure projects. This is probably the most logical approach for this project, and follows the models of the Manzanillo, Evergreen and Balboa container terminals.

Assuming that the investment cost of a fully developed 32 ha terminal module with eight gantry cranes, as presented in Section 6.1, is on the order of $149 million, this then converts to an added unit cost of $466/m2, over and above the improved island construction costs presented earlier.

Assuming that the discounted island costs are applied, the total unit cost of the container terminal is likely to be on the order of $584.00/m2 ($118.10 + $466.00) for the P1 option with the full breakwater and $553.00/m2 for the short breakwater option.

These total costs increase to $691.00 and $647.00/m2 respectively for similar breakwater scenarios under the P2 Locks option, again assuming that the cost of ACP disposal is discounted from the islands construction cost.

12.2.2 Container Terminal Construction costs at other Locations

Direct comparison of the container terminal costs with other projects on a square meter basis can be misleading, since throughput and revenue potential will vary considerably. For example, US west coast terminal throughput is often on the order of 10,000 teus per hectare per year, while throughput at transshipment terminals such as Manzanillo or HIT in Panama is on the order of 20,000 teus per hectare. Ports such as Singapore and Hong Kong claim throughputs of 30,000 to 50,000 teus per hectare.

In order to compare construction costs with other container terminals, it is therefore useful to use a cost per teu of annual throughput capacity as a baseline.

On this basis, the Container Terminal module described in this report will cost approximately $157 per teu of annual throughput. Construction of the land and infrastructure to support the terminal will cost $40 per teu, indicating a total cost, including cranes, of $197 per teu of annual throughput, if it is assumed that the cost of disposal to the ACP sites can be discounted from the estimate. If the full cost of the island construction is included, the cost per teu will increase to $263 per teu of annual throughput.

Very few new US terminals are being built on Greenfield sites similar to this project, but in these cases, land purchase costs must then be included the project cost estimate. A typical west coast terminal upgrade will cost on the order of $175 per teu of throughput, and land costs will vary from $40 to $95 per teu of annual throughput depending on location and demand. Asian and Far East terminal construction costs are slightly higher than the US counterparts, with land costs varying considerably depending on location.

This crude comparison indicates that the Panama island container terminal is at the higher end of new terminal cost, if full cost recovery is required. If the cost of disposal to the ACP sites is discounted from the computations, the Panama island terminal cost is within an acceptable range when compared with US or international container terminal construction costs.

12.2.3 Value added and Distribution Facilities

Given the wide variety of potential development options for commercial and value added installations, it is not practical to estimate investment costs at this time. Typically each developer will wish to build its own complex or facility on leased or purchased land. Under this scenario, the development costs shown in Table 12-1 give an indication of the cost of providing a site to a potential value added or commercial developer.

12.3 Potential Income scenarios

12.3.1 Container Terminals

For terminals that are financed, built and operated by the owner or concessionaire, revenue after operating costs is on the order of $60 per teu, out of which the amortization of capital must be deducted. Net revenues after all costs are typically on the order of $15 to $40 per teu, depending on the capital investment required.

If it is assumed that the project sponsor builds a 950,000 teu terminal module as illustrated in Section 6.1, net income to the landlord entity will be on the order of $20 to $30 per teu handled.

12.3.2 Value Added installations

As noted above, most developers will wish to build their own facilities on the island. A detailed study is required to determine a typical range of lease or sale costs that would apply to this project.

However, as a rough guide, potential lease rates for prime waterfront development ready sites in the US are on the order of 8.0 to 12.0% of appraised value per year. This then translates to a low of $30,000 to as much as $120,000/ha/year, depending on location, market potential and level of demand.

13 IMPLEMENTATION PROGRAM

13.1 Key Project Milestones

In order to meet the Locks construction start up target of year-end 2005, the rail system for the island must be ready to receive materials. This then implies that the rail system must be constructed well ahead of the Locks project commencement. The contractors working area for the island indicated in Figure 9-1 must be available to receive and temporarily hold incoming material during the construction of the causeway to the island.

Prior to commencement of any work on the island or land connections, the requisite permits must be obtained.

Finally, the permitting and contracting process will be based on engineering and technical studies, which will include a significant number of field investigations.

If it is assumed that permitting and engineering for the project will take approximately 18 months, with construction of the rail link taking a similar time, it is critical that the technical and environmental studies begin no later than the beginning of 2002.

13.2 Special Study Requirements

A major marine related development project of this category requires a considerable effort both from permitting and engineering standpoint. As indicated in the discussions in this report, there are a number of major issues and cost factors that will require detailed study before final design documents can be prepared. Key issues identified to date include:

- Geotechnical characteristics of the island and causeway area
- Need or otherwise for breakwater protection
- Need or otherwise for open sections or bridges in the causeway
- Characteristics and Volumes of material to be removed from Locks excavation
- Sub bottom conditions (rock quantities) in dredged channel areas
- Reaction of public and interest groups to the project
- Shoreline and other impacts of the project
- Future use of rail link

In order to address these issues, the following special studies are required as a matter of urgency:

13.2.1 Offshore

A coordinated program of over water studies represents the first priority for the fieldwork. These studies will then provide the basic information required to confirm the island location, characteristics of sub bottom materials and refinement of the cost estimates presented earlier.

Seismic Profile, exploratory boreholes

Given the extensive area of the island, and the intermittent nature of the rock outcrops in the area north of Taboga, it is recommended that a seismic survey be undertaken with calibration boreholes to confirm materials characteristics. This survey can be integrated with the bathymetric work discussed below. The duration of the fieldwork is on the order of one month, following arrival of specialist equipment at the project site. Production of the survey report will take approximately two months. The area of coverage should be one km on each side of the causeway alignment, a similar distance north and south of the proposed access channel and at least 2 km greater than the side dimensions of the proposed island.

Bathymetry

Navigation charts and other bathymetry indicate minimal changes in the bottom profile over a significant period of time. However, a full bathymetric survey should be undertaken in conjunction with the Seismic work discussed above.

Wave Studies

At this time, it is now known whether any useful wave data is available to support ship motion and breakwater design studies. However, the incidence of very long period waves in the Pacific will almost certainly require a wave measurement program in the vicinity of the project. This program should be continued for the full duration of the technical and design work, in order to cover the widest spectrum of the wave climate in the area.

Hydrodynamics & Sedimentation Model

A hydrodynamic model will be required to simulate tidal driven currents in and around the proposed development. It is understood that some modeling work has been done in the vicinity of the Canal entrance. However site specific information on tides, currents, sediment loads, salinity, temperature and other parameters will be required for the model. This work can be programmed to coincide with the other offshore field surveys.

Dredged Materials Sampling

Bottom samples of material should be taken to below the proposed dredging depths in order to identify the environmental characteristics of the material and prepare technical studies of dredging work.

13.2.2 Onshore Studies

Onshore technical field studies will be limited to topography over the rail route and recommended contractor's working and materials stockpile areas. Following a data search covering the recommended route, a series of test pits, soundings and boreholes will be required to support the design effort for the rail and crossing structures.

Right of way studies will also be required, and can be included in the topographic work.

13.2.3 Environmental Baseline Studies

A series of baseline environmental studies will be required to support the permitting effort for the project. These should be coordinated with the hydrodynamic and other offshore studies, since much of the information to be derived is applicable to both the technical and environmental work tasks. Typical studies for a project of this magnitude include:

- Bottom sampling for fauna and flora
- Identification of sensitive ecological areas (coral beds etc)
- Detailed evaluation of near shore sediments and ecological characteristics
- Water samples for dissolved oxygen and contaminant levels
- Fish and crustacean sampling in project area of influence
- Environmental baseline studies to include the effects of the Project on Punta Bruja environmentally protected areas.
- Air quality sampling
- Bio diversity and species evaluations along rail route and island access
- Surveys of bird and indigenous species on islands or shoreline with the area of influence of the island

13.3 Technical & Design Studies, Permits

Prior to the undertaking of any detailed engineering work, the following special studies should be undertaken, using the results of the field studies noted above.

Offshore Wave modeling

Twenty years of hindcasted waves are available from the United Kingdom Meteorological Office (UKMO). In conjunction with any local data and the results of specific wave measurement for the project, these data can be used to provide statistics for operational and design waves offshore of the study site. Design waves (e.g., 10, 25, 50 and 100- year return period values) should then be developed using a point over threshold extreme value analysis.

Near-shore Wave Modeling.

A MIKE 21 or similar near-shore wave model (NSW) will be required to transfer the offshore wave climate to the project site. An offshore grid will take the waves from deep water to an area fronting the project site and cover a wide portion of the Bay south of the Panama Canal. Waves from the offshore grid are then transferred to a project site inner grid. This inner grid will transfer waves past and around the islands fronting the proposed harbor development, in order to establish near-shore design waves for breakwater design.

Refraction-Diffraction Modeling

A second level model will also be required to evaluate wave heights within the harbor behind the breakwater, such that several alternative breakwater alignments can be evaluated. Given the high cost of the breakwater, this will be one of the key elements of the early technical studies for the project.

Ship Motion evaluation

In conjunction with the wave modeling efforts, a ship motion study may be required to support the breakwater and island planning work tasks.

Hydrodynamics & Sedimentation Model

A Mike 21 HD/MD or similar model will be required to simulate tidal driven currents in and around the proposed development. The model will be used to evaluate the impact of project development on tidal flows and sedimentation within the harbor and approach channel. Results from this work will be used to evaluate long-term maintenance dredging requirements and can also be used in environmental studies.

Ship Maneuvering Simulation and Under keel Clearance Model

A fast-time ship maneuvering or navigation model should be used to confirm the navigation channel design and configuration. There are several categories of model available for this task, starting from a fully computer based model to full sized replicas of the ship bridge area and digitized images of the proposed approaches.

Geotechnical Evaluation

The geotechnical evaluation represents one of the most critical elements of the technical studies. Given the varied nature of the bottom materials in the vicinity of the island, causeway and approach channel, the geotechnical studies are crucial to obtain a satisfactory level of confidence in the cost estimating efforts.

Materials Evaluation

It is assumed that extensive site investigations will be undertaken for the Locks concept and design studies to be carried out in conjunction with the island technical studies. However, it is crucial that the island technical team coordinate these studies with the locks design group, since the objectives of each group will differ. In particular, the island project will require rock as small as can be reasonably obtained, together with sufficient yield of large rock for the wave protection elements of the project. While this can be obtained by modifying blasting patterns and techniques, this may not meet the production or cost objectives for construction of the Locks.

In this case, the materials evaluation may be extended to research other sources of large material for armor stone for the breakwater and shore protection items.

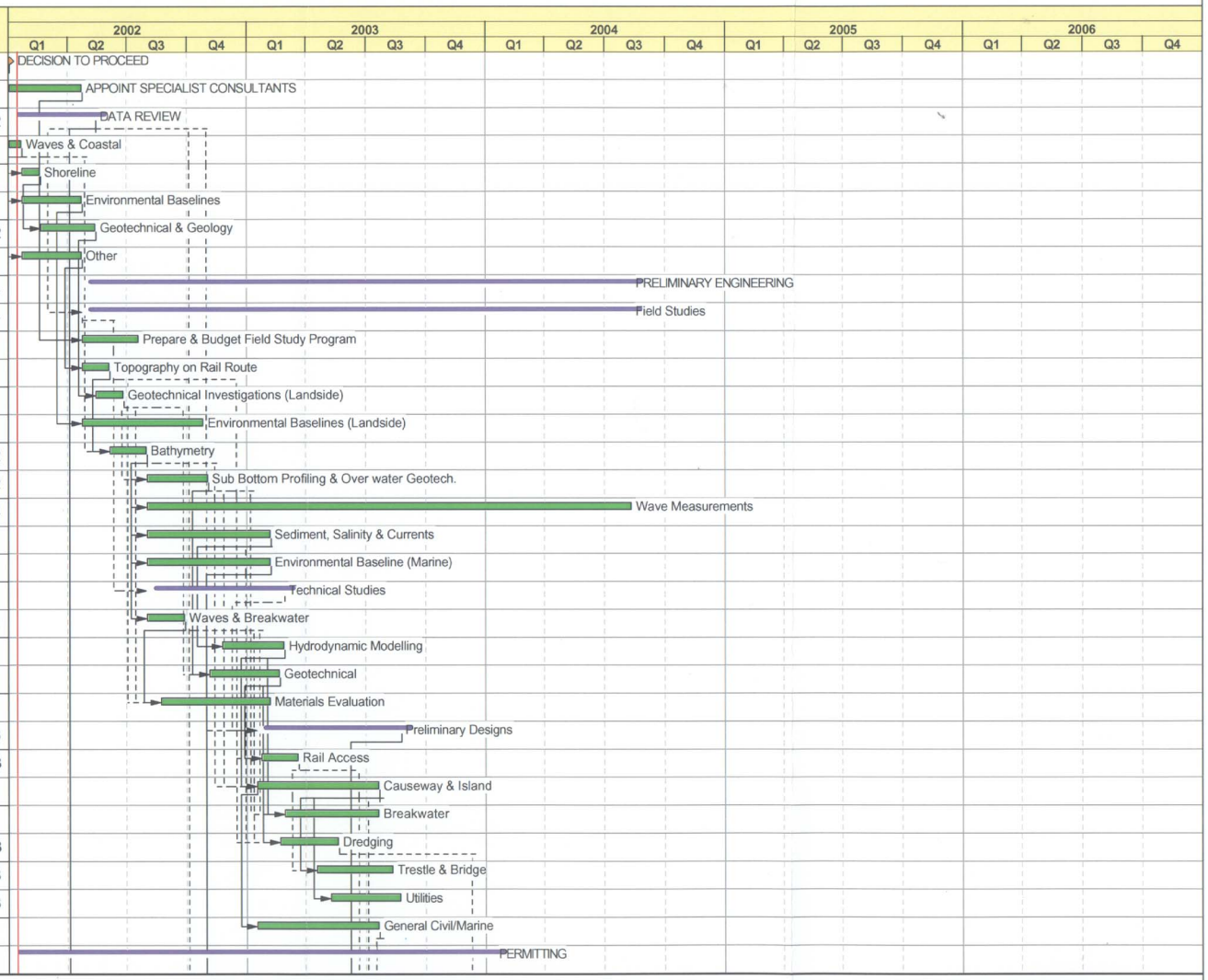
13.4 Implementation Schedule

In order to meet the key milestones for the Locks project, the field investigations and technical studies will require close coordination and early mobilization.

Figure 13-1 shows a general schedule of pre construction and construction tasks considered critical to meet the established deadlines for the Locks project.

Figure 13-1: Island Construction Schedule

Description	Orig Dur	Early Start	Early Finish
DECISION TO PROCEED	0	02JAN02	
APPOINT SPECIALIST CONSULTANTS	16w	02JAN02	23APR02
DATA REVIEW	19w *	02JAN02	14MAY02
Waves & Coastal	3w	02JAN02	22JAN02
Shoreline	4w	23JAN02	19FEB02
Environmental Baselines	13w	23JAN02	23APR02
Geotechnical & Geology	12w	20FEB02	14MAY02
Other	13w	23JAN02	23APR02
PRELIMINARY ENGINEERING	118w *	24APR02	12AUG04
Field Studies	118w *	24APR02	12AUG04
Prepare & Budget Field Study Program	12w	24APR02	18JUL02
Topography on Rail Route	6w	24APR02	05JUN02
Geotechnical Investigations (Landside)	6w	15MAY02	26JUN02
Environmental Baselines (Landside)	26w	24APR02	25OCT02
Bathymetry	8w	06JUN02	01AUG02
Sub Bottom Profiling & Over water Geotech.	13w	02AUG02	01NOV02
Wave Measurements	104w	02AUG02	12AUG04
Sediment, Salinity & Currents	26w	02AUG02	05FEB03
Environmental Baseline (Marine)	26w	02AUG02	05FEB03
Technical Studies	29w1d	02AUG02	27FEB03
Waves & Breakwater	8w	02AUG02	27SEP02
Hydrodynamic Modelling	13w1d	25NOV02	27FEB03
Geotechnical	15w	04NOV02	19FEB03
Materials Evaluation	23w	23AUG02	05FEB03
Preliminary Designs	31w *	17JAN03	25AUG03
Rail Access	8w	23JAN03	19MAR03
Causeway & Island	26w	17JAN03	21JUL03
Breakwater	20w	28FEB03	21JUL03
Dredging	13w	20FEB03	21MAY03
Trestle & Bridge	16w	18APR03	11AUG03
Utilities	15w	09MAY03	25AUG03
General Civil/Marine	26w	17JAN03	21JUL03
PERMITTING	104w *	02JAN02	15JAN04



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Finish date	25JUL16
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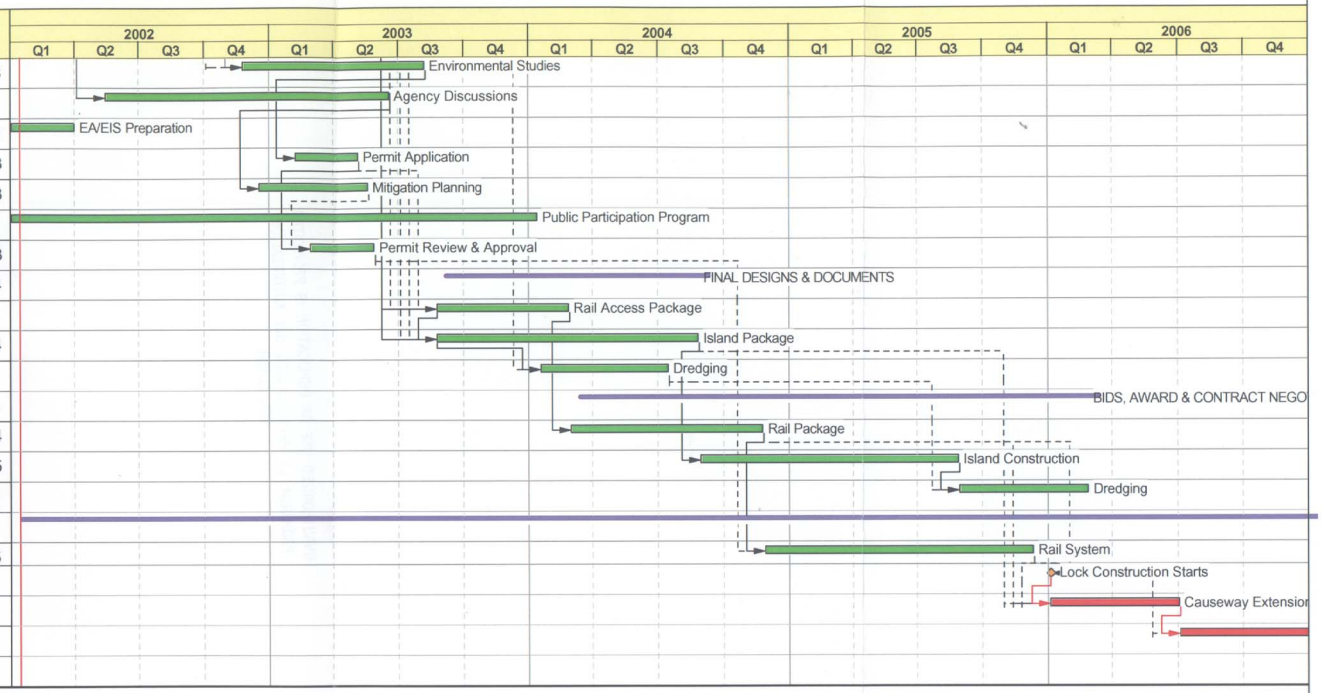
Early bar
Progress bar
Critical bar
Summary bar
Start milestone point
Finish milestone point

Figure 13-1: Island Construction Schedule

Description	Orig Dur	Early Start	Early Finish
Environmental Studies	36w	25NOV02	08AUG03
Agency Discussions	56w	15MAY02	19JUN03
EA/EIS Preparation	13w	02JAN02	02APR02
Permit Application	13w	06FEB03	07MAY03
Mitigation Planning	22w	17DEC02	21MAY03
Public Participation Program	104w	02JAN02	15JAN04
Permit Review & Approval	13w	27FEB03	29MAY03
FINAL DESIGNS & DOCUMENTS	52w *	26AUG03	27AUG04
Rail Access Package	26w	26AUG03	27FEB04
Island Package	52w	26AUG03	27AUG04
Dredging	26w	19JAN04	16JUL04
BIDS, AWARD & CONTRACT NEGOTIATION	104w *	01MAR04	27FEB06
Rail Package	39w	01MAR04	26NOV04
Island Construction	52w	30AUG04	29AUG05
Dredging	26w	30AUG05	27FEB06
CONSTRUCTION	752w2d	02JAN02	25JUL16
Rail System	54w	29NOV04	12DEC05
Lock Construction Starts	0		03JAN06
Causeway Extension to Island	26w	04JAN06	05JUL06
Island Construction	520w	06JUL06	25JUL16
	1d	02JAN02	02JAN02



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Progress bar
Critical bar
Summary bar
Start milestone point
Finish milestone point