AUTORIDAD DEL CANAL DE PANAMA

CONTRACT No. CMC-146911

FEASIBILITY STUDY OF PALO SECO/FARFAN LAND RECLAMATION TO DEVELOP A PORT FACILITY

TECHNICAL APPENDICES

June 2005

MOFFATT & NICHOL

Golder Associates

TECHNICAL APPENDICES

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MOFFATT & NICHOL
ENGINEERS

"QUICKTERM" CONTAINER TERMINAL SIZING MODEL

(Version 10.28.98)

Project Title:	***Panama***
User:	***RMB***
Date:	***4/4/2005***

INPUT

1. Enter Gross Terminal Area (acres)	**277.76**
2. Enter Berth Length (feet)	**5,250**
3. Enter Dockside Crane Gauge (feet)	**100**
4. On-Terminal Railyard? (1=yes 2=no)	**1**
5. Enter Gate Type (1=1 Stage 2=2 Stage)	**2**
6. Enter Trial Annual Throughput (TEU)	**2,400,000**
7. Enter Ratio (Average TEU/Container)	**1.70**
Equivalent Annual Throughput (lifts)	**1,411,765**

8. Enter Throughput Distribution & Dwell	**% of Total Throughput**	**Dwell (days)**
Imports	**2.5%**	**7**
Exports	**2.5%**	**7**
Empties	**1.0%**	**7**
Transhipment	**84.0%**	**7**
Intermodal Imports	**5.0%**	**7**
Intermodal Exports	**5.0%**	**7**
Check Total (Must = 100%)	100.0%	

OUTPUT

A. Resultant Areas (acres)	**Minimum Density Wheeled Mode**	**Maximum Practical Storage Density**	**Maximum Density Grounded Mode**
Berth:	24	24	24
Net Container Yard:	726	216	213
Gate:	2	2	2
Buildings & Parking:	33	33	33
Railyard:	24	24	24
Gross Terminal Area	**809**	**299**	**296**
Percent Net C.Y.	**90**	**72**	**72**

B. TEU's / Acre / Year	**2,968**	**8,022**	**8,097**

C. Model Status Report

Berth Length:	**Length Insufficient**	**Length Insufficient**	**Length Insufficient**
Gross Terminal Area:	**Area Insufficient**	**Area Insufficient**	**Area Insufficient**

OUTPUT

A. Resultant Areas (acres)	Maximum Wheeled Mode	Maximum Grounded Mode	Maximum Practical Storage Density
Berth:	24	24	24
Net Container Yard:	726	213	216
Gate:	2	2	2
Buildings & Parking:	33	33	33
Railyard:	24	24	24
Gross Terminal Area	**809**	**296**	**299**

MOFFATT & NICHOL
ENGINEERS

CONTAINER STORAGE YARD SIZING MODEL

(Version 12.02.98)

Project Title:	**Panama Container Terminal**
Job Number:	
User:	**RMB**
Date:	**Rev. 5/5/2005**

Description of Model Runs:

Run A;	**6x4 RTG**
Run B;	**6x4 RTG w/TP Access**
Run C;	**6x5 RTG**
Run D;	**6x5 RTG w/TP Access**

Basic Model Assumptions: (User Input)

	Run A	Run B	Run C	Run D
Annual Throughput (lifts)	**1,412,000**	**1,412,000**	**1,412,000**	**1,412,000**
Actual Net C.Y. (acres) If Known	85.76	85.76	85.76	85.76
Percent of 40' Containers	70.0%	70.0%	70.0%	70.0%

Summary Results:

Annual Throughput (TEU)	2,400,400	2,400,400	2,400,400	2,400,400
Net C. Y. Area Required (Ha)	**85.3**	**111.2**	**72.5**	**94.1**
Additional C.Y. Required (acres)	-0.5	25.4	-13.3	8.4

Storage Capacity Required				
40' Wheeled (Slots)	513	513	513	513
20' Wheeled (Slots)	205	205	205	205
Rubber Tired Gantry (TEU)	73,032	73,032	73,032	73,032
Top Pick (TEU)	0	0	0	0
Side Pick (TEU)	0	0	0	0
Straddle Carrier (TEU)	0	0	0	0
Total Capacity Required, TEU	74,298	74,298	74,298	74,298
Total Capacity Required, Containers	41,461	41,461	41,461	41,461

Model Data (User Input)

Throughput Distribution

Imports	2.5%	2.5%	2.5%	2.5%
Exports	2.5%	2.5%	2.5%	2.5%
Empties	1.0%	1.0%	1.0%	1.0%
Transhipment	84.0%	84.0%	84.0%	84.0%
Intermodal Imports	5.0%	5.0%	5.0%	5.0%
Intermodal Exports	5.0%	5.0%	5.0%	5.0%
	100.0%	100.0%	100.0%	100.0%

Average Dwell Time (days)

Imports	7	7	7	7
Exports	7	7	7	7
Empties	7	7	7	7
Transhipment	7	7	7	7
Intermodal Imports	7	7	7	7
Intermodal Exports	7	7	7	7

Storage Density

Wheeled (TEU/acre) (Calculated)	91.84	91.84	91.84	91.84

Grounded (TEU/acre) (Input, See Look-Up Table on Storage Density Sheet)

RTG (TEU/acre)	371	280	442	334
Top Pick (TEU/acre)	480	480	480	480
Strad 2H (TEU/acre)	240	240	240	240
Side Pick (TEU/acre)	480	480	480	480

Storage Modes Distribution

Imports				
Wheeled	2.0%	2.0%	2.0%	2.0%
RTG	98.0%	98.0%	98.0%	98.0%
Top Pick	0.0%	0.0%	0.0%	0.0%
Strad	0.0%	0.0%	0.0%	0.0%
	100.0%	100.0%	100.0%	100.0%
Exports				
Wheeled	2.0%	2.0%	2.0%	2.0%
RTG	98.0%	98.0%	98.0%	98.0%
Top Pick	0.0%	0.0%	0.0%	0.0%
Strad	0.0%	0.0%	0.0%	0.0%
	100.0%	100.0%	100.0%	100.0%
Empties				
Wheeled	2.0%	2.0%	2.0%	2.0%
RTG	98.0%	98.0%	98.0%	98.0%
Side Pick	0.0%	0.0%	0.0%	0.0%
Strad	0.0%	0.0%	0.0%	0.0%
	100.0%	100.0%	100.0%	100.0%
Transhipment				
Wheeled	2.0%	2.0%	2.0%	2.0%
RTG	98.0%	98.0%	98.0%	98.0%
Top Pick	0.0%	0.0%	0.0%	0.0%
Strad	0.0%	0.0%	0.0%	0.0%
	100.0%	100.0%	100.0%	100.0%
Intermodal Imports				
Wheeled	2.0%	2.0%	2.0%	2.0%
RTG	98.0%	98.0%	98.0%	98.0%
Top Pick	0.0%	0.0%	0.0%	0.0%
Strad	0.0%	0.0%	0.0%	0.0%
	100.0%	100.0%	100.0%	100.0%
Intermodal Exports				
Wheeled	2.0%	2.0%	2.0%	2.0%
RTG	98.0%	98.0%	98.0%	98.0%
Top Pick	0.0%	0.0%	0.0%	0.0%
Strad	0.0%	0.0%	0.0%	0.0%
	100.0%	100.0%	100.0%	100.0%

Model Factors

Vessel Peaking Factor	85.0%	85.0%	85.0%	85.0%
C. Y. Shape Factor	95.0%	95.0%	95.0%	95.0%
Grounded Storage Sorting Factor	85.0%	85.0%	85.0%	85.0%
Seasonal Peaking Factor	90.0%	90.0%	90.0%	90.0%
Storage Conversion Factor (TEU/box)	1.70	1.70	1.70	1.70

Model Results

Factored Storage Densities

Wheeled (TEU/acre)	67	67	67	67
Grounded RTG (TEU/acre)	229	173	273	206
Grounded Top Pick (TEU/acre)	297	297	297	297
Grounded Strad (TEU/acre)	148	148	148	148
Grounded Side Pick (TEU/acre)	297	297	297	297
Average Factored Storage Den. (TEU/acre)	36	27	43	33
Average Dwell Time (days)	1.1	1.1	1.1	1.1

Annual Throughput By Mode (lifts)

Imports				
Wheeled	706	706	706	706
RTG	34,594	34,594	34,594	34,594
Top Pick	-	-	-	-
Strad	-	-	-	-
Exports				
Wheeled	706	706	706	706
RTG	34,594	34,594	34,594	34,594
Top Pick	-	-	-	-
Strad	-	-	-	-
Empties				
Wheeled	282	282	282	282
RTG	13,838	13,838	13,838	13,838
Side Pick	-	-	-	-
Strad	-	-	-	-
Transhipment				
Wheeled	23,722	23,722	23,722	23,722
RTG	1,162,358	1,162,358	1,162,358	1,162,358
Top Pick	-	-	-	-
Strad	-	-	-	-
Intermodal Import				
Wheeled	1,412	1,412	1,412	1,412
RTG	69,188	69,188	69,188	69,188
Top Pick	-	-	-	-
Strad	-	-	-	-
Intermodal Export				
Wheeled	1,412	1,412	1,412	1,412
RTG	69,188	69,188	69,188	69,188
Top Pick	-	-	-	-
Strad	-	-	-	-
Total	1,412,000	1,412,000	1,412,000	1,412,000

Net CY Area Allocation (acres)

Imports				
Wheeled	0.3	0.3	0.3	0.3
RTG	4.9	6.5	4.1	5.5
Top Pick	0.0	0.0	0.0	0.0
Strad	0.0	0.0	0.0	0.0
Exports				
Wheeled	0.3	0.3	0.3	0.3
RTG	4.9	6.5	4.1	5.5
Top Pick	0.0	0.0	0.0	0.0
Strad	0.0	0.0	0.0	0.0
Empties				
Wheeled	0.1	0.1	0.1	0.1
RTG	2.0	2.6	1.7	2.2
Side Pick	0.0	0.0	0.0	0.0
Strad	0.0	0.0	0.0	0.0
Transhipment				
Wheeled	11.6	11.6	11.6	11.6
RTG	165.4	219.1	138.8	183.7
Top Pick	0.0	0.0	0.0	0.0
Strad	0.0	0.0	0.0	0.0
Intermodal Import				
Wheeled	0.7	0.7	0.7	0.7
RTG	9.8	13.0	8.3	10.9
Top Pick	0.0	0.0	0.0	0.0
Strad	0.0	0.0	0.0	0.0
Intermodal Export				
Wheeled	0.7	0.7	0.7	0.7
RTG	9.8	13.0	8.3	10.9
Top Pick	0.0	0.0	0.0	0.0
Strad	0.0	0.0	0.0	0.0
Total	210.6	274.6	179.0	232.5

Static Capacity Required (TEU)

Imports				
Wheeled	32	32	32	32
RTG	1,826	1,826	1,826	1,826
Top Pick	0	0	0	0
Strad	0	0	0	0
Exports				
Wheeled	32	32	32	32
RTG	1,826	1,826	1,826	1,826
Top Pick	0	0	0	0
Strad	0	0	0	0
Empties				
Wheeled	13	13	13	13
RTG	730	730	730	730
Side Pick	0	0	0	0
Strad	0	0	0	0
Transhipment				
Wheeled	1,064	1,064	1,064	1,064
RTG	61,347	61,347	61,347	61,347
Top Pick	0	0	0	0
Strad	0	0	0	0
Intermodal Import				
Wheeled	63	63	63	63
RTG	3,652	3,652	3,652	3,652
Top Pick	0	0	0	0
Strad	0	0	0	0
Intermodal Export				
Wheeled	63	63	63	63
RTG	3,652	3,652	3,652	3,652
Top Pick	0	0	0	0
Strad	0	0	0	0
Totals				
Imports	1,857	1,857	1,857	1,857
Exports	1,857	1,857	1,857	1,857
Empties	743	743	743	743
Transhipment Import	62,411	62,411	62,411	62,411
Intermodal Import	3,715	3,715	3,715	3,715
Intermodal Export	3,715	3,715	3,715	3,715
Total Wheeled TEU	1,267	1,267	1,267	1,267
Total Grounded TEU	73,032	73,032	73,032	73,032
TOTAL REQUIRED CAPACITY, TEU	74,298	74,298	74,298	74,298

Static Capacity Required (Containers)

Imports				
Wheeled	19	19	19	19
RTG	1,074	1,074	1,074	1,074
Top Pick	0	0	0	0
Strad	0	0	0	0
Exports				
Wheeled	14	14	14	14
RTG	663	663	663	663
Top Pick	0	0	0	0
Strad	0	0	0	0
Empties				
Wheeled	5	5	5	5
RTG	265	265	265	265
Side Pick	0	0	0	0
Strad	0	0	0	0
Transhipment Import				
Wheeled	626	626	626	626
RTG	36,086	36,086	36,086	36,086
Top Pick	0	0	0	0
Strad	0	0	0	0
Intermodal Import				
Wheeled	27	27	27	27
RTG	1,327	1,327	1,327	1,327
Top Pick	0	0	0	0
Strad	0	0	0	0
Intermodal Export				
Wheeled	27	27	27	27
RTG	1,327	1,327	1,327	1,327
Top Pick	0	0	0	0
Strad	0	0	0	0
Totals				
Imports	1,093	1,093	1,093	1,093
Exports	677	677	677	677
Empties	271	271	271	271
Transhipment Import	36,712	36,712	36,712	36,712
Intermodal Import	1,354	1,354	1,354	1,354
Intermodal Export	1,354	1,354	1,354	1,354
Total Wheeled Container Slots	718	718	718	718
Total Grounded Container Slots	40,743	40,743	40,743	40,743
TOTAL REQ. CAPACITY, CONTAINERS	41,461	41,461	41,461	41,461

MOFFATT & NICHOL
ENGINEERS

ON-DOCK RAILYARD CAPACITY

(Version 12.01.00)

Project Title:	**Panama**
Job Number:	**5582**
User:	**RMB**
Date:	**4/6//05**

	INPUTS	OUTPUTS
Working Track Length, Feet	8,100	
Storage Track Length, Feet	8,100	
Total Working & Storage Track		16,200
Car Length	305	
TEU's / Car	20	
Working Track Capacity, cars		26
Storage Track Capacity, Cars		26
Gross Car Capacity		52
Dedicated Arrival Track (1=Yes, 2=No)	1	1
Dedicated Departure Track (1=Yes, 2=No)	2	0.7
Dedicated Runaround Track (1=Yes, 2=No)	1	1
Dynamic Capacity, Working Track Turns per Day		2.10
Working Days per Week	7	
TEU's / Box	1.75	
Week Peaking Factor (Annual)	1.15	
Day Peaking Factor	1.2	
Car Fit to Track Factor	0.9	
Box Fit to Car Factor	0.9	
East / West Throughput Balance		
Percentage Eastbound Throughput	80%	
Percentage Westbound Throughput		20%
Annual Capacity, TEU's		**291,635**
Annual Capacity, Lifts		**166,649**

Terminal Gate Sizing Component

INPUTS:

1	NUMBER OF DAYS PER WEEK GATE WILL BE OPEN:	5
2	NUMBER OF HOURS PER DAY GATE WILL BE OPEN:	8
3	PERCENTAGE OF DUAL-TRANSACTION TRUCKS (DEFAULT=25%):	25.00%
4	RECEIVING PRE-GATE PROCESSING RATE (DEFAULT = 30 TRANS/HR/LANE)	30
5	1-STAGE RECEIVING INSPECTION RATE (DEFAULT = 20 TRANS/HR/LANE)	20
6	2-STAGE RECEIVING INSPECTION RATE (DEFAULT = 25 TRANS/HR/LANE)	25
7	DELIVERY INSPECTION RATE (DEFAULT = 25 TRANS/HR/LANE)	25

OUTPUTS:

1	ANNUAL TRANSACTIONS				101,647
2	PEAK WEEK GATE VOLUME	TRANSACTIONS:	2,346	TRUCKS:	1,759
3	PEAK DAY GATE VOLUME	TRANSACTIONS:	405	TRUCKS:	304
4	PEAK HOUR GATE VOLUME	TRANSACTIONS:	64	TRUCKS:	48
5	NUMBER OF PRE-GATE LANES REQUIRED:				2
6	NUMBER OF RECEIVING (INBOUND) INSPECTION LANES REQUIRED:				2
7	NUMBER OF DELIVERY (OUTBOUND) INSPECTION LANES REQUIRED:				2
8	APPROXIMATE LAND REQUIRED, PRE-GATE, ACRES:				0.7
9	APPROXIMATE LAND REQUIRED, RECEIVING INSPECTION, ACRES:				0.7
10	APPROXIMATE LAND REQUIRED, DELIVERY INSPECTION, ACRES:				0.7
11	APPROXIMATE TOTAL GATE AREA, ACRES				2.1

APPENDIX B - ENVIRONMENTAL BASELINE DATA

ENVIRONMENTAL & SOCIO ECONOMIC BASELINE CONDITIONS

Introduction

The following sections describe the existing physical, biological, social-economic, and archeological/cultural environments within the Direct Impact Areas (DIA) and Indirect Impact Areas (IIA) associated with the preliminary study related to the Port Development at Palo Seco Peninsula (Project).

The Project consists of both terrestrial and marine components. The proposed development consists of an 140 hectares man-made container island (terminal) located offshore of the Farfan/Palo Seco. The terminal will be located approximately 200m offshore from the coastal shoreline in an area that is characterized by relatively shallow depths of water with numerous rock outcrops along the shoreline near the Pacific entrance to the Panama Canal.

The terminal is connected to the mainland by rail and road access to the terminal. Three potential access corridors were evaluated connecting the terminal to modal point east of the Panama Canal near Miraflores Lock. Terminal supporting facilities will be located on land-side immediately north of a proposed corridor.

The source of fill required to construct the proposed project has been evaluated using independent and approved sources of borrow material. If the proposed terminal project construction coincides with the Gaillard Cut Deepening and Widening projects planned by ACP, the excavated material can be beneficially used in the construction of the terminal.

The information contained in these sections is based on readily available information provided by ACP and information gathered from the existing data base of field studies and technical assessments that were prepared as part of the Artificial Island Study and Disposal Options Study by the Project team in 2004. As part of the data collection, meetings were made with the following agencies and interviews were conducted with appropriate environmental personnel.

- Panama Canal Railroad
- Panama Institute of Tourism-Instituto Panameño de Turismo (IPAT)
- National Environmental Authority-Autoridad Nacional del Ambiente (ANAM)
- Smithsonian Tropical Research Institute Library
- Howard Air Force Base
- Interoceanic Regional Authority -Autoridad de la Región Interoceánica (ARI)
- National Institute of Culture-Instituto Nacional de Cultura (INAC)

The methodology used in evaluating the environmental aspects of this Project considered the above referenced technical data and meetings as well as site visits to observe the potential access routes to the terminal, coastal shoreline, sources of borrow materials, and nearby communities.

Previous studies conducted as part of the Artificial Island Study and Disposal Options Study describe current conditions of natural communities and land use characteristics of disposal sites evaluated that lie close to the proposed terminal access and offshore terminal. The environmental characterization presented in these referenced studies included rapid ecological assessments, water quality analyses, and soil samples.

The environmental evaluation of existing conditions and potential impacts of this project were established by the use of Direct Impact Areas (DIA) which consist of the footprint of the proposed container island and the road and rail associated with the project. The Indirect Impact Areas (IIA) include those areas and communities potentially impacted by the proposed new infrastructure.

Physical Environment

Climatology

Separating two oceans, the country of Panamá enjoys a tropical climate similar to other Central American countries, although some regions of Panamá experience different weather patterns that are mostly related to their altitude and proximity to the ocean. According to Koppen, the climate in the area of the Project is classified as tropical humid with two distinct seasons, the Rainy Season (May to December) and the Dry Season (January to April). Monthly climatology information pertaining to temperature, precipitation, relative humidity and wind velocities and direction have been obtained from the ACP for the Balboa station for the period of 1985 to 2003. A summary of the average climatic conditions is presented in Table 1 as follows with detailed information compiled by ACP presented in Table 2 to Table 11.

Table 1: Average Climatic Conditions, Balboa FAA

Average Climatic Parameter	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Temperature, (ºC)												
(ºF)	26.6	27.1	27.8	27.8	27.1	26.7	26.7	26.4	26.2	26.1	26	26.2
	79.8	80.8	81.3	82.1	80.8	80	80	79.6	79.2	78.9	78.8	79.2
Precipitation												
mm	38	230	230	81	241	226	198	193	236	184	241	129
inches	1.5	0.8	0.8	3.2	9.5	8.9	7.8	7.6	9.3	11.2	9.5	5.1
RH, %	52.7	48	46.8	51.1	63.7	67.9	67.8	67.8	69.9	70.7	70	63.2
Wind Velocity,												
m/s												
mph	2.19	2.41	2.46	2.35	1.70	1.56	1.74	1.65	1.56	1.56	1.65	1.74
	4.9	5.4	5.5	5.0	4.0	3.5	3.9	3.7	3.5	3.5	3.7	3.9
Wind Direction	336.4	340.1	343.5	338	303	292.4	311.4	310.5	260.4	256.8	300.8	327.7

Source: ACP 2004

Temperature

Panamá does not experience marked seasons based on changes in temperature, rather, Panamá's seasons are divided into so called Wet and Dry Seasons. The Dry Season begins around the middle of December which is marked by strong north-easterly winds, known as the 'trade winds'. During the Dry Season, day-time air temperatures also increase slightly to around 30-31 degrees Centigrade (ºC) or 86-88 degrees Fahrenheit (ºF), but night-time temperatures remain around 22-23ºC (72-73ºF). Relative humidity drops throughout the season, reaching average values as low as 70 percent (%). The Wet Season commences around early May and is considered as one of the wettest months. The transition from the very dry conditions at the end of the Dry Season to the Wet Season can be very dramatic. The arrival of the rains during the Wet Season cools down the region a little during the day as the trade winds disappear. Relative humidity during the Wet Season increases quickly and may hover around 90-100% throughout season. The region's normal daily temperature varies little throughout the year. During the evening hours, however, the temperatures can fluctuate as much as 6 to 10 ºC (42.8 to 50 ºF). The evenings are typically cooler.

As shown in Table 1, the average monthly temperature for the general study area was based on the Balboa meteorological station data provided by ACP. The station's annual monthly average temperature is about 26.7ºC (80ºF) for the recording period. The average monthly temperatures vary from a minimum of 26.2ºC (79.2ºF) to a maximum of 27.8ºC (81.3ºF) and although the average monthly temperature varies little from month to month throughout the year (i.e. less than 2 ºF) what does change is the precipitation. The average temperatures area also fairly constant between the Wet and Dry Seasons with a monthly average temperature of 27.2ºC (81ºF) during the Dry Season and (26.4 ºC) 79.6ºF during the Wet Season.

The variation of monthly instantaneous minimum and maximum temperatures for the Balboa station are presented in Table 3 and Table 4, respectively. The recorded data in indicates that the annual instantaneous minimum temperature is 17.6ºC (63.8ºF) and the annual instantaneous maximum is 40.2ºC (104.4ºF).

The variation in temperature between the Dry Season minimum and maximum temperature varies from 17.6ºC (63.8ºF) to 40.2ºC (104.4ºF) while the Wet Season minimum and maximum temperatures vary from 18.5 ºC (65.4ºF) to 38.8ºC (101.9ºF).

Figure 1: Classification of Climates in Panama

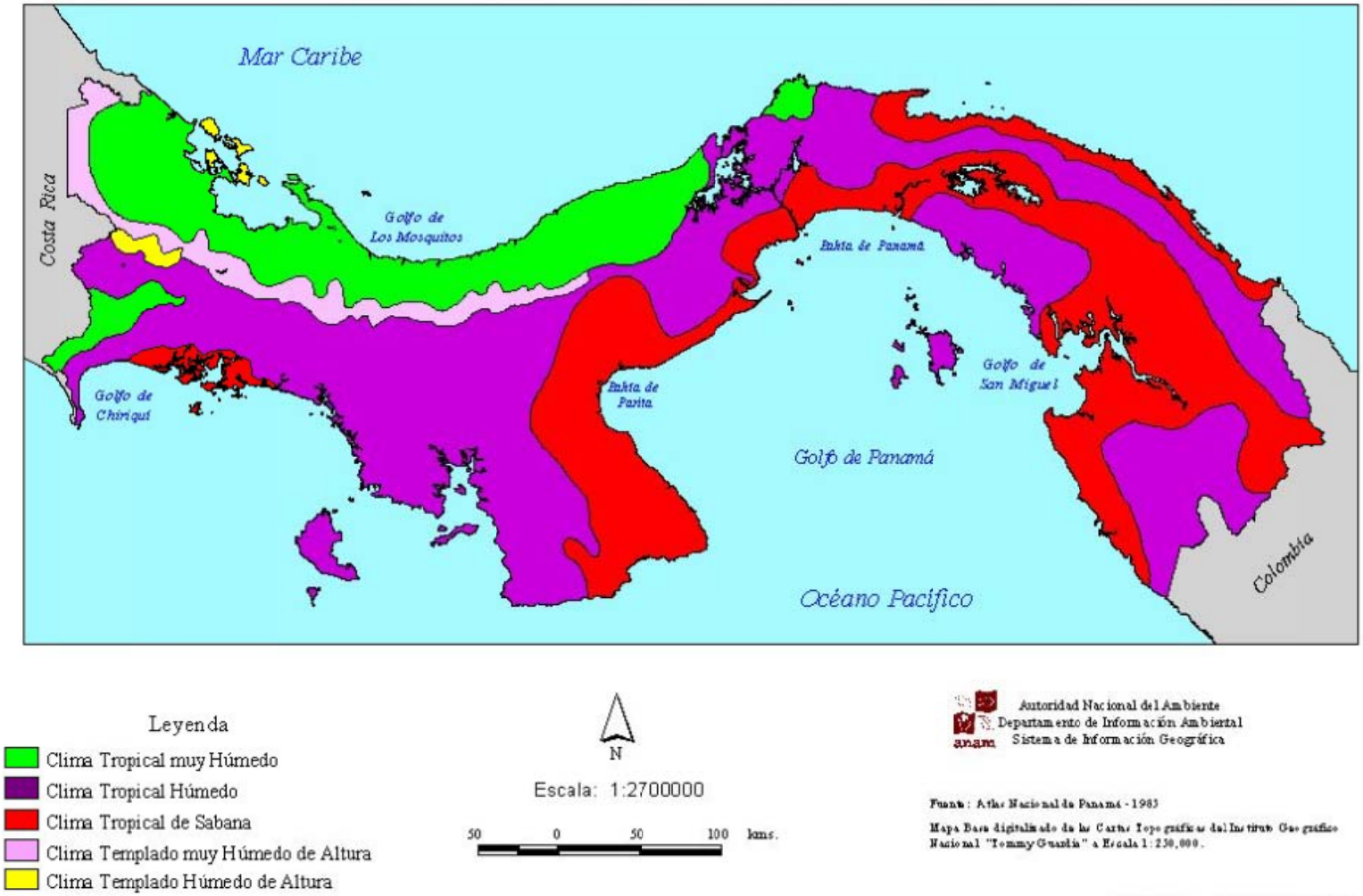


Table 2: Balboa FAA - Monthly Average Air Temperature (deg F)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Ave
1990	80.4	80.4	82.0	83.0	81.1	80.9	80.1	80.3	79.8	78.8	79.9	79.6	80.5
1991	80.4	81.3	82.4	82.9	81.1	80.4	80.4	79.9	79.2	78.3	78.5	79.1	80.3
1992	80.9	81.6	81.2	81.6	80.0	79.0	81.5	**77.3**	79.6	79.5	79.1	80.1	80.1
1993	80.1	81.1	82.3	82.0	81.4	81.0	80.8	80.9	78.9	79.8	79.0	80.3	80.6
1994	80.5	81.2	81.7	82.7	80.6	80.3	80.9	79.8	80.6	79.3	79.4	80.5	80.6
1995	81.4	81.5	81.6	81.7	80.6	81.2	78.8	78.7	79.5	78.6	78.2	78.2	80.0
1996	77.9	79.0	79.7	80.7	**79.3**	79.2	**78.5**	78.6	78.4	78.5	78.0	78.2	**78.8**
1997	78.2	80.5	80.3	81.8	82.0	80.0	81.2	81.2	79.5	79.7	79.3	81.2	80.4
1998	82.1	82.3	83.6	83.3	81.9	80.7	79.8	79.3	79.8	79.7	78.4	78.1	80.7
1999	78.9	79.5	80.5	80.6	79.5	**78.6**	79.0	78.4	78.3	78.2	**77.7**	**77.0**	78.9
2000	77.7	79.5	80.2	81.4	79.9	79.3	79.1	78.9	**77.6**	78.0	78.1	78.1	79.0
2001	78.9	80.1	80.4	82.1	80.3	79.9	78.9	80.4	78.0	78.7	77.8	78.2	79.5
2002	80.8	81.4	82.4	81.8	**82.3**	80.8	80.7	80.4	79.9	79.5	79.7	79.7	80.8
2003	80.7	82.3	82.1	82.8	80.8	78.7	80.1	79.7	79.1	79.0			
Monthly Maximum	82.9	83.7	83.8	83.7	82.3	82.3	82.0	82.0	81.2	80.5	81.5	82.3	81.5
Monthly Minimum	77.5	78.7	79.6	80.6	79.3	78.6	78.5	77.3	77.6	77.4	77.7	77.0	78.8
Monthly Average	79.8	80.8	81.3	82.1	80.8	80.0	80.0	79.6	79.2	78.9	78.8	79.2	80.0

Source: ACP, 2004

Table 3: Balboa FAA Minimum Air Temperature (deg F)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1990	70.7	68.5	67.6	70.7	72.3	72.1	70.0	71.9	72.7	69.9	72.1	69.9
1991	68.3	67.4	68.9	68.3	74.0	72.1	71.7	71.9	71.6	70.0	71.3	**67.4**
1992	68.9	68.1	67.5	69.5	72.5	68.9	69.8	**65.4**	72.2	70.3	**72.3**	68.5
1993	**71.1**	68.9	67.4	72.3	**74.7**	72.1	72.9	70.0	71.7	72.5	71.3	70.9
1994	67.4	69.5	68.9	72.1	73.3	68.9	72.3	72.5	72.1	71.5	72.2	68.9
1995	68.9	69.2	68.7	71.6	73.4	**73.7**	70.4	71.2	71.7	70.2	71.3	70.0
1996	68.3	68.4	65.6	70.3	70.6	72.8	69.9	70.2	70.9	71.4	69.6	69.7
1997	68.4	69.3	66.2	68.9	73.8	72.4	71.6	71.5	68.9	72.4	70.8	69.3
1998	70.9	**65.8**	69.7	70.8	74.4	73.2	73.0	70.7	71.5	71.7	71.1	70.1
1999	68.4	68.7	67.9	70.0	71.7	72.0	71.3	69.2	71.9	71.4	69.3	69.7
2000	66.6	68.0	67.1	68.6	71.9	70.1	69.7	70.0	70.0	70.9	70.0	69.0
2001	68.0	70.0	67.0	70.0	71.0	71.0	71.0	72.0	70.0	71.0	71.0	68.0
2002	71.0	**71.0**	**71.0**	70.0	**69.1**	72.0	**69.0**	67.3	**68.8**	68.2	**67.2**	67.8
2003	71.0	**71.0**	69.0	**73.0**	70.9	**68.0**	70.8	73.0	68.9	**73.3**		
Monthly Maximum	71.1	71.0	71.0	73.0	74.7	73.7	73.5	74.5	72.9	73.3	72.3	71.9
Monthly Minimum	65.4	65.8	63.8	65.2	69.1	68.0	69.0	65.4	68.8	67.9	67.2	67.4
Monthly Average	68.6	68.8	67.8	70.2	72.2	71.6	71.0	70.5	71.1	70.9	70.7	69.3
Dry Season Minimum	63.8											
Wet Season Minimum	65.4											
Annual Minimum	63.8											

Table 4: Balboa FAA Maximum Air Temperature

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1990	93.8	95.2	97.4	99.1	95.6	94.0	94.0	96.3	93.6	89.1	93.3	94.6
1991	96.2	97.8	98.3	99.1	93.2	94.8	93.1	92.1	92.4	92.7	91.3	93.4
1992	95.9	97.6	96.9	98.7	95.3	93.9	97.4	97.7	93.4	94.5	92.5	94.5
1993	94.1	97.6	97.8	96.1	93.1	96.4	94.4	94.5	92.1	91.7	91.1	94.0
1994	97.0	97.0	97.1	98.4	94.0	93.8	93.8	92.3	92.9	92.5	93.1	94.8
1995	96.3	98.4	98.2	95.1	**92.7**	93.4	93.3	93.6	93.1	89.3	**90.6**	92.3
1996	92.3	92.6	94.6	95.8	93.4	92.7	93.1	**91.1**	91.8	92.5	90.7	91.2
1997	92.8	94.7	96.6	98.5	97.2	92.7	94.5	94.2	92.8	94.6	91.7	93.6
1998	97.6	98.5	98.5	99.3	97.0	93.7	95.8	91.5	92.7	91.3	92.1	92.3
1999	94.0	93.7	97.6	95.2	93.9	**90.7**	92.9	91.5	92.7	89.7	92.3	91.2
2000	93.2	94.0	96.0	97.2	94.2	92.1	**92.8**	92.5	**89.0**	90.0	92.0	92.0
2001	93.0	93.0	96.0	97.0	94.0	92.0	93.0	95.0	92.3	91.0	91.0	**89.6**
2002	93.7	95.0	97.0	97.0	96.0	93.0	96.5	97.6	94.5	93.7	94.7	95.0
2003	95.0	97.0	96.0	97.0	95.8	**99.5**	96.3	92.5	91.0	90.9		
Monthly Maximum	102.6	102.7	103.3	104.4	100.5	99.5	100.4	99.8	100.0	97.0	100.6	101.9
Monthly Minimum	90.7	91.8	94.2	95.0	92.7	90.7	92.8	91.1	89.0	89.0	90.6	89.6
Monthly Average	94.8	96.4	97.5	97.9	95.3	94.2	94.8	93.7	93.0	92.0	92.8	93.6
Dry Season Maximum	104.4											
Wet Season Maximum	101.9											
Annual Maximum	104.4											

Source ACP - 2004

Precipitation

The mountainous topography leads to measured rainfall being dominated by orographic processes and rainfall amounts being quite variable across the Isthmus. In fact, the annual rainfall along the Atlantic coast is almost double of that experienced along the Pacific coast (average along Atlantic Coast = 305 cm/yr (120 in/yr), average along Pacific Coast = 152 cm/yr (60 in/yr)). ACP has a network of over 40 hydro-meteorological stations throughout the Canal watersheds, and these stations have been operating over a long period of time.

The precipitation associated with the region is typical of a humid tropical climate with an average annual precipitation of 2,032 millimeters (mm) or 80 inches. The precipitation for the recorded periods at Balboa, the nearest meteorological station, indicates that mid-December through April are the driest months with average monthly recorded precipitation of less than 81mm (3 inches) (January through April). Average monthly precipitation during this period varies from 20mm (0.8 inches) to 81mm (3.2 inches) with minimum and maximum monthly average precipitation ranging from 0 to 325mm (0 to 12.8 inches). During the Wet Season (May through mid-December) the average monthly precipitation ranges from 129 to 284mm (5.1 to 11.2 inches) with an minimum monthly average precipitation ranging from 5 to 152 mm (0.2 to 6.0 inches) and maximum monthly average precipitation ranging from 251 to 566mm (9.9 to 22.3 inches). The differences in rainfall between the Wet and Dry Seasons are considerable, with a great majority of the precipitation occurring during the Wet Season.

The variation of monthly instantaneous minimum and maximum precipitation for the Balboa station are presented in Table 5.

Relative Humidity

The monthly average relative humidity recorded for the Balboa station is presented in Table 6 and monthly average minimum and maximum relative humidity is presented in Table 7and Table 8, respectively. According to the recorded data, the monthly average relative humidity varies from 67.7 percent to 82.7 percent with an average annual value of 76.7 percent. The Dry Season has a monthly average relative humidity ranging from 67.7 to 72.2 percent.

Table 5: Balboa FAA Rainfall (inches) 1978-2003

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1978				6.9	8.5	8.1	4.3	7.1	8.2	11.7	12.4	7.7	
1979	0.0	0.8	0.2	4.6	8.4	4.9	2.0	8.7	5.1	11.7	6.1	5.9	58.40
1980	1.3	0.6	0.0	0.5	6.8	2.7	4.9	7.5	8.9	6.0	6.4	3.3	48.90
1981	0.1	0.3	1.3	**12.8**	16.5	7.4	11.1	9.3	9.5	8.8	8.2	8.4	93.70
1982	3.6	0.0	0.0	4.3	5.5	5.3	9.2	6.7	12.1	10.7	5.3	0.9	63.60
1983	0.0	0.0	0.0	1.8	10.1	5.7	5.9	10.9	7.9	13.8	6.5	3.6	66.20
1984	2.5	3.8	0.4	1.2	8.9	8.1	7.7	6.5	8.8	13.0	5.8	0.2	66.90
1985	0.7	0.0	0.5	0.0	5.7	10.6	4.9	3.9	12.0	8.6	6.4	5.8	59.10
1986	0.5	0.1	0.3	4.4	7.2	5.2	6.4	5.7	7.2	11.3	7.5	3.4	59.20
1987	0.0	0.6	0.2	5.3	7.7	6.6	9.3	6.0	5.8	14.6	9.6	2.5	68.20
1988	0.0	0.3	0.5	0.3	6.1	14.5	8.4	**14.8**	10.3	15.3	10.6	5.9	87.00
1989	2.6	0.2	0.5	0.0	2.7	3.3	4.0	10.5	5.8	9.4	**17.6**	6.4	63.00
1990	2.1	0.9	0.3	3.3	12.5	12.5	12.4	7.7	6.0	9.5	6.4	3.7	77.30
1991	1.9	0.0	0.4	3.0	15.3	10.1	11.7	4.7	14.8	9.9	10.1	1.7	83.60
1992	0.0	0.2	0.0	0.9	10.6	8.4	10.1	11.8	10.7	**17.0**	11.8	5.4	86.90
1993													
1993	2.7	0.0	**3.6**	3.0	**19.2**	8.1	**18.2**	8.5	11.5	6.8	10.0	4.6	96.20
1994	0.0	1.3	2.2	1.6	12.4	9.8	5.1	10.5	7.2	12.6	16.2	3.8	82.70
1995	0.0	0.0	2.5	3.2	15.5	**22.3**	12.0	8.5	**19.3**	15.8	6.2	7.9	**113.20**
1996	6.1	**3.9**	3.0	3.6	13.3	10.0	7.9	6.6	5.6	12.5	16.1	7.9	96.50
1997	**6.7**	0.6	0.0	0.0	5.7	8.5	5.3	5.8	14.2	14.1	13.7	0.4	75.00
1998	0.0	0.6	0.0	2.9	14.7	11.0	7.8	6.8	10.0	6.6	8.6	7.9	76.90
1999	1.7	0.7	3.4	2.7	8.8	9.5	6.5	5.2	6.8	8.0	13.2	**9.9**	76.40
2000	2.1	3.2	0.9	3.0	7.1	11.3	7.7	5.9	10.1	11.5	7.9	5.2	75.90
2001	0.7	0.0	0.0	2.0	8.0	10.0	4.7	2.8	10.5	8.8	9.5	9.3	66.30
2002	3.4	0.0	0.6	5.0	3.8	5.4	7.8	7.7	5.2	8.4	6.8	2.4	56.50
2003	0.0	0.9	0.3	6.1	7.0	12.6	8.5	6.6	7.2	14.2	8.3	7.8	
AVG	1.5	0.8	0.8	3.2	9.5	8.9	7.8	7.6	9.3	11.2	9.5	5.1	74.9
MAX	6.7	3.9	3.6	12.8	19.2	22.3	18.2	14.8	19.3	17.0	17.6	9.9	113.2
MIN	0.0	0.0	0.0	0.0	2.7	2.7	2.0	2.8	5.1	6.0	5.3	0.2	48.9

Source: ACP 2004

Table 6: Balboa FAA Monthly Average Relative Humidity (%)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Ave
1990	69.2	69.2	67.5	68.4	79.9	80.5	79.5	79.1	79.3	80.4	78.5	73.5	75.4
1991	65.8	**58.4**	**57.2**	**56.5**	**61.8**	**64.8**	75.7	80.3	79.4	77.5	77.6	**69.9**	**68.7**
1992	**64.0**	61.6	61.5	62.1	70.5	74.3	**68.8**	74.0	74.0	**67.9**	81.9	76.7	69.8
1993	73.8	64.8	65.9	70.4	76.3	77.7	76.4	75.9	75.9	82.3	81.3	75.7	74.7
1994	68.9	65.0	65.3	66.0	75.7	77.1	75.6	78.4	77.5	77.3	77.0	70.9	72.9
1995	66.4	61.6	64.8	79.0	83.1	81.4	85.1	86.1	84.7	85.4	86.0	83.7	78.9
1996	80.2	75.2	72.8	74.2	83.7	85.3	83.6	84.0	84.9	84.1	83.2	80.0	80.9
1997	75.3	72.3	66.1	69.3	77.3	83.5	82.5	82.7	85.2	85.2	85.4	75.9	78.4
1998	70.5	70.2	64.9	70.9	81.1	84.6	84.3	84.7	82.5	82.8	84.3	85.4	78.9
1999	76.2	70.7	69.9	75.3	82.2	84.2	83.0	84.1	82.5	82.9	83.3	82.7	79.8
2000	73.7	68.8	65.4	69.8	80.4	83.0	81.8	88.8	90.0	90.0	88.9	87.3	80.7
2001	81.3	77.2	77.9	76.8	84.7	87.3	87.8	87.7	89.6	89.7	89.4	**89.0**	84.9
2002	**84.1**	**79.2**	78.3	**81.5**	81.3	84.2	88.4	89.0	90.0	90.5	**90.1**	86.1	**85.2**
2003	80.7	78.4	**79.6**	80.3	**89.7**	**91.8**	**90.4**	**90.8**	**90.9**	**92.8**			
Monthly Maximum	84.1	79.2	79.6	81.5	89.7	91.8	90.4	90.8	90.9	92.8	90.1	89.0	85.2
Monthly Minimum	64.0	58.4	57.2	56.5	61.8	64.8	68.8	72.8	72.4	67.9	76.8	69.9	68.7
Monthly Average	72.2	68.3	67.7	70.4	78.3	81.0	81.1	81.9	81.7	82.7	82.3	78.4	76.7
Dry Season Ave.	69.7												
Wet Season Average	81.0												
Annual Average	77.2												

Source ACP 2004

Table 7: Balboa FAA Monthly Average Minimum Relative Humidity (%)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Average
1990	52.6	46.1	45.9	47.6	66.1	67.3	64.8	64.8	64.8	69.2	65.9	57.8	59.4
1991	48.8	41.9	41.8	**42.0**	**54.0**	**55.4**	62.2	65.5	65.3	62.9	63.0	**52.1**	54.6
1992	43.6	40.8	40.9	44.3	55.6	61.6	**54.8**	60.9	66.5	**58.8**	71.7	59.7	54.9
1993	59.3	44.0	46.3	54.0	65.7	65.1	64.9	65.3	66.9	70.3	68.8	60.7	60.9
1994	49.6	45.8	46.8	48.9	68.8	70.9	67.7	70.6	70.6	69.1	70.4	57.7	61.4
1995	49.9	42.5	51.3	63.2	70.8	71.1	73.3	73.7	74.4	76.4	74.9	70.0	66.0
1996	64.9	58.7	55.6	57.0	**72.6**	**74.3**	73.0	72.2	74.3	75.0	74.5	68.0	68.3
1997	59.9	56.8	45.8	52.3	62.9	72.1	70.4	70.1	74.0	74.0	75.1	59.0	64.4
1998	50.7	51.2	44.7	52.4	68.8	73.0	72.4	73.9	72.7	74.0	72.1	71.7	64.8
1999	57.7	52.1	49.6	58.9	69.5	73.2	71.5	73.9	73.8	74.6	71.9	71.9	66.6
2000	56.4	50.4	45.5	52.6	69.8	73.7	72.1	**76.7**	**79.7**	77.3	74.8	72.6	66.8
2001	52.9	51.8	50.3	47.8	55.3	64.7	74.9	75.6	79.4	**79.5**	**79.0**	**77.8**	65.8
2002	**69.1**	**60.6**	**59.7**	**63.5**	67.1	70.8	**75.1**	75.1	78.4	78.7	77.4	72.3	70.7
Monthly Maximum	69.1	60.6	59.7	63.5	72.6	74.3	75.1	76.7	79.7	79.5	79.0	77.8	72.3
Monthly Minimum	40.4	40.6	39.9	42.0	54.0	55.4	54.8	58.8	58.2	58.8	61.7	52.1	51.4
Monthly Average	52.7	48.0	46.8	51.1	63.7	67.9	67.8	68.8	69.9	70.7	70.0	63.2	61.7
Dry Season Avg Min	49.7												
Wet Season Avg Min	67.8												
Annual Average Min	61.7												

Source: ACP 2004

Table 8: Balboa FAA Average Maximum Monthly Relative Humidity (%)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Average
1990	81.0	87.5	83.5	83.9	88.2	88.0	87.6	86.5	86.9	87.5	86.6	83.7	85.9
1991	**77.6**	**71.4**	**69.7**	**67.7**	**67.2**	**71.2**	83.5	88.4	86.7	85.4	84.9	**81.4**	77.9
1992	78.2	77.7	79.1	75.6	80.0	82.7	**77.5**	81.8	**79.5**	**73.3**	87.8	88.0	80.1
1993	84.6	81.1	79.9	81.8	83.3	83.9	83.3	82.5	81.7	89.4	88.7	85.6	83.8
1994	81.9	79.7	79.8	79.8	82.9	83.9	83.1	85.7	84.7	85.7	**84.7**	84.5	83.0
1995	81.1	78.0	77.8	91.7	91.7	89.1	93.1	95.3	92.8	92.8	93.1	92.5	89.1
1996	91.7	88.2	86.6	87.2	91.7	92.1	91.1	91.9	93.3	92.1	88.9	88.7	90.3
1997	87.0	84.8	82.9	83.5	87.7	92.9	91.5	92.8	94.0	94.2	94.0	88.9	89.5
1998	85.0	84.9	80.7	85.8	91.5	93.4	92.5	93.2	92.1	90.1	93.4	91.5	89.5
1999	88.4	83.8	84.1	86.4	90.3	90.7	89.7	90.4	89.3	89.8	89.8	89.1	88.5
2000	85.2	82.4	81.5	83.1	87.7	89.5	88.6	96.2	**97.0**	96.6	96.9	**96.1**	90.1
2001	94.1	90.3	91.5	89.6	93.7	**95.6**	95.0	95.1	96.2	96.2	95.3	96.0	94.1
2002	**94.8**	**92.0**	91.8	**94.0**	91.7	93.5	**96.9**	**98.1**		98.0	**97.6**	94.8	94.8
2003	91.2	85.6	91.0	90.7	**95.0**	94.7	95.7	93.8	96.0	**99.6**			93.3
Monthly Maximum	94.8	92.0	93.2	94.0	95.0	95.6	96.9	98.1	97.0	99.6	97.6	96.1	95.8
Monthly Minimum	77.6	71.4	69.7	67.7	67.2	71.2	77.5	81.3	79.5	73.3	84.7	81.4	75.2
Monthly Average	85.3	82.7	83.1	83.9	87.2	88.6	89.0	89.8	89.0	90.2	90.0	88.6	87.3
Dry Season Avg Max	83.8												
Wet Season Avg Max	89.0												
Annual Avg Max	87.3												

Source: ACP 2004

The minimum monthly average relative humidity for the recorded period is 46.8 percent and varies from a monthly minimum of 46.8 percent to a monthly maximum of 70.7 percent. The maximum monthly average relative humidity is 90 percent and varies from a monthly minimum of 82.7 percent to a monthly maximum of 90.2 percent. The relative humidity for Wet Season minimum average ranges from 63.2 to 70.7 percent.

Predominant Wind

Wind data obtained from the ACP for Balboa station are presented in Table 9 through Table 11. The data presented includes a summary of average monthly wind speed, monthly maximum wind speed and direction from the years 1985 to 2003. According to the data reviewed, the monthly average wind speed during the recorded years is 6.2 kilometer per hour (km/h) or 3.9 miles per hour (mph) with a monthly minimum and maximum average of 4.5 and 8.2 km/hr (2.8 and 5.1 mph), respectively. The monthly average wind speed during the Dry Season is 8.2 km/hr (5.3 mph) and during the Wet Season is 5.9 km/hr (3.7 mph). The annual maximum instantaneous wind speed is 81.9 km/hr (50.9 mph) with a variation of 49 to 81.9 (30.5 to 50.9 mph) between the Dry season and Wet Season monthly maximum instantaneous wind speed.

The average wind direction during the Dry Season is 339.6 degrees (originating from the northwest) and 300.7 degrees during the Wet Season (originating from the northwest). The overall annual monthly average wind direction is 319 degrees (originating from the north-northwest).

Table 9: Balboa FAA monthly Average Wind Speeds (mph)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1990	4.6	5.7	6.2	5.8	4.2	4.1	3.7	3.5	3.6	3.3	3.6	3.6
1991	5.3	6.5	5.8	4.9	4.2	3.5	3.9	3.9	3.4	3.2	4.1	3.6
1992	5.8	5.9	**6.7**	5.8	**5.4**	3.8	3.9	4.5	3.7	3.7	3.2	3.4
1993	4.7	5.7	5.7	5.0	4.2	3.5	4.0	3.8	3.2	3.2	3.8	4.3
1994	5.2	5.7	5.3	4.9	3.6	3.7	4.1	3.3	3.7	**2.5**	3.6	3.5
1995	4.8	5.2	4.8	**3.2**	2.8	2.9	2.9	2.9	2.9	3.2	**2.7**	**2.8**
1996	**3.1**	**3.8**	**4.2**	3.6	**2.1**	**2.5**	**2.6**	**2.7**	**2.5**	3.4	4.1	3.3
1997	4.0	4.1	5.2	5.2	4.4	3.5	4.0	4.3	3.4	3.0	3.4	5.1
1998	5.5	4.8	5.8	4.8	3.9	3.4	3.6	3.6	3.5	4.0	2.9	2.9
1999	3.2	4.6	4.8	4.3	3.4	3.3	4.0	3.5	3.7	3.7	3.8	4.1
2000	3.8	4.2	4.2	4.6	3.9	3.5	3.9	3.7	3.4	**4.1**	3.3	4.3
2001	5.4	6.6	6.1	5.7	4.5	3.4	3.9	4.1	3.3	3.3	4.3	4.1
2002	5.0	5.9	6.0	4.3	5.0	4.1	3.6	4.0	3.0	3.3	3.4	4.5
2003	6.6	6.1	5.6	5.1	3.8	3.6	3.4	4.3	3.2	3.0		
Monthly Maximum	6.7	6.8	6.7	6.0	5.4	4.4	5.2	4.6	4.3	4.1	4.4	5.1
Monthly Minimum	3.1	3.8	4.2	3.2	2.1	2.5	2.6	2.7	2.5	2.5	2.7	2.8
Monthly Average	4.9	5.4	5.5	5.0	4.0	3.5	3.9	3.7	3.5	3.5	3.7	3.9
Dry Season Ave.	5.3											
Wet Season Ave.	3.7											
Annual Average	4.2											

Note: These values are the maximum wind speed for a 20 second period during the month

Source ACP 2004

Table 10: Balboa FAA monthly Maximum Wind Speeds (mph)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1990	25.0	24.6	30.8	27.9	**33.2**	**50.9**	36.6	23.9	24.6	21.9	21.9	23.5
1991	24.8	34.3	27.2	29.4	23.9	24.8	34.3	25.2	24.6	24.8	21.0	21.2
1992	26.8	27.4	27.7	25.4	27.0	31.4	27.2	32.3	28.5	**38.3**	**33.0**	**20.6**
1993	25.9	26.5	28.3	24.8	23.7	29.9	28.1	25.2	**35.6**	21.0	25.2	24.3
1994	25.2	28.1	**33.4**	28.3	24.1	25.9	23.0	22.1	24.1	23.2	25.0	23.5
1995	28.3	26.8	29.6	**23.0**	29.0	25.0	26.5	30.3	27.9	29.0	23.7	21.7
1996	25.0	23.7	30.8	23.9	21.2	21.7	23.7	21.5	**19.7**	23.2	23.9	21.2
1997	**22.3**	**23.0**	26.3	25.0	22.8	26.5	29.0	30.1	29.4	20.8	24.3	**28.1**
1998	27.0	25.2	30.1	**30.5**	24.8	30.1	23.2	25.9	22.1	27.7	23.5	23.0
1999	23.5	25.0	24.8	24.6	**21.0**	22.3	23.2	21.5	21.7	26.3	21.5	27.2
2000	**33.4**	25.2	25.0	26.5	27.0	21.9	25.4	33.3	28.1	23.1	25.1	24.8
2001	24.3	25.9	25.5	24.5	24.0	30.5	22.3	28.9	29.4	22.3	22.1	24.4
2002	22.8	25.4	**24.5**	28.4	21.9	26.9	21.1	25.0	20.1	21.9	30.8	25.7
2003	23.8	28.3	25.7	26.8	25.7	22.0	**18.7**	25.3	34.1	21.2		
Monthly Maximum	33.4	35.2	33.4	30.5	33.2	50.9	42.3	46.0	35.6	38.3	33.0	28.1
Monthly Minimum	22.3	23.0	24.5	23.0	21.0	21.1	18.7	20.4	19.7	19.5	20.1	20.6
Monthly Average	25.7	27.1	28.5	26.5	25.0	27.4	26.5	27.2	25.8	24.2	24.4	24.1
Dry Season Max.	35.2											
Wet Season Max.	50.9											
Annual Maximum	50.9											

Note: These values are the maximum wind speed for a 20 second period during the month.

Source: ACP 2004

Table 11: Balboa FAA Monthly Average Wind Direction (degrees)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	WD AVG
1990	354.6	343.6	343.4	338.7	293.1	311.0	304.4	301.1	305.6	218.8	298.7	336.1	**316.36**
1991	335.2	351.8	340.8	339.7	270.6	318.0	308.9	305.0	295.6	275.0	308.7	348.1	**318.96**
1992	336.2	336.8	345.5	334.6	316.2	305.0	313.9	318.5	269.7	297.8	285.5	323.9	**317.91**
1993	324.7	337.1	330.7	318.8	227.5	294.4	303.6	300.1	259.0	274.0	297.1	320.7	**302.38**
1994	327.9	337.1	333.1	339.8	274.6	302.4	302.1	295.6	278.5	204.8	259.4	332.9	**305.80**
1995	337.1	342.5	339.5	299.5	289.5	194.0	284.9	180.3	188.4	185.6	303.2	316.7	**284.64**
1996	331.9	346.1	342.4	329.2	202.7	297.0	301.2	337.2	279.0	216.3	278.3	335.1	**306.51**
1997	336.9	344.2	349.7	341.8	334.2	287.6	325.3	326.6	316.5	285.4	288.3	337.5	**325.56**
1998	341.5	336.8	346.8	335.4	328.7	307.5	314.8	309.9	219.8	206.7	308.5	327.7	**314.45**
1999	357.5	354.4	351.4	338.4	315.8	300.7	320.8	299.7	193.6	194.5	316.2	327.4	**316.50**
2000	351.8	353.4	354.7	354.5	321.3	302.9	311.6	299.0	184.5	301.7	296.3	313.0	**318.17**
2001	328.6	332.9	325.6	336.0	295.9	296.3	298.3	302.8	267.9	267.8	303.8	319.1	**309.00**
2002	340.3	352.2	348.6	346.7	292.7	256.6	319.8	313.1	239.3	287.9	323.3	331.3	**316.79**
2003	355.0	347.9	352.6	337.4	317.4	191.4	311.8	284.1	190.5	174.2			
Monthly	336.4	340.1	343.5	338.0	303.0	292.4	311.4	310.5	260.4	256.8	300.8	327.7	
Dry Season Ave.	339.6												
Wet Season Ave.	300.7												
Annual Average	319.4												

Source: ACP 2004

Topography

Depending on the source of materials used for the construction of the island, it may be necessary to establish a haul corridor from the Miraflores areas to the project site.

The topography on the west side of the Canal from Miraflores locks to the Terminal site at Palo Seco vary from low lying areas close to the west side of the Canal to marshes and wetlands near Diablo Heights and associated with the watershed of Rio Farfan. The areas directly west of Miraflores lock have been severely modified from excavations associated with work done for the locks and connecting waterways. The topography from the road located west of the Canal leading to Miraflores locks is relatively flat with slopes extending from the roadway to the Canal having grades ranging between 0 and 20% and elevations ranging between 20 and 40 meters. The actual alignment of an access road/rail near Miraflores from the proposed terminal will be a function of the final orientation of the new Locks, approach channels and water saving basins.

The shoreline consists of coastal mud flats to rocky outcrops that extend from the proposed terminal to north to the Miraflores locks. The waterfront along the proposed corridor is relatively shallow with numerous rock outcrops that are covered with soft silt varying in thickness from 0 to 2 m (ACP-Golder, January 2003). The shoreline along the study segment is covered with extensive tree cover and vegetation to the waters edge. Several coves of sandy beaches are present along the Palo Seco shoreline. South of the proposed terminal, within an area of influence of the project, a resort is under construction at Kobbe Beach.

Immediately west of shoreline and low lying areas, several hills are along the corridor including Farfan Hill located north of the Terminal site and un-named hills located just north of the hospice/rest home. Elevations in the terrestrial portion of the project vary from 20 to 100m with slopes ranging from 10 to 20 degrees in the steepest areas according to the 1:50,000 topographic Sheet 4242 I, Panama.

Geology and Soil Conditions

The predominant geology of the project area from Miraflores to Farfan/Palo Seco area is best defined by geologic plans and profiles prepared by ACP in the area of the excavation of the proposed third locks. The geology and subsurface information for portions of the proposed corridor in the Farfan/Palo Seco area will require further studies during subsequent detailed studies of the project.

The overburden over most of the area of the proposed third locks consist of weathered rock and residual soil, and/or fill material derived from previous canal excavation. The thickness of the overburden soils in borings drilled for the third locks project indicates

that overburden ranges from 0 to 52 meters. The borings indicate that these soils are variable in their particle size, consistency, moisture content, plasticity and strength.

The borings logs indicate that the fill material consist primarily of hard basalt boulders with thickness of 3 to 12 meters.

The soils underlying the overburden soils consist of rock formation such as Basaltos, Pedro Miguel Formation, La Boca Formation, Cucaracha Formation and Culebra Formation.

The Basaltos Formation consist of sound, strong to very strong basalt with an average strength of 70 Mpa from point load test performed by ACP. This formation has typical spacing of joints from moderately close to close (0.06 to 0.6 meters).

Sound agglomerate that makes up the Pedro Miguel Formation encountered in excavations indicates that this formation is medium strong to strong and its durability varies. Average strength of 30 Mpa was determined from point loads tests performed by ACP.

La Boca Formation is comprised of interbedded sandstone, siltstone, conglomerate and tuffaceous beds of varying thickness. The Cucaracha Formation is comprised mainly of shale with local sandstone or conglomerate layers. The sedimentary rocks are typically soft to medium soft and of weak to moderate strength.

Soils

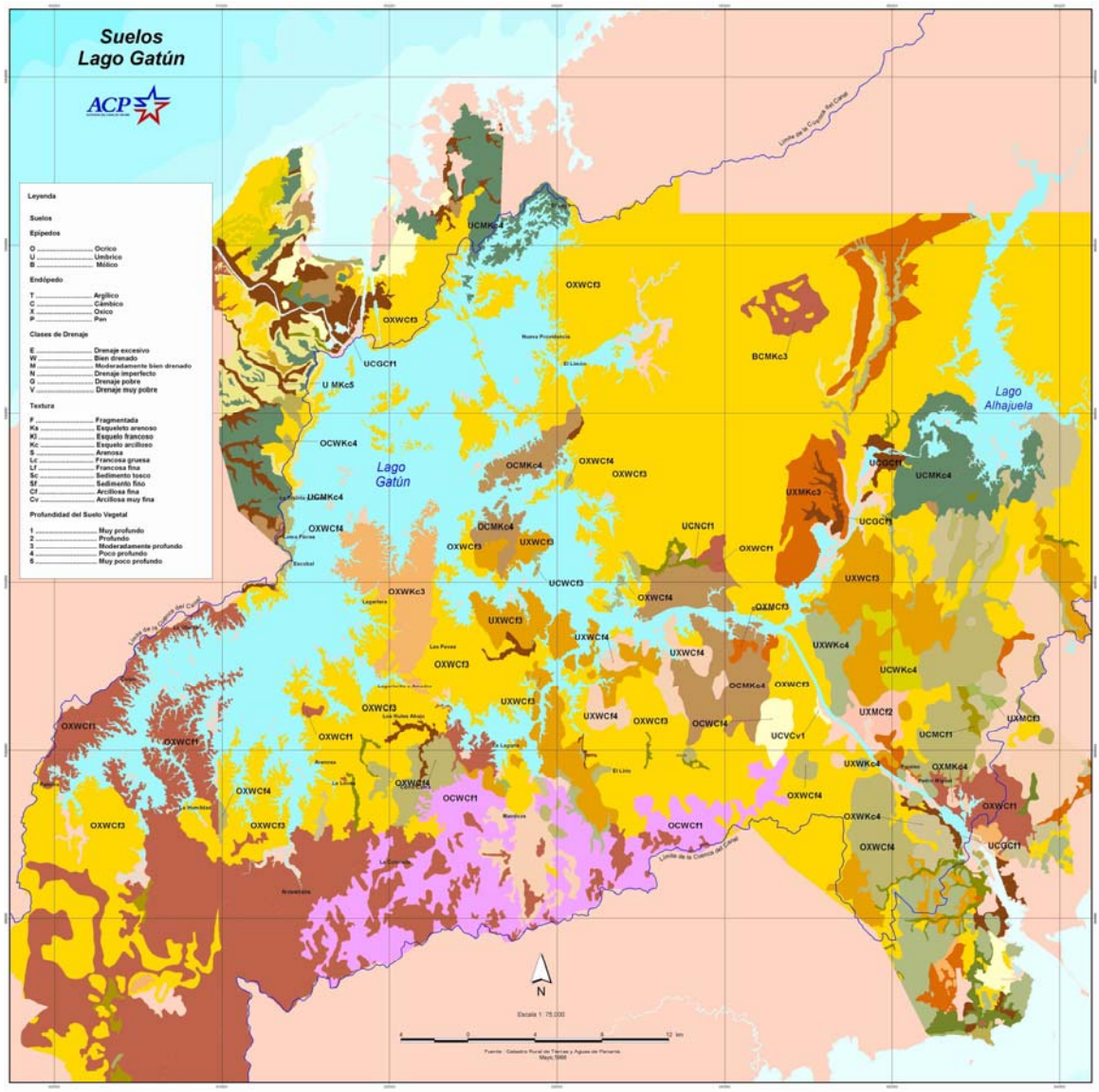
The soils encountered in the area of the project are typical of the soil conditions found in tropical regions that have humid climates and the high temperatures through the year. As reported in the PMCC report, the Catastro Rural de Tierras y Aguas de Panamá (CATAPAN, 1970) made the first complete inventory of the agricultural soils of Panamá. This survey of soils was only partially characterized using the taxonomic system for soil classification of the United States Department of Agriculture (Soil Survey). Most of the soils reported are classifieds as oxisols. Oxisols are very highly weathered soils that contain few weatherable minerals and are characterized by extremely low native fertility, resulting from low nutrient reserves, high phosphorous retention by oxide mineral, and low cation exchange capacity. Nutrients in Oxisol ecosystems are contained in the standing vegetation and decomposing plant material. These soils can be productive if appropriate amounts of fertilizers are applied. Within the Canal System some poorly drained inceptisols soils are encountered mainly in the alluvial plains of the watershed. Figure 7-3 presents a map of the soil conditions in the watershed that further characterizes the soils by horizons, texture, drainage, and vegetation.

The oxisols soils are characterized by a red coloration that ranges from yellowish-red to brownish-red and dark brown. Oxisols consist of clayey soils, encountered moderately deep to deep without well-defined horizons. These soils are classifies as having a relatively good permeability, internal drainage, and a granular structure with low organic matter content. These soils are moderate to strongly acidic with relatively low levels of exchangeable bases and other nutrients such as phosphorus.

The inceptisols encountered in the watershed originated from the alluvial deposits, under poor to moderate drainage, allowing the accumulation of silica and exchangeable bases in their framework. Inceptisols are soils that exhibit minimal horizon development. These soils are widely distributed and occur under a wide range of ecological settings. They are often found on fairly steep slopes, young geomorphic surfaces and resistant parent materials. Inceptisols are found in mountainous areas and are used for forestry, recreation and watershed. The natural fertility of inceptisols is better than the oxisols, because of the poor drainage characteristic their agricultural use is restricted and is generally prone to periodic flooding (NRCS 1993; ARI 1996, PMCC, 1999).

The ultisols are classified as acidic forest soils found in humid regions that have been exposed to intense leaching. These soils are typically older and found in stable landscapes under forests but also grasslands. Ultisols have a subsurface horizon in which clays accumulate. They are often with yellowish or reddish colors resulting from Ferrous oxides. Due to their favorable environment in which they are found, ultisols often support productive forest and are poorly suited for continuous agricultural production. The application of fertilizers can result in productive applications.

Figure 2: Panama Canal Watershed Soil Conditions



Hydrology

The proposed access to Miraflores from the terminal will cross several rivers

As reported in the Pacific Side Excavation Study, the riverine systems crossed by the proposed rail and access roads were defined using Strahler's river order to define the size and the importance of the river. Streams classified using Strahler's ordering system is based on the number of tributaries upstream (i.e., a first order stream has no tributaries, a second-order stream has first-order tributaries, and a third-order stream has first- and second-order tributaries).

The terrestrial access road and rail cross the following rivers:

- Quebrada Victoria
- Rio Velasquez
- Rio Matutela
- Rio Farfan

These rivers have been a stream order of 1 or 2 and were further evaluated in previous studies for physical habitat quality of the streams using a ranking system to evaluate the freshwater courses. A criterion of 20 points was assigned for each of the 11 criteria. The scores were evaluated using and quality ranges of poor (score 0-63); sub-optimal (64-126) and optimal (127-190) were utilized. Data presented indicates that the Rio Velazquez has a sub-optimal quality with a reported score of 118. Farfan River is a stream order 2 that runs through the former Howard Naval Base where it joints other secondary courses, forming a floodplain. The water quality of the Farfan River is characterized in the Disposal Study as brackish and high values of salinity and conductivity associated with a saline system and therefore was not characterized using the physical habitat quality criteria. The Farfan River has been modified by the diversion of artificial channels from the main stream which results in river drying up during the summer. The northern are of the river mouth is characterized by the presence of salt marshes, mangroves and important habitat for waterfowl.

No data was available on the quality of the Quebrada Victoria and Matutela Rivers. However, based on the connection between Matutela and Farfan rivers, it is anticipated that Matutela Rivers is also a saline system. The Dejal River although located south of any proposed access corridor is also identified as a saline river located south of the proposed.

Natural Hazards

The Republic of Panamá is located on a relatively rigid block of the Earth's crust, at the southern end of the Central American volcanic arc. This volcanic arc, which is still active, started about 70 to 50 million years ago, although the present configuration is probably less than about 25 million years old.

The present-day tectonic setting of Panamá is dominated by ongoing under thrusting of the Nazca and Caribbean tectonic plates beneath the Pacific and Caribbean coasts, respectively. Plate under thrusting generates moderate to large earthquakes in offshore regions to the north and south of Panamá. Some of the largest earthquakes in Panamá's history, including the September 1882 earthquake that resulted in 68 deaths from an earthquake-related tsunami, have occurred in offshore regions.

Recent studies by Cowan (2001) and U.S. Geological Survey (Petersen et. al., 2003) have identified the principal sources of large earthquakes of significance to the Panamá Canal system, including Lake Gatún. The studies provide comprehensive summaries of historical earthquakes, major active faults onshore and offshore of the Panamá Canal area. Quantification of these sources and application of earthquake ground motion attenuation relations have been used to develop a probabilistic seismic hazard assessment for six sites along the Panamá Canal, including Gatún Dam. Earthquake shaking of about 0.15g is estimated to have a return period at Gatún Dam of about 500 years. This level of earthquake shaking indicates that the Lake Gatún area has a moderate level of earthquake hazard.

Marine Environment

The Gulf of Panama lies within the Equatorial Low Pressure Trough, a low atmospheric pressure and is affected by the Intertropical Convergence Zone (ITCZ). The ITCZ is formed by the trade winds that converge to this area from both hemispheres. (D'Croz, 1998). Weak variable winds, cloud masses and intense rainfall are associated with the ITCZ which depending on its position over the Isthmus and as influenced by winds results in producing the rainy season.

The Pacific entrance to the Panama Canal lies at the north end of the Gulf of Panama which encompasses and area of 34,000 square kilometers (200 km wide in an East-West direction and 170 km long in a North-South direction). The Gulf of Panama includes two sets of natural islands: Taboga and Taboguilla, and the Archipelago de Las Perlas located 20 km south and 90 km southeast of Panama City.

Wave Climate. A preliminary evaluation of the environmental conditions that may impact the proposed terminal site were evaluated for the Feasibility Study of Island

Development. The evaluation considered offshore waves, winds and extreme wave conditions. Oceanweather's GROW (Global Reanalysis of Ocean Waves) for a period of 31 years (1970-2000) was utilized. The GROW model provides global wind and wave hindcast at grid points throughout the world. A grid point located at 6.875º Latitude and 280.0º Longitude which captures the wave climates that are predominantly expected to impact the site was used in the previous modeling effort.

The configuration of the entrance to Panama Bay restricts the wave energy that can reach the Gulf by the actual shape of the gulf and the surrounding geography of South America with the west coast of Ecuador providing a natural blockade of large swells that originate from Antarctic. A window extending from south to west-southwest (180º to 247.5º) is considered the zone where any significant energy can enter the Gulf of Panama. The configuration of the Gulf also restricts the area from offshore waves. The waves generated at the site are result of local winds, resulting in shorter and limited height and energy.

Based on the analysis of data conducted during previous studies, the most significant wave heights vary between 0.5 and 2.5 meters. The predominant waves are around 1.0 to 1.25 m for the months of December to April and 1.5 to 1.75 meters for July through November.

Thee majority of waves that arrive at the entrance to the Gulf of Panama are from 200 to 250 degrees with little seasonable variation in the direction. The offshore hind cast wind field is slightly shifted from the wave direction, since the wind field is not constrained by the land masses as the waves.

Tides. Tides in Panama Bay are semi-diurnal with two high waters and two low waters per day with a period of about 12.25 hours. The tidal ranges for stations within the Gulf of Panama as obtained from the British Admiralty Tide Tables indicate that the overall tidal range is about 4 to 5 meters. The tidal station at Balboa indicates a Mean High Water Spring (MHWS) of 4.8 m and a Mean Low Waters Spring (MLWS) of 0.2 meters.

Currents. The currents generated in the Gulf of Panama by are attributed by tidal, oceanic and wind. The tidal influences result in a northern current during the filling of the bay and a southern direction during the empting of the bay during. The magnitude of the tidal currents varies with the highest values during the spring tide and the lowest during the neap tide.

The oceanic currents in the eastern tropical Pacific Ocean including the Isthmus of Panama and extending westward from the coast of Panama, Colombia and Ecuador are very complex and are subject to the oceanic conditions related to the to changes in the

Intertropical convergence and the interannual effect of El Nino Southern Oscillation (Rodriguez-Rubio, Schneider, 2003).

The main currents affecting the Gulf of Panama include two distinct season patterns. During the summer, the circulation in the Gulf of Panama is anticyclonic (clockwise), with a coastal current to the south. The circulation reverses and is cyclonic (contraclockwise) with coastal currents to the north.

The net current in the Gulf of Panama as presented in the Atlas of Pilot Charts indicates that the net current is highest during the months of April, May and June. The net average flow throughout the year at the northern end of the Bay is in the order of 0.3-0.5 knots (0.15-0.26 m/s).

The mechanism associated with the generation of currents from wind involves the kinetic energy transferred from the wind to the surface water as a result of fiction between the two. This kinetic action to the ocean surface layer of water generates both waves and currents. Previous studies at Panama Bay have concluded that the local wind contributes a very small impact on the magnitude and the pattern of currents at the north end of the Panama Bay (Delft Hydraulics, 1999).

Coastal upwelling in the Gulf is induced by offshore displacement of surface water by northerly winds during the dry season. The winds displaces the surface water allowing the rise of deeper cooler waters to the surface which result in the seawater temperature decreasing down to 18 ºC from 28ºC during the rainy season (D'Croz, 1998).

Bathymetry.

The bathymetry of the marine area of study was obtained from nautical charts presented in the Island Feasibility study from the Admiralty Chart 1929 entitled "Gulf of Panama" and Chart 1401 and later surveys undertaken by ACP. The bathymetry for the Gulf of Panama for the study region was digitized from the above data and recently completed hydrographic survey. Mean Low Water Springs (MLWS) was used as the vertical datum.

Marine Physical-Chemical Parameters

The water of the Gulf of Panama are influenced by the season changes in climatic conditions as well as man-induced alterations associated with organic loading from domestic pollution of untreated waste waters disposed into the sea. The upwelling as previously described which result in its low temperature during the dry season, high salinity and high concentrations of nutrients. During the rainy season, run-off and drainage from rivers and streams produce an increase in sweater temperature, reduction in salinity and elevation of nitrates and silicates (Kwiecinski & D'Croz, 1994).

The domestic waste that is disposed of in the Bay of Panama has led to reduced levels of dissolved oxygen, high coliform counts in certain areas of the Bay. At the entrance of

the canal, high levels of biochemical oxygen demand (BOD) are present which reduce the levels of dissolved oxygen.

Marine sampling program conducted during the Pacific Side Excavation Study during tow sampling events during daytime in 2002 and the second event between February and March 2003. The samples collected locations east of Amador Causeway in the Bay of Panama, at the end of the Causeway, at a proposed artificial island and locations located approximately 8 km offshore. The results of the sampling event indicated that the temperature during the day at all these stations varied from 24.4ºC at the Causeway to 25.05ºC at the Fishing Site (offshore location). Suspended solids and the highest level of salinity were measured at the offshore site (fishing site) at 34.06 mg/l of suspended solids and 35.1 0/00 salinity. Salinity for all samples analyzed during this first event ranged from 33.89 to 35.1 and suspended solids varied from 33.01 to 34.06.

The second sampling event consisted of diurnal and nocturnal measurements of temperature, salinity and suspended solids. The daytime surface temperatures reported Island Feasibility Study ranged form 25.1 ºC to 27.9 ºC over the entire study area. The nighttime temperature varied from 24 to 25 ºC. Turbidity ranged from 10.2 NTU during the day to 2 NTU at night at the offshore Fishing Site. Oxygen levels ranged from 5.2 to 8.5 mg/l with the highest recorded levels encountered at the offshore site. Salinity records ranged from 31 during the day to 37 o/00 at night.

Environmental Quality

This section describes a variety of studies that have been conducted to evaluate and describe the existing or baseline conditions of the environment that may be affected by this Project. The evaluation of the existing conditions in the study area focused primarily on atmospheric, noise levels, soil, water, and lake sediment baseline conditions. The study area encompasses the Gatún Lake Watershed including the various hydraulic structures that control and manage the water used in the operation of the Panamá Canal. The environmental conditions reported in this section have been obtained through a review of literature and monitoring information provided by the ACP.

Air Quality

The Gatún Lake system is located in an environmental setting that consists of protected areas with agricultural land use with low density occupancy west and south of the Lake and low to moderate density populated areas with light industrial and commercial establishments within the Chagres National Park and along the Trans-Isthmian highway. The existing air quality at the study site is considered representative of an area where

the major source of air pollution is predominantly associated with a major highway and air borne particulate matter resulting from seasonal burning of grass fires and other outdoor burning which is common throughout the country. During the dry season, stronger winds and low moisture conditions disperse ashes, smoke and dust over considerable distances.

Air quality associated with the operations and improvements; transiting ships and other transportation sources at the Canal are small in relation to the overall air quality and have not meaningfully changed for many years (Panamá Canal Gaillard Cut Widening Feasibility study, 1987).

Ambient Air Quality Regulations

For the evaluation of ambient air quality, data obtained from the ACP were compared to the World Bank (General Environmental Guidelines-Pollution and Prevention and Abatement Handbook, 1998) in Table 12.

Table 12: World Bank Guidelines for Ambient Air Quality

Pollutants	Amount	Units	Averaging Period	Air Quality Airshed Classification
Sulfur Dioxide	80	$\mu g/m^3$	Annual Average	Moderately degraded
	150	$\mu g/m^3$	24-hour; 98th percentile	
Particulate Matter [as total suspended particulate (TSP)]	80	$\mu g/m^3$	Annual Average	Moderately degraded
	300	$\mu g/m^3$	24-hour; 98th percentile	
Particulate Matter (as PM_{10})	50	$\mu g/m^3$	Annual Average	Moderately degraded
	150	$\mu g/m^3$	24-hour; 98th percentile	
Nitrogen Dioxide	100	$\mu g/m^3$	Annual Average	Moderately degraded
	150	$\mu g/m^3$	24-hour; 98th percentile	

Note: $\mu g/m^3$ = micrograms per cubic meter.

Ambient Air Quality Results

Air quality monitoring conducted by ACP in stations within the Canal indicate that the air quality for suspended solids, sulfur dioxide, and nitrogen oxides from a period of 1977 to 1979 (This information needs to be updated) at ambient air monitoring stations located at Miraflores, Pedro Miguel, Balboa and Alhajuela. The results of the average high air quality data are summarized in Table 13

Table 13: Maximum Average Annual Air Quality Data, Panamá Canal, ug/m^3

Sampling Station	Suspended Solids			Sulfur Dioxide			Nitrogen Oxides		
	1977	1978	1979	1977	1978	1979	1977	1978	1979
Miraflores	38.98	33.60	37.50	12.67	11.49	10.21	21.33	23.08	20.16
Pedro Miguel	44.99	35.87	40.72	7.57	13.69	11.80	27.30	29.11	30.55
Balboa	56.08	48.40	51.24	12.69	19.53	14.21	49.11	45.87	46.32
Alhajuela	55.81	49.31	50.82	5.80	11.42	8.00	16.14	17.75	15.71

Source: Panamá Canal Gaillard Cut Widening Feasibility study, 1987.

The results of the baseline air quality monitoring data are discussed below and compared with ambient air quality standards.

Suspended Solids (PM)

As shown on Table 13, the maximum annual concentration recorded at all 4 monitoring locations ranged from 33.60 ug/m3 (Miraflores, 1978) to 56.08 ug/m3 (Balboa, 1977). The maximum average annual concentration ranges from 41.3 to 70 percent of the World Bank Guideline for PM of 80 ug/m3.

Sulfur Dioxide

The maximum annual concentration recorded at all 4 monitoring locations for sulfur dioxide ranged from 7.57 ug/m3 (Pedro Miguel, 1977) to 19.53 ug/m3 (Balboa, 1978). The maximum average annual concentration ranges from 9.5 to 24.4 percent of the World Bank Guideline for sulfur dioxide of 80 ug/m3.

Nitrogen Oxides

The maximum annual concentration recorded at all 4 monitoring locations for nitrogen oxides ranged from 15.71 ug/m3 (Alhajuela, 1979) to 49.11 ug/m3 (Balboa, 1977). The maximum average annual concentration of nitrogen oxides ranges from 15.7 to 49.1 percent of the World Bank Guideline for nitrogen oxide of 100 ug/m3.

Noise

Noise is defined as the intensity, duration and character of unwanted or nuisance sounds from sources of human activities that can impact workers or the general public's

well-being or health. The level of impact is related to the magnitude of the noise, which is referred to as sound pressure level (SPL) and measured in decibels (dB).

To account for the effect on how the human ear perceives sound pressure, at moderate to low levels, the octave band frequency (pitch), measured in cycles per second or hertz (Hz), is adjusted or weighted. One of the most commonly used and accepted frequency weightings is the A-weighted (dBA) filter, that adjusts the measurements for the approximated response of the human ear to low frequency SPLs (i.e., below 1,000 Hz) and high frequency SPLs (i.e., above 1,000 Hz). These measurements are known as "A-weighted decibels" referred to as dBA.

Noise Regulations & Criteria

For the evaluation of the environmental quality of the study area related to the noise, data obtained in each measured site were compared to the World Bank Guidelines.

The maximum Leq (hourly), as A-weighted dB, was measured during the daytime and the nighttime. For residential, institutional, and educational receptors, the daytime and nighttime guidelines are 55 and 45 dBA, respectively. For industrial and commercial receptors, the daytime and nighttime guidelines are 70 dBA based on hourly measurements as described below. Instead of the specific ambient noise guidelines for land use receptors, a maximum increase of 3 dBA over background levels is also allowed by the World Bank Guidelines.

The World Bank has developed noise guidelines regarding average hourly noise levels that were designed to protect the general public. These guidelines are split between two distinct land uses:

- residential, institutional, and educational
- industrial and commercial. Maximum Leq (hourly), as A-weighted dB, during the daytime and the nighttime have been established.

Table 14: World Bank Guidelines for Noise

Receptor	Hour	L_{eq} (per hour) Maximum Permissible dBA
Residential; Institutional and Educational	7 a.m. — 10 p.m.	55
	10 p.m. — 7 a.m.	45
Industrial and Commercial	7 a.m. — 10 p.m.	70
	10 p.m. — 7 a.m.	70

Ambient Noise Results

Final recommendations regarding ambient noise results are pending additional data yet to be received and reviewed.

Biological Environment

Marine

General Characterization of the Bay of Panama

Tides in Panama Bay are diurnal and amplitudes may range up to 6 meters (D'Croz and Robertson, 1997). Surface water circulation in the Bay follows a counterclockwise eddy (Smayda, 1966 in D'Croz, 1988). Water quality in the Bay is negatively influence by the discharge of untreated domestic and light industrial waste into the Bay, which causes high BOD and fecal coliform counts (D'Croz, 1988).

The Bay is influenced by the Inter-Tropical Convergence Zone (ITCZ), zone of low atmospheric pressure that defines the seasonal pattern of wind and rain in the area. During Panama's rainy season from May to September, the ITCZ is located over or slightly to the North of Panama. Between January and March, Panama's dry season, the ITCZ moves South of Panama (Forsbergh, 1969 in D'Croz and Robertson, 1997). Northerly tradewinds present during the dry season displace surface water offshore and induce a seasonal coastal upwelling (Fleming 1939 and Schaefer, Bishop, and Landa 1958 in D'Croz et al., 1991). The water brought to the surface generates a high level of plankton production due to its high concentration of nutrients, especially phosphate and nitrate (D'Croz and Robertson, 1997). This peak in plankton production plays an important role in sustaining the Bay fisheries.

General Characterization of the Coastal Area

The coastal portion of the project study area extends from Farfan Hill to Veracruz. The study area is bounded to the east by the Amador Causeway, which contains tourist related development such as restaurants, museums, etc. The main points of access to this part of the coast are the roads leading from Farfan Hill to Palo Seco, from the former Howard Air Force Base to Kobbe Beach and from Howard to Veracruz.

The shoreline from Farfan Hill to Veracruz is mainly rocky, although there are some pocket beaches and areas of deposited silt. The silt deposits, or mudflats, are important feeding habitat for wading birds and semi-terrestrial crabs during periods when they are exposed or when water levels are very low. The mudflats are also important feeding areas for fishes and other marine organisms when they are flooded.

Figure 3: Top: Mudflat area near Farfan Beach (April 2005)

Figure 4: Rocky intertidal area at Palo Seco (April 2005)

The near shore area is relatively shallow with numerous rock outcrops (exposed wave cut platforms) that prohibit the passage of even small vessels. These rocky, intertidal areas provide habitat for juvenile stages of various species of fish, portunid crabs, fiddler crabs, various species of semi-terrestrial crabs, and various types of mollusks.

The largest areas of silt deposition are located at the mouth of the Farfan River, between Farfan Hill and Guinea Point, and west of Punta Bruja. An extensive mangrove community exists at the mouth and along the banks of the Farfan River. A control structure is located at the mouth of the Farfan River to regulate the amount of seawater that flows back into the river during high tides.

Beach areas exist at Farfan, Palo Seco, Kobbe, and Veracruz. Kobbe Beach has recently been augmented as part of construction of a resort development. Granulometric analysis of sediments collected at Palo Seco Beach and Kobbe Beach indicate the presence of significantly larger grain sizes at Kobbe Beach. Grain sizes at Palo Seco Beach were mostly in the range of very fine sand and clay (Moffatt & Nichol et al., 2004b).

For the most part, the shoreline is heavily wooded between Farfan Hill and Punta Bruja, except for the area cleared for the Kobbe Beach resort development. Forest areas are generally classified as dry forest, which is becoming increasingly rare in Central and South America, or mangrove. Large areas of shoreline between Punta Bruja and Veracruz were previously cleared for construction of the access road and the town of Veracruz.

Figure 5: Kobbe Beach and Resort (under construction – April 2005)

Development of the shoreline south of the Bridge of the Americas is limited. A retirement home/hospital exists at the former leper's hospital in Palo Seco, but it is scheduled for closure in the next few years. A resort development is under construction in Kobbe Beach. The largest residential area in the project study area is located at Veracruz, which is a coastal town of approximately 15,000 residents.

Coastal and Marine Resources in the Project Vicinity

Mangroves

Research carried out as part of the Canal Alternatives Study (ANCON and University of Panama, 1993) identified the presence of mangroves in the following regions of the Pacific Coast: Perequete, Caimito, Veracruz, Balboa, and Juan Diaz. Helicopter surveys conducted in 2002 as part of the Island Feasibility Study (Moffatt Nichol et al., 2004b) confirmed the continued presence of mangrove communities in these areas. Mangrove communities were also observed at Rio Farfan, adjacent to Howard Air Force Base (Rio Venado), and Kobbe Beach during reconnaissance conducted in February as part of this study. Mangroves were estimated to cover 6 percent of the vegetated area of the Former Howard AFB, with the greatest areas of mangroves associated with the Rio Farfan and Rio Venado (Arden & Price, 2001). Mangroves were also observed in the

vicinity of the 1939 locks excavation area during a transect survey conducted as part of the Environmental Evaluation of Options for the New Locks (Louis Berger Group, Inc., 2004).

According to remote sensing data carried out by the Instituto Geografico Nacional Tomy Guardia (IGNTG) and summarized by D'Croz (1993), mangroves covered approximately 262 km^2 of the coastal area in the Bay of Panama at the time of the survey. *Rhizophora mangle* and *R. brevistyla* (red mangroves) are the principal components of forests in brackish areas. Monocultures of red mangrove tend to form along river deltas and mouths where tides fluctuate between 2-6 meters. *Avicennia germinans* and *A. bicolor* (black mangroves), *Mora oleifera* (mora), and *Montrichardia arborescens* ("castaño") develop along a salinity gradient at the mouth of rivers. Other tree species such as *Pellicera rhizophorae* ("mangle piñuelo") are also important within mangrove forests.

Mangroves are important nursery sites for several commercial species and they contribute to the organic output of the coast. At least 9 species of commercially-fished shrimps from the Pacific coast of Panama are known to inhabit mangrove channels and estuaries as juveniles (D'Croz and Kwiecinski, 1980 in D'Croz 1993). The three species of commercially important white shrimp (*Penaeus occidentalils*, *P. stylirostris*, and *P. vannamei*) are most abundant in tidal mangroves (D'Croz and Kwiecinski, 1980 in D'Croz 1993). These species spawn offshore and reach the coast as post larvae where they live for a period of 4 to 5 months before migrating to the ocean to complete their life cycle (D'Croz, 1993).

Over thirty species of fish are reported as associated with mangroves on the Pacific Coast during their juvenile stages. The most common are *Mugil curema* (white mullet), *Eucinostomus californiensis* (mojarra cantilena), *Centropomus armatus* (armed snook), *C. nigrescens* (black snook), *C. rabalito* (yellowfin snook), *C. unionensis* (union snook), *Lutjanus aratus* (mullet snapper), *L. argentiventris* (yellow snapper), and *Micropogon altipinnis* (tallfin croaker or corvina) (D'Croz, 1993). Many of these species, especially *Lutjanus* spp. (snappers), corvinas, and *Centropomus* spp. (snook or robalos) are important to the artisanal fisheries (D'Croz, 1993). Mangroves may also play an important role in the life cycle of *Centegraulis mysticetus* (Pacific anchoveta), which is used for fish meal. Adult Pacific anchoveta inhabit the coastal area, specifically shallow muddy areas. The largest Pacific anchoveta catches in the Gulf of Panama correspond to the coastal areas with the most mangrove cover and mangrove bordered estuaries (D'Croz and Kwiecinski, 1980 in D'Croz, 1993). The economic benefits of this fishery may reach up to 20 million dollars per year (D'Croz, 1993). Estimates for 1980 showed that each kilometer of mangrove covered coastline along Panama Bay produced benefits of nearly $100,000 per year (D'Croz and Kwiecinski, 1980 in D'Croz, 1993).

Seagrasses

Little is known about the location or abundance of seagrass on the Pacific coast. Research by ANCON and University of Panama (1993) indicated the presence of seagrass located in Punta Bruja on a reef flat behind an area of living coral and reef rock. The seagrass was patchily distributed and limited to the protected area behind the reef. It is not known if the coral mentioned at this site is still living.

Plankton

Two marine sampling studies were conducted in the overall study area as part of the Feasibility Study of Island Development at the Pacific Entrance of the Panama Canal (Moffatt Nichol et al., 2004b). The first study was conducted in 2002 and the second study was conducted in February and March of 2003. The same sampling areas were used for both studies: Chorillo Bay, the Amador Causeway near Flamenco Island, an open water area near Palo Seco, the artificial island site, Site 15 (between the artificial island site and the fishing grounds), and the fishing grounds near Taboga Island . Diurnal and nocturnal collections were made of zooplankton in both studies. Phytoplankton studies were also conducted in 2003 using some of the same sampling stations.

Phytoplankton

Phytoplankton collections were made as part of the Feasibility Study of Island Development at the Pacific Entrance of the Panama Canal (Moffatt Nichol et al., 2004b). The collection stations were located at the Causeway (3 locations), the artificial island site, Site 15, and the fishing grounds site. The study identified 115 taxa of microalgae belonging to 49 genera, including the divisions of Bacillariophyta and Dinophyta. The diatoms contributed a total of 39 genera and 91 species. Dinoflagellates represented 10 genera and 24 taxa. The Bacillariophyceae species abundant during this study were: *Chaetoceros anastomosans*, *C. lorenzianus*, *C. socialis*, *Coscinodiscus* spp., *Proboscia alata*, and *Pseudonotzschia pungens*. Almost all of the diatom species collected were planktonic in nature. The most abundant diatoms collected were *Ceratium furca*, *Ceratium tripos*, *Noctiluca scintillans*, *Peridinium* cf. *granii*, and *Pyrophacus horologcium*.

In general, the diatoms did not show a preferential diel distribution among the diurnal and nocturnal samples. Dinoflagellates tended to show a higher occurrence during diurnal samples, except for *Pyrophacus horologicum* which occurred frequently in nocturnal samples.

The average number of species collected in the summer (January-February) samples was lower than the average number collected in the winter (June –August) samples. However, the average number of organisms collected in the winter months was higher

than in the summer months. Some species that were abundant in the summer months such as *Pyrophacus horologium*, *Noctiluca scintillans*, *Chaetoceros anastomosans*, and *C. socialis* were not observed in the winter samples. Species present at most of the sampling sites include *Coscinodiscus* spp., *Proboscia alata*, *Pseudonitzchia pungens*, *Chaetoceros curvisetus*, *Pseudosolenia calcar avis*, *Ceratium furca*, *Noctiluca scintillans*, and *Pyrophacus horologicum*.

The number of taxa collected as part of the Island Feasibility study was less than that collected at the Smithsonian Tropical Research Institute pier on Naos Island from January 1985 through December 1988 (D'Croz et al., 1991). Two hundred and eleven (211) taxa of phytoplankton were collected during the Naos Island study, and most (165) were diatoms. Nine taxa of dinoflagellates, three taxa of ciliates, a blue-green algae, and a silicoflagellate were also found. Thirty-two (32) taxa were not able to be identified. *Chaetoceros cinctus* and *C. curvisetus* were the numerically dominant diatoms in the collections. Other common taxa were *Cyclotella* sp., *Nitzschia pungens*, *Rhizosolenia stolterfothii*, and *Chaetoceros socialis.* D'Croz et al. found that phtytoplankton densities roughly followed the concentration of dissolved nutrients, with cell densities higher during the dry season (January to April) and lower during the rainy season (May to December). This finding is in agreement with the data from the phytoplankton data from the Island Feasibility Study. D'Croz et al. data also suggest that the phytoplankton population is basically indigenous since species found in each season are basically the same, only their rank of importance changes seasonally.

Zooplankton

A total of 26 taxa were identified during the first study. Calanoid copepods were the most abundant, followed by Cladocerans and *Chaetognatha* spp. The fishing grounds near Taboga Island had the highest diversity (15 taxa) of all the sites. Results of the first study indicate that the greatest mean diurnal (249,753.10 organisms/m^3) and nocturnal (5,987,826.00 organisms/m^3) zooplankton densities were found at the Chorillo Bay site. The lowest mean diurnal (2,824.11 organisms/m^3) nocturnal (5,987,826.00 organisms/m^3) and nocturnal densities (33,936.12 organisms/m^3) were recorded at the Palo Seco site. The highest diurnal biomass (1.64 mg/m^3) was recorded at the Causeway site, while the lowest diurnal biomass (012 mg/m^3) was recorded at Site 15. The highest nocturnal biomass (3.96 mg/m3) was recorded at the Chorillo site, while the lowest nocturnal biomass (0.26 mg/m^3) was recorded at Site 15. The highest density of fish eggs (811,169.01 organisms/m^3) occurred at night. The greatest density of fish larvae in the diurnal and nocturnal collections was recorded at the Chorillo site 3,718.41organisms/m^3 and 3,486.60 organisms/ m^3, respectively. The most abundant fish larvae were Sciaenidae (drums or croakers), Engraulidae (anchovies), Gobiidae (gobies), and Haemulidae (grunts).

A total of 31 taxa were identified in the second study. As in the first study, Calanoid copepods were the most abundant organisms. The greatest number of taxa (18) was reported at the Causeway site at night. During the day, the greatest number of taxa was reported from the Chorillo and Palo Seco sites (13 taxa each). The greatest mean diurnal density was recorded at Palo Seco (123,076.33 organisms/m^3), while the greatest mean nocturnal density was recorded at the Chorillo site (302,044.65 organisms/m^3). The lowest mean diurnal density was recorded from Site 15 (18,816.15 organisms/m^3) as was the lowest mean nocturnal density (4,421.55 organisms/m^3). The greatest mean diurnal biomass was recorded at the artificial island site (0.52 mg/$m^{3)}$ and the greatest mean nocturnal biomass was recorded at the Chorillo site (1.50 mg/$m^{3)}$. The lowest mean diurnal biomass was recorded at the Causeway site (0.37 mg/m^3), while the lowest mean nocturnal biomass was recorded at Site 15 (0.11 mg/m^3). The greatest diurnal density of fish eggs and larvae was recorded at Palo Seco (5,833 organisms/m^3) and the greatest mean nocturnal density was recorded at Chorillo (25,711 organisms/m^3). No fish larvae were reported from the fishing grounds site and Site 15. At the Palo Seco site, the larvae were identified as Carangidae (jacks and pompanos) and Gobiidae. At the Chorillo and artificial island sites the larvae were Engraulidae. The larvae identified at the Causeway site were Engraulidae, Gobiesocidae (clingfishes), Polynemidae (threadfins), and Paralichthydae (sand flounders). The Shannon-Weaver Diversity Index (H), Maximum Diversity (H_{max}), and Equitability Index (J) were calculated for each of the sampling sites and are presented in Table 15.

Table 15: Shannon-Weaver Diversity (H), Maximum Diversity (H_{max}) & Equitability Values for Zooplankton Sampling Sites

Site	Shift	H	H_{max}	J
Causeway	Day	0.91	1.70	0.54
Causeway	Night	1.03	2.22	0.47
Chorillo	Day	1.03	1.78	0.58
Chorillo	Night	0.99	1.97	0.51
Artificial Island	Day	0.99	1.92	0.52
Artificial Island	Night	0.94	1.96	0.48
Site 15	Day	0.52	1.38	0.37
Site 15	Night	0.89	1.64	0.55
Palo Seco	Day	0.85	2.08	0.41
Palo Seco	Night	0.94	1.91	0.49
Fishing Site	Day	0.81	1.75	0.46
Fishing Site	Night	1.10	2.01	0.55

The data from the second study suggest the existence of a typical zooplankton community in the Bay of Panama, with vertical movement and migration, accentuated in the coastal stations. The majority of organisms collected were considered common for the coastal region and consistent with those reported from other studies. The dominance of copepods in the samples is significant due to their role in energy transfer from primary producers to organisms in higher trophic levels, such as fish (Roman, 1991 in Moffatt & Nichol, 2004a; Turner, 2004). The presence of *Chaetognatha* spp. at some of the collection sites during nocturnal periods is indicative of waters with relatively high salinity. The high density of organisms at the Chorillo site may be due to the influence of domestic waste water discharge. The Palo Seco site and the fishing grounds site are oceanic sites whose plankton communities may be impacted by boat traffic entering the canal.

Data analyses of meroplankton collections from the Canal Alternatives Study (ANCON and University of Panama, 1993) indicate that in the Pacific, most fish larvae in were collected near the end of the rainy season (November 1992) near the Canal entrance. The most common larvae collected were Engraulids, Carangids, Mugilids (mullets), and Sciaenids and most of these were at the preflexion stage. Eggs from clupeid (herrings, shads, sardines, menhadens) and engraulid fishes were among the most abundant in the Pacific collections. The highest densities of eggs collected for clupeids and engraulids were 3,503 eggs/100m^3 and 2,861 eggs/100m^3, respectively. Crustacean zoea were the most common marine invertebrates in the samples. The highest observed density of crustacean zoea was 45,793 zoea/100m^3. Postlarval penaeid shrimp (white shrimps) were present in the samples from November 1992-February 1993. Gastropod and pteropod larvae were abundant in the November 1992 samples and numerous types of bivalve larvae were present in the February 1993 samples.

Coral

Historically, coral communities existed close to the Pacific entrance of the Panama Canal near Taboga, Urabá, Taboguilla, and Otoque (ANCON and University of Panama, 1993). Most of these communities have disappeared and now only a few representatives remain around Taboga and Urabá Islands (Morales and Muñiz, 1988 in Moffatt Nichol et al., 2004b). Currently, the only known population in the eastern Pacific of *Siderastrea glynni*, a coral species endemic to Panama, exists near the island of Urabá (Moffatt Nichol et al., 2004b).

While coral reefs are an important habitat of Caribbean coastal habitats, they make up only a small portion of the coastal habitats in the eastern Pacific. The largest coral reef (3.7 km^2) in the tropical Eastern Pacific is the offshore island of Clipperton (Glynn et al., 1996 in D'Croz and Robertson, 1997), while the largest reef close to the mainland, at Coiba Island in Panama, covers only 1.6 km^2 (Glynn and McCosker, 1972, Glynn and Maté, 1996, and Guzmán and Cortés, 19994 in D'Croz and Robertson, 1997). The difference in abundance may be due to the seasonal variability in water temperature, nutrient concentrations, and plankton densities on the Pacific coast caused by seasonal upwelling (D'Croz and Robertson, 1997). Approximately 20 hermatypic scleractinian corals are known to exist on the Pacific Coast, compared to the 49 hermatypic corals known from the Caribbean reefs of Panama (Glynn, 1972).

Benthos

Benthic samples were collected in January and February 2003 as part of the Feasibility Study of Island Development at the Pacific Entrance of the Panama Canal (Moffatt Nichol et al., 2004b). The samples were collected from nearshore and oceanic areas.

The nearshore sites were Kobbe Beach and Palo Seco Beach. The offshore sites were Chorilla Bay, the Amador Causeway near Flamenco Island, an open water area near Palo Seco, the artificial island site, Site 15 (between the artificial island site and the fishing grounds), and the fishing grounds near Taboga Island.

In the nearshore areas the highest number and diversity of organisms was collected at Kobbe Beach during high tide. The lowest numbers and diversity were collected at Palo Seco Beach (East) at low tide. Mollusks were the most abundant taxon in the nearshore areas. Data from the offshore areas indicated that the highest numbers of organisms were found at the open water Palo Seco site and the highest diversity was found at the artificial island site. Polychaetes were the most abundant organisms in the offshore stations. Table 16 lists the type and number of organisms collected as well as what percentage they made up of the total samples for the beach sites. Table 17 lists the same information for the offshore sites.

Table 16: Type and number of macrofauna collected at Beach Stations

Taxa	Number	Percentage
Protothaca asperrima	35	13.73
Amphipods	32	12.55
Nereidae	29	11.37
Isopods	27	10.59
Capitellidae	17	6.67
Cossuridae	15	5.88
Copepods	14	5.49
Tellina sp. (1)	14	5.49
Nephtyidae	9	3.53
Mytella guyanensis	8	3.14
ECHIURA	6	2.35
Nucula sp.	5	1.96
Tellina sp.	5	1.96
Anadara sp.	4	1.57
Donax sp.	4	1.57
Ofiuroidea sp.	4	1.57
Ostracods	4	1.57
Pisionidae	4	1.57
Tellina sp. (2)	4	1.57
Nassarius sp.	3	1.18
Cladocera	2	0.78
Crassinella sp.	2	0.78
Bivalve larvae	2	0.78
Ophediae	2	0.78
Porcelanidae	2	0.78
Bivalve (1)	1	0.78
Serpulidae	1	0.39
Total	255	100.00

Table 17: Type and number of macrofauna collected at the offshore stations

Taxa	Number	Percentage
Phylllocidae	96	13.62
NEMATODES	74	10.50
Nephtyidae	53	7.52
Spionidae	47	6.67
Amphipod	46	6.52
Glyceridae	40	5.67
Nereidae	38	5.39
Capitelidae	36	5.11
Cirratulidae	23	3.26
Goniadidae	21	2.98
Sabellidae	20	2.84
ECHIURA	19	2.70
Copepod Calanoida	17	2.41
Protothaca asperrima	14	1.99
Arenicolidae	13	1.84
Cossuridae	12	1.70
Tellina sp. (1)	12	1.70
Ophelidae	11	1.56
Solen sp.	11	1.56
Lumbrineridae	9	1.28
Magelonidae	9	1.28
Serpulid	8	1.13
Anadara sp.	7	0.99
Ostracods	6	0.85
Callinectes sp.	5	0.71
Crassinella sp.	5	0.71
Owenidae	5	0.71
Pilargidae	5	0.71
Bivalve larvae	4	0.57
Pilargidae	4	0.57
Arca sp.	3	0.43
Dorvidallidae	3	0.43
Onuphidae (1)	3	0.43
Onuphidae (3)	3	0.43
Ophiuroidea	3	0.43
Squillia sp.	3	0.43
OLYGOCHAETE	2	0.28
Onuphidae	2	0.28

Porcellanidae	2	0.28
Trachypenaeus sp.	2	0.28
Gobidae	1	0.14
Isopod	1	0.14
Gastropod larva	1	0.14
Mytella guyanensis	1	0.14
Onuphidae (2)	1	0.14
Pisces	1	0.14
Polyodontidae	1	0.14
Starnospidae	1	0.14
Brachyura larva	1	0.14
Total	705	100.00

The highest density was observed at Kobbe Beach during high tide (2,633 individuals/m^2). The lowest densities was observed at Site 15 (201 individuals/m^2) and the Amador Causeway (277 individuals/m^2). On average, the beach stations had a density of 1,547 individuals/m^2 and the offshore stations had a density of 490 individuals/m^2. The most abundant organisms at the offshore stations were the Phyllodocidae, a polychaete that is a detritivore. The bivalve *Protothaca asperrima* was the most abundant organism at the beach sites. This species is collected at low tide by local fisherman and used as a protein source. Other bivalves that are collected and sold for human consumption include *Mytella guanensis*, *Anadara* sp., and *Donax* sp.

The Shannon-Weaver Diversity Index (H) value was calculated for each of the sampling locations. The Shannon-Weaver Index incorporates the number of species (species richness) and the relative abundance or distribution (evenness) of the species. The Palo Seco open water site had the highest Shannon-Weaver values, while the Palo Seco Beach West (high tide) site had the lowest values. The Shannon-Weaver Diversity Index values for each site are presented in Table 18.

Table 18: Shannon-Weaver Diversity Index (H) Values for the Benthic Collection Sites

Sampling Site	Index Value (H)
Palo Seco Beach East – high tide	2.002
Palo Seco Beach West – high tide	1.236
Palo Seco Beach West – low tide	1.957
Kobbe Beach – high tide	2.475
Kobbe Beach – low tide	2.032
Artificial Island	2.883
Palo Seco open water	2.998
Site 15	2.386
Fishing Grounds	2.165
Amador Causeway	2.025
Chorillo Bay	1.755

At least 172 benthic taxa are known from the Pacific coast of Panama (ANCON and University of Panama, 1993). Data collected from the Pacific coast for the Canal Alternatives Study (1993) showed a mean abundance of benthic organisms of 147 organisms/m^2 and a seasonal pattern with two peaks of abundance in July 1992 and March 1993. The data also showed a pattern of decreasing abundance from nearshore to offshore the Panama Canal entrance. Polychaeta, Crustacea, Sipuncula, Nemertina, and Mollusca taxa were the numerically dominant fauna. Bivalves belonging to the Nuculanidae, Solecurtidae and Tellinidae families were the dominant mollusks.

Macroinvertebrate sampling conducted in the Pacific for the biological inventory conducted as part of the Canal Alternatives Study (ANCON and University of Panama, 1993) found that the dominant species in terms of biomass collected were *Callinectes arcuatus* (swimming crab), *Euphylax robustus* (portunid crab), *Lolliguncula panamensis* (squid), *Portunus xanthussi xanthussi*, *Renilla amethystina* (sea pen), *Ptylosarcus sinosus*, *Squilla aculeata aculeata* (mantis shrimp), *Xiphopenaeus riveti* (seabob), *Hepatus kossmani* (box crab), and *Penaeus occidentalis* (white shrimp). *Callinectes arcuatus* was the abundant species comprising 31 percent of the total catch, followed by

Euphylax robustus which comprised 15 percent of the total catch. A total of 56 species were identified in the Pacific within the 50-meter isobath through this study.

Fishes

Fishes were sampled in the Pacific for the biological inventory conducted as part of the Canal Alternatives Study (ANCON and University of Panama, 1993). In the Pacific, 5 littoral stations and 7 sublittoral stations were sampled in July, August, and November of 1992, and February and May of 1993. The littoral samples were collected using 10-meter and 30-meter haul seines that were 1.5-1.75 meters in height with a mesh size of 0.64 cm; while the sublittoral samples were collected using twin otter trawls 20-meters in length with 8.0 cm mesh. All collections were conducted within the 50-meter isobath.

The mean abundance was highest at the beginning of the rainy season (532.5 individuals/collection) and decreased through the dry season, indicating a possible relationship between with the period that follows the upwelling in the dry season. The low sea temperature of the upwelling event is known to cause displacement of several species of fish and invertebrates to warmer, shallower waters (Smayda, 1996; Forsbergh, 1969; and D'Croz et al. in ANCON and University of Panama, 1993). Species diversity was also highest at the beginning of the rainy season (75 species) and generally decreased through the dry season.

In the Pacific, the sampling stations with the highest mean abundances and diversity (sublittoral zone) were located in the vicinity of the Chame estuary. Fish collected from the sublittoral zone ranged in size from 5.0-135.20 cm and weight from 0.06-2,969.00 g. Carangidae and Sciaenidae were the most dominant families in the catch. The lowest diversity in the sublittoral samples was recorded at the sampling station in front of the Pacific entrance to the Canal. The highest abundance in littoral samples was recorded in May 1993, with Engraulidae dominating the catch. The littoral samples were characterized by fish ranging in size from 2.0-31.0 cm and weighing 0.01-265.0 g. The most abundant species in each sampling event at presented below in Table 19

Table 19: Most Abundant Species Collected During the Biological Inventory Monitoring, 1992-1993

Sampling Event	Species Ranked by Mean Abundance (Ind./Collection)								
	Species	Common Name	Abundance	Species	Common Name	Abundance	Species	Common Name	Abundance
July 1992	*Paralicthys woolmani*	Speckled flounder	37.88	*Vomer declivifrons*	Pacific moonfish	35.75	*Gerres cinereus*	Yellowfin mojarra	33.50
August 1992	*P. woolmani*	Speckled flounder	19.83	*Bairdiella chrysoleuca*	Shortnose stardrum	14.71	*V. declivifrons*	Pacific moonfish	9.96
November 1992	*Diapterus peruvianus*	Peruvian mojarra	29.13	*Felicthys panamensis*	Chilhuil seacatfish	18.33			
February 1993	*G. cinereus*	Yellowfin mojarra	318.48	*Mugil curema*	White mullet	155.08			
May 1993	*Chloroscombrus orqueta*	Pacific bumper		*Guenthendia formosa*	Spotted puffer	50.83			

Coastal Birds

Panama is one of the premier bird migration corridors in the Western Hemisphere. Each year from December to April, millions of birds migrate between their summer breeding grounds in North America and their wintering grounds in South America, using the Bay of Panama as a staging area. Typically most species are associated with the tidal mudflats, but some can also be found in wetland and grassland habitats. Especially high numbers of seabirds are also present during seasonal upwelling events (April – December), which bring high numbers of anchovies and smelt to the nearshore areas (RPI, 2004).

The island of Taboga contains a 252 hectare protected area that is an important nesting area for waterfowl and coastal birds. Approximately 55,000 to 70,000 individuals nest in the southwest corner of the island and feed in the Bay waters and shallow areas close to the Pacific entrance of the Canal. The majority of the birds nesting on Taboga are Brown pelicans and paticuervos (ANCON and University of Panama, 1993). The Taboga Island colony is one of the largest breeding colonies of brown pelicans in the world (RPI, 2004).

Table 20 presents the coastal birds observed near Palo Seco during surveys conducted for the Island Feasibility Study (Moffatt & Nichol et al., 2004a) and the Dredging Disposal Study (Moffatt & Nichol et al., 2004a):

Table 20: Coastal Birds Observed near Palo Seco (Site M4)

Species	Spanish Common Name	English Common Name	National Rank	Global Rank
Actitis macularia	Playero coleador	Spotted sandpiper	NN/BBS	G5
Catoptrophorus semipalmatus	Playero aliblanco	Willet	NN	G5
Numenius phaeopus	Zarapito trinador	Whimbrel	NN	G5
Calidris pusilla	Playero semiplameado	Semipalmated sandpiper		
Eudocimus albus	Ibis blanco	White ibis	N4	G5
Fregata magnificens	Fragata magnifica	Magnificent frigate bird	N5	G5
Pelecanus occidentalis carolinensis	Pelicano marrón	Brown pelican	N4	G4
Phalacrocorax o. olivaceous	Comorán neotropical	Neotropic cormorant	-	-

Surveys conducted as part of the Biological Inventory for the Canal Alternatives Study identified 229 species of birds at the South Entrance of the Panama Canal (ANCON and University of Panama, 1993). The most abundant species observed in the marine areas were *Fregata magnificens* (magnificent frigate bird), *Pelecanus occidentalus* (brown pelican), and *Coragyps atratus* (black vulture). *Progne chalybea* (gray-breasted martin) was observed in open areas near water. *Dendrogygna autumnalis* (black-bellied whistling duck), *Actitis macularis* (spotted sandpiper), and *Phalacrocorax olivaceous* (neotropic cormorant) were observed near the coastline and in the Farfan Lagoon.

Marine Mammals

Megaptera novaeangliae (humpback whales) have been reported near the island of Taboga between June and September. Dolphins have also been reported in the vicinity of Taboga Island. Bottlenose dolphins and other cetaceans may be present year round in the both the Atlantic and Pacific entrances to the Canal (RPI, 2004).

Protected, Rare, or Commercially Important Species

Rare and Protected Species

The biological inventory conducted by the University of Panama and ANCON discovered the coral *Siderastrea* sp. *nova* at Uraba Island near the Pacific entrance to the Canal. This was the first report of this genus in the eastern, central, and western Pacific. Although sea turtles were not observed during the biological inventory, the following endangered species are known to frequent the Panamanian coast: *Chelonia agassizi* (East Pacific green turtle), *Eretmochelys imbricata* (hawksbill), *Caretta caretta* (loggerhead), *Lepidochelys olivacea* (olive ridley), *Dermochelys coriacea* (leatherback).

Commercially Important Species

The most important fisheries resources within Panama are located within the Gulf of Panama. Fishing activities thought to involve approximately 10,000 people and is mostly concentrated on the Pacific Coast. According to the Ministry of Commerce at Industry, some 2,000 people work in the fishing industry, 6,500 are artisanal fisherman, and around 1,500 are involved in processing and marketing seafood. The annual revenue from the exportation of sea products is around $100,000,000, with shrimp representing $65,000,000 to $70,000,000 (MICI, 1990 in ANCON and University of Panama, 1993).

The community of coastal fish located just above the thermocline is dominated by *Centengraulis mysticetus* (Pacific anchoveta), *Opisthonema libertate* (Pacific thread herring), and several *Anchoa* species (anchovies). Predator species such as *Scomberomorus maculatus* (Spanish mackerel), barracudas, and sharks are often found in association with the herring and anchoveta. Below the thermocline, *Decapterus macrosoma* (shortfin scad) and *Etrumeus teres* (round herring) can be found at high densities. *Thunnus albacares* (yellowfin tuna) and *Katsuwonus pelamis* (skipjack herring) are among the pelagic ocean stocks, but are usually located off the 100 fathom isobath (ANCON and University of Panama, 1993).

The Pacific anchoveta is believed to spawn in low salinity areas close to the Pacific entrance of the Canal and in the coastal area near the mouth of the Juan Diaz River (Simpson 1959 and D'Croz and Kwiecinski, 1980 in (ANCON and University of Panama, 1993). Results from the biological Inventory indicate that the maximum peak spawning for anchoveta was in November in 1992, which agrees with previous reports by Howard and Landa (1958), but that some spawning occurs year round (ANCON and University of Panama, 1993). The economic benefits of this fishery may reach up to 20 million dollars per year (D'Croz, 1993).

The extractable biomass in the Gulf of Panama may be around 400,000 metric tons per year, but most of this is mainly demersal fish and squid which are not fished. Demersal stock that are fished such as stromateid fish (dollar fish), and some species of serranids, and snappers represent an estimated 200,000 metric tons/yr. The yearly available biomass of pelagic fish (anchoveta and herring) in the Gulf of Panama varies between 70,000 and 160,000 metric tons/yr. The annual catch of penaeid shrimp is approximately 5,000-6,000 metric tons/yr (ANCON and University of Panama, 1993).

Artisanal fishery activities are one of the fastest growing fishery activities in Panama. The most common taxa in artisanal landings are snappers, Spanish mackerel (scombrid), jacks (carangid), corvinas (scianid), lobsters and scallops (*Argoppecten circularis*) (ANCON and University of Panama, 1993). Local fishermen are known to collect the bivalves *Protothaca asperrima*, *Mytella guanensis*, *Anadara* sp., and *Donax* sp. during low tide for their own consumption or sale at local markets (Moffatt & Nichol et al., 2004b).

There is no regulation of sport fishing in Panama so it is difficult to assess the fishing effort and volume of catch. Some of the most attractive local sport fishing areas in the vicinity of the Project area the Amador Causeway, Taboga, Taboguilla, Uraba, and the small rocky islands that stretch from the Pacific entrance of the Canal to Punta Chame. Important sport fishes in the Pacific are *Tylosurus fodiator* (Mexican needlefish), *Thunnus albacares* (Yellowfin tuna), *Thunnus alalunga* (Albacore), *Katsuwonus pelamis* (Skipjack tuna), *Cynoscion phoxocephalus* (Cachema weakfish or Corvina), *Macrodon mordax* (Dogtooth weakfish or corvina), *Coryphaena hippurus* (Common dolphin fish), *Centropomus robalito* (Yellowfin snook), *Centropomus unionensis* (Union snook), *Caranx hippos* (Crevalle jack), *Trachinotus kennedyi* (blackblotch pompano), *Tarpon atlanticus* (tarpon), *Lutjanus guttatus* (Spotted rose snapper), *L. colorado* (Colorado snapper), *Scomberomorus* spp.(Spanish mackerel), *Istiophorus* spp. (Sail fish), *Xiphias gladius* (Swordfish), *Maikaira indica* (Black marlin), and *Nematistius pectoralis* (Rooster fish) (ANCON and University of Panama, 1993).

Freshwater and Terrestrial Resources

General Description of the Project Area

Highway Access

The proposed terminal will be connected to the main highway system via the existing coastal road from the Bridge of the Americas to Veracruz township. Some upgrading or widening of this road is expected, which may involve the construction of a parallel road and improvement of several intersections. The section of the road that will connect the

port passes through a generally undeveloped area and crosses wetlands and disposal sites for dredged materials from Panama Canal maintenance works.

Potential Rail Corridor

The proposed rail access route to the container port island will connect the container port, located in the coastal zone of Palo Seco, to the Miraflores swing bridge and a swing bridge over the new locks. The route will pass through a mixture of urban areas, commercial/industrial areas, secondary forests, and wetlands. Most urban development is associated with the towns of Cocolí, Lacona, and Farfan. Portions of the access routes are proposed to pass through portions of the former Howard Air Force Base, which has been divided into multiple commercial and industrial concession areas.

The Miraflores area was examined as part of the evaluation of the new locks project (Louis Berger Group, Inc., 2004). The former Howard Air Force Base, Fort Kobbe, Fort Farfan, and the Arraijan tank farm (Howard AFB area/complex) were studied during the Evaluation of Natural Resources at Howard Air Force Base (Arden & Price). The Palo Seco region was studied extensively during the Pacific Side Excavation & Dredging Materials Disposal Study (Moffatt &Nichol et al., 2004a) and the Feasibility Study of Island Development at the Pacific Entrance to the Panama Canal (Moffatt &Nichol et al., 2004b). Little published information is available for the areas between Palo Seco and Miraflores.

General Description of Freshwater Resources

There are two main freshwater rivers in the Farfan/Palo Seco region: Río Farfán and Río Dejal. Río Dejal is an intermittent stream that drains Palo Seco. Río Farfán is a dendrical, second order stream that joins other second order streams and forms a floodplain. The river's natural channel has been modified to accommodate a parallel artificial channel that carries seawater. Several diversion channels have also been created to draw water off the natural channel, which results in the river drying up during the dry season. Water quality samples taken as part of the Disposal Alternatives Study (Moffatt & Nichol et al., 2004a) indicate that Río Farfan is brackish and turbid. Río Dejal was dry at the time of the site and could not be sampled, but it showed signs of sea water intrusion.

The following rivers and streams are located north of the Palo Seco/Farfan and may be crossed by alternative rail and roadway access alignments: Río Matuela; Río Velasquez; and, Quebrada Victoria.

Forest Resources

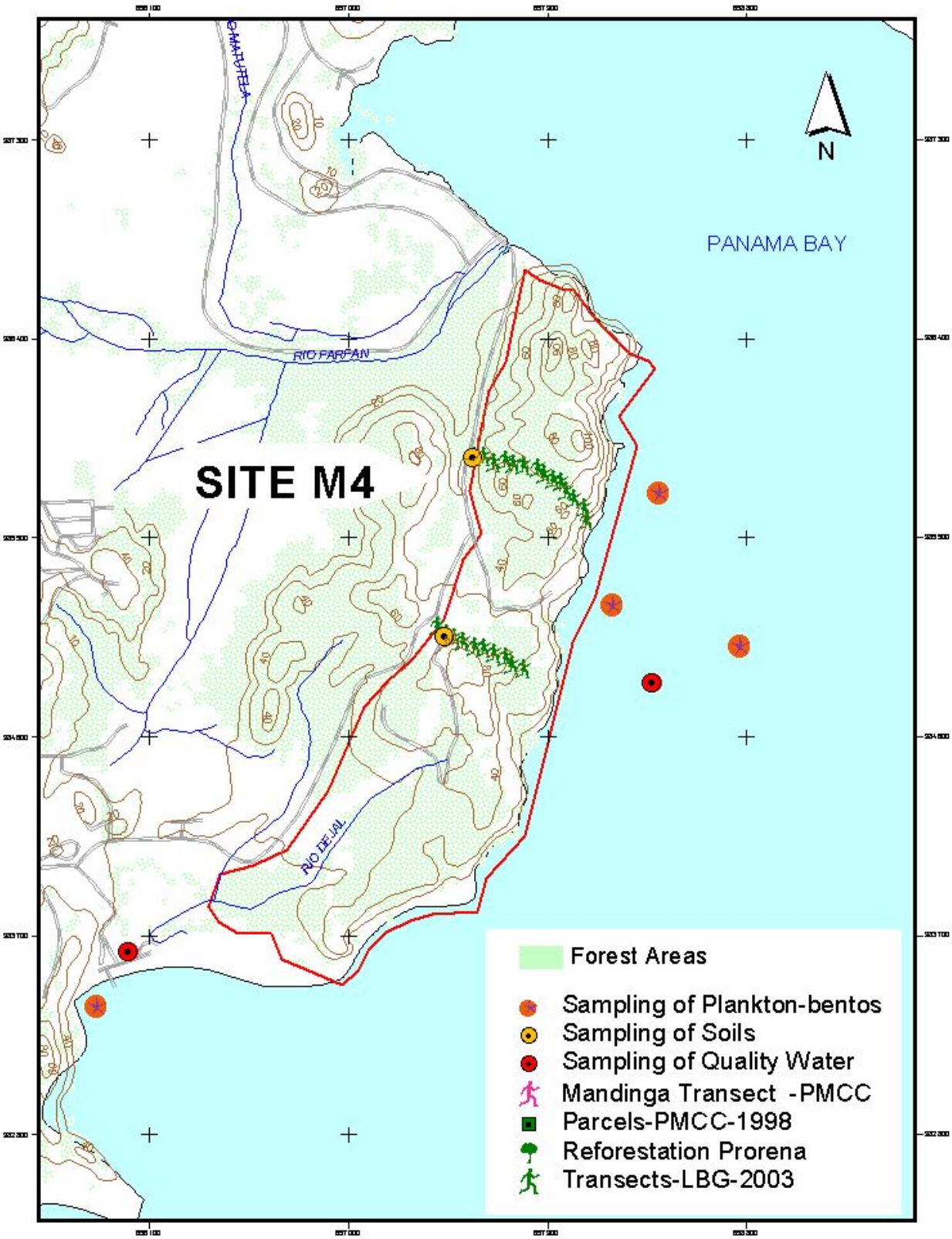
Palo Seco Area

The coastal forest areas between Farfan Hill and Kobbe Beach are secondary forest, the majority of which is characterized by dry forest vegetation. This area is classified as Pre-Montaine Humid Forest according to the Holdridge Zone of Life Classification System and Semi-deciduous Tropical Lowland Forest according to UNESCO (Moffatt & Nichol, 2004a).

Approximately 88 hectares of this area was deforested during construction of the Palo Seco Hospital (now a retirement home) and access roads. Additional areas have been cleared for the Kobbe Beach resort development. Although the coastal area of Palo Seco has been disturbed, it still serves as a biological corridor between Guinea Point and Punta Bruja, and the forested areas of the former Howard Air Force Base (Moffatt & Nichol, 2004a).

Transect surveys of vegetation and wildlife were conducted in two locations, north and south of the Palo Seco Hospital.

Figure 6: Location of Transects taken at Palo Seco/Farfan in 2003



The average canopy coverage of the transects was 78.98 percent. One hundred twenty-three (123) taxa of flora were identified of which, 14 were identified to the familial level and 108 to the species level. The most common species of trees found in the high canopy were *Astronium graveolens* (zorro), *Sapindus saponaria* (jaboncillo or soapberry), *Bursera simaruba* (almácigo or gumbo limbo), *Protium tenuifolium* (chutra), *Ficus insipida* (higueŕon or fig), *Zanthoxylum setulosum* (tachuelo), *Luehea seemannii* (guácimo colorado), and *Antirhea trichantha* (mazanuco). The most common species in the low canopy were *Hirtella racemosa* (camarillo), *Thevetia ahouai* (heuvo de gato), *Bactris major* (caña brava), *Bactris barronis*, *Psychotria* sp. (wild coffee), *Piper marginatum* (hinojo or cake bush), *Piper aduncum* (hinojo or spiked pepper), *Heliconia latispatha* (heliconia or expanded lobster claw), *Heliconia platystachys* (heliconia), *Acacia melanoceras* (cachito), *Carludovica palmate* (sombrero panama or Panama hat palm), and *Connarus panamensis*. The most common understory species were *Astronium graveolens*, *Luehea seemannii*, *Sterculia apetala* (árbol Panamá or Panama tree), *Ormosia macrocalyx*, *Albizia adinocephala* (cream albizzia), *Enterolobium cyclocarpum* (corotú or earpod), *Godmania aesculifolia* (cacho del Diablo), and *Chrysophyllum cainito* (caimito or star apple).

Thirty (30) of the identified species are considered rare or have international conservation rankings. Three species identified were ranked G2N2 (locally and globally imperiled): *Antirhea trichantha*; *Bactris barronis*; and, *Bactris coloradonis*. Two species identified are classified as G4N2 (apparently secure locally, but globally imperiled: *Acacia melanoceras* and *Swietenia macrophylla* (caoba or true mahogany). *S. macrophylla* is also protected under Panamanian law and is listed as Vulnerable by the IUCN (International Union for the Conservation of Nature). *Pachira quinata* (cedro espino) was also identified and is listed as Vulnerable by the IUCN. The orchids *Brasavola nodosa* (lady of the night), *Catasetum viridiflavum*, and *Vanilla planifolia* (vanilla orchid) were also found and are listed in CITES Appendix 1.

Twenty-three (23) species of economic importance were identified including *Tabebuia rosea* (roble or pink trumpet tree), *Apeiba tibourbou* (peine de mono), and *Ochroma pyramidale* (balso). Numerous medicinal plants were observed including *Urera baccifera* (ortiga), *Simaba cedron* (cedró), and *Passiflora vitifolia* (passionaria or vine leaf passion flower). One endemic species, *Acrocomia aculeata* (palma de vino) was observed during the transect survey.

Howard Air Force Base Area

Arden & Price undertook an evaluation of the natural resources at the former Howard Air Force Base in 2004 (Arden & Price, 2001). The study found that there were seven main terrestrial ecosystem types in the Howard area: mixed forest; high forest; low forest;

deciduous forest; savanna; and, grassland (herbazal). The dominant species in the high deciduous forests were *Hymenaea courbaril* (locust), *Brosimum* sp. (verbá), and *Astronium graveolens* (fox). *Spondias mobin* (jobo), *Luehea seemannii* (Guácimo colorado), and *Anacardium excelsium* (espavé) were found as codominants within the semi-deciduous forests. *Luehea seemannii*, *Zuelania guidonia* (acompañada de cagajón), *Spondias mombin*, and *Cupania rufescens* (gorgojo) were dominant in low semi-deciduous forests. Deciduous forest was found only at the summit of a hill at Fort Kobbe and the dominant species were *Vitex* sp. (cuajo) and a type of Fabaceae. Savanna, which was found to occupy only 2% of the vegetated area of Howard, was dominated by *Curatella americana* (chumico), *Hyparrhenia rufa* (faragua), and *Saccharum spontaneum* (paja canalera).

Miraflores Area

Transect surveys were conducted at the Miraflores North (SiteT7) disposal site and the 1939Third Locks Excavation Lagoons (Site T8) as part of the Pacific Side Excavation & Dredging Materials Disposal Study (Moffatt & Nichol, 2004a). This area contains secondary intermediate forest and grasses fragmented by roads and highways. Forest areas are classified as Tropical Humid. Dominant species in the canopy near T7 include *Bursera simaruba*, *Antirhea tricantha*, *Matayba glaberrima* (soapberry), *Guazama ulmifolia* (mutamba), *Apeiba tibourbou*, *Xylopia frutescens* (malagueto), *Attalea butyracea*(American oil palm or palma real), *Hirtella racemosa*, *Cupania rufescens* (gorgojo), *Posoqueria latifolia* (tree jasmine or Boca de vieja), *Coussarea curvigemmnia*, and *Flemingia strobilifera* (wild hops). Dominant species in the canopy near T8 include *Curatela Americana* (chumico), *Bursera simaruba*, *Cecropia peltata* (trumpet tree or yagrumo hembra), *Cochlospermum vitifolium* (silkcotton tree or poro-poro), *Muntigia calabra* (strawberry tree), and *Enterolobium cyclocarpum*.

Several species were observed during the T7 and T8 transect surveys that have international conservation rankings. *Pachira quinata*, *Cedrela odorata* (Spanish cedar or cedro), and *Dahlbergia retusa* (cocobolo) were observed in the T7 transects and are listed as Vulnerable by the IUCN. *Dahlbergia retusa* is also protected under Panamanian law. The orchids *Notylia pentachne*, *Oeceoclades maculate* (monk orchid), and *Oncidium stipulatum* were also observed in the T7 transects; they are listed in Appendix II of CITES. *Cedrela odorata* was also observed in the T8 transects.

A transect survey was also conducted in the vicinity of the 1939 locks excavation as part of the Environmental Evaluation of the New Locks (Louis Berger Group, 2004). Two species of mangroves were identified during the transect survey: *Rhizophora mangle* (red mangrove) and *Pelliceria rhizophora* (tea mangrove). All species of mangrove are protected under Panamanian law.

Grasslands

Palo Seco/Howard AFB Area

Large areas maintained and unmaintained grassland are found within and near the former Howard Air Force Base. Approximately 12 percent of the vegetated area of the Howard complex is covered by grassland. The dominant species in these areas are *Hyparrhenia rufa* (jaraguagrass or faragua), *Panicum maximum* (Guinea grass or paja elefante), and *Saccharum spontaneum* (wild sugarcane or paja canalera).(Arden & Price, 2001). There is a small amount of grassy area associated with the Palo Seco retirement home/hospital.

Miraflores Area

Saccharum spontaneum, *Hyparrhenia rufa*, and *Panicum maximum* are found in grassland areas near Miraflores (Sites T7 and T8) (Moffatt & Nichol et al., 2004a).

Wetlands

The majority of wetlands in the study area appear to be mangrove forests or other types of wet forest. The largest area of mangrove forest in the study area is associated with Río Farfán. Mangroves are also known to exist in the vicinity of the proposed crossing at Miraflores.

Marshland occupies approximately 10 percent of the total vegetated area of the Howard complex (Arden & Price, 2001). The largest areas are located south of Farfan, west of Howard AFB, and north of Fort Kobbe. The dominant species in this area are *Eleocharis fistulosa* and *Typha dominguensis*

There is also some swamp or marshland located between Cocolí and San Juan Hill. Additional wetlands are associated with the UXO/ACP dredge material disposal site located between Farfan and Farfan Hill.

Fauna

Reptiles and Amphibians

<u>Palo Seco Area</u>

Three species of amphibians and 9 species of reptiles were observed during the transect surveys conducted at Palo Seco as part of the Pacific Side Excavation & Dredging Materials Disposal Study (Moffatt & Nichol et al., 2004a). Three of the species observed are protected by Panamanian law and are listed in CITES: *Crocodylus acutus* (American crocodile), *Boa constrictor*, and *Iguana iguana* (green iguana). The American crocodile is also listed as Vulnerable by the IUCN.

Howard AFB Area

Numerous species of reptiles and amphibians were reported at the former Howard AFB. The greatest number of species of reptiles and amphibians was associated with mixed deciduous forest vegetation cover. The least number of reptile species (1) was associated with mangrove forest. No amphibians were observed in the following vegetation cover types: low semi-deciduous forest; deciduous forest; mangroves; and, savanna. Two species protected under Panamanian law were observed: *Iguana iguana* and *Boa constrictor*. Green iguanas were observed in deciduous forests and low semi-deciduous forests. Boa constrictors were observed in mixed semi-deciduous forest. Two species of poisonous snakes were observed in tall semi-deciduous forest: *Bothrops asper* (Central American lancehead) and *Micrurus nigrocinctus* (coral snake) (Arden & Price, 2001).

Miraflores Area

Four species of amphibians and 12 species of reptiles were observed during the T7 transect surveys. Only one amphibian species and 8 reptile species were observed during the T8 transect surveys. Three of the reptiles observed (*Crocodylus acutus*, *Boa constrictor*, and *Iguana iguana*) are protected by Panamanian law and are listed in CITES. *Crocodylus acutus* is also listed as Vulnerable by the IUCN (Moffatt & Nichol et al., 2004a).

Seven species of amphibians and 13 species of reptiles were observed during the transect surveys of the Pedro Miguel/Miraflores area, including the three protected species observed in the T7 and T8 transect surveys (Louis Berger Group Inc., 2004). Two additional protected species were observed: *Caiman crocodilus* (speckled caiman) and *Trachemys venusta* (Tabasco slider). *Caiman crocodilus* is protected under Panamanian law and listed in CITES. *Trachemys venusta* is also listed in CITES.

Birds

Palo Seco Area

Two hundred and twenty-nine (229) species of birds representing 47 families and 19 orders were identified near the South Entrance of the Canal as part of the Biological Inventory for the Canal Alternatives Study (ANCON and University of Panama, 1993). *Cathartes aura* (turkey vulture), a migrant species, was the most abundant species observed during the inventory. *Coragyps atratus* (black vulture) was also present in forested areas. *Columba cayennensis* (pale-vented pigeon), a species protected under Panamanian law, was also observed at the southern entrance of the canal.

A total of 36 species of birds were observed during the transect surveys conducted at Palo Seco as part of the Pacific Side Excavation & Dredging Materials Disposal Study (Moffatt & Nichol et al., 2004a). Eight (8) of the species observed are considered coastal, 3 are game species, and 25 are forest dwelling. Two of the species observed, *Milvago chimachima* (yellow-headed caracara) and *Amazilia t. tzacatl* (rufous-tailed hummingbird) are listed in CITES Appendix II. One Species protected by Panamanian law was observed during the survey, *Ortalis cinereiceps* (gray-headed chachalaca), a game bird. A complete list of birds observed during the Palo Sec transect surveys is presented in Table 21

Table 21: Bird Species Observed During Transect Surveys at Palo Seco

Species	English Common Name	Spanish Common Name	Global Rank	Local Rank
		Coastal Birds		
Actitis macularia	Spotted sandpiper	Playero coleador	G5	NN/BBS
Catoptrophorus semipalmatus	Willet	Playero aliblanco	G5	NN
Numenius phaeopus	Whimbrel	Zarapito trinador	G5	NN
Calidris pusilla	Semipalmated sandpiper	Playero semiplameado		
Eudocimus albus	White ibis	Ibis blanco	G5	N4
Fregata magnificens	Magnificent frigate bird	Fragata magnifica	G5	N5
Pelecanus occidentalis carolinensis	Brown pelican	Pelicano marrón	G4	N4
Phalacrocorax o. olivaceous	Neotropic cormorant	Comorán neotropical		
		Game Birds		
Leptotila v. verreauxi	White-tipped dove	Paloma raiblanco	G5	N5
Ortalis cinireiceps	Gray-headed chachalaca	Chachalaca cabecigris	G5	N3
		Forest Birds		
Ardea h. herodias	Great blue heron	Garza azul mayor	G5	NN
Casmerodius albus egretta	Great egret	Garceta grande	G5	N5
Egretta t. thula	Little blue heron	Garceta nivea	G5	N5
Pandion haliaetus	Osprey	Águila pescadora	G5	NN
Milvago chimachima	Yellow-headed caracara	Caracara cabeciamarilla	G5	N5
Amazilia t. tzacatl	Rufous-tailed hummingbird	Amazilla colirrufa	G5	N5
Chlorostilbon assimilis	Garden emerald hummingbird	Esmeralda jardinera	G4	N4
Chloroceryle americana	Green kingfisher	Martin pescador verde	G5	N5

Sporophila americana hicksii	Variable seedeater	Espiguero variable	G4	N4
Hirundo rustica	Barn swallow	Golondrina tijereta	G5	NN
Progne chalybea	Gray-breasted martin	Martin pechgris	G5	N5
Riparia riparia	Sand martin	Martin arenero	G5	NN/BBS
Stelgidopteryx ruficolis	Southern rough-winged swallow	Golondrina-alirrasposa sureña	G5	N5
Stelgidopteryx s. serripennis	Northern rough-winged swallow	Golondrina-alirrasposa norteña	G5	NN
Cacicus cela vitellinus	Yellow-rumped caciques	Cacique lomiamarillo		
Psarocolius wagleri	Chestnut headed oropendula	Oropéndola cabecicastaña		
Cassidix mexicanus	Boat-tailed grackle	talingo	G5	N6
Scaphidura oryzivora	Giant cowbird	Vaquero gigante		
Turdus grayi casius	Clay colored thrush	Mirlo pardo	G5	N5
Microcerculus marginatus	Southern nightingale-wren	Soterrey-ruiseñor sureño	G5	N4
Elaenia flavogaster	Yellow-bellied elania	Elania penachuda	G5	N5
Myiarchus panamensis	Panama flycatcher	Copetón panameño	G4	N4
Myiozetetes similis	Social flycatcher	Mosquero social	G5	N5
Myiodynastes maculatus	Streaked flycatcher	Mosquero rayado	G5	N5
Tyrannus melancholicus	Tropical kingbird	Tirano tropical	G5	N5

Howard AFB Area

Numerous species of birds were observed in the Howard AFB area. The largest numbers of migratory bird species were observed in the deciduous forest and the savanna (17 species each), while the fewest species (6) were observed in marsh areas. The largest number of resident bird species (67) was observed in mixed semi-deciduous forest, while the fewest number of resident species were recorded from marsh areas.

Four species protected by Panamanian law were observed in the Howard AFB area: *Crypturellus soui* (Little tinamou); *Columba cayennensis* (pale-vented pigeon); *Ortalis cinereiceps*; and, *Dendrocygna autumnalis* (black-bellied whistling duck).

Miraflores Area

Thirty-six bird species were observed during the transect surveys conducted at T7 and 22 species were observed *during the T8 surveys.* Four of the species observed *(Ortalis cinereiceps, Brotogeris j. jugularis, Amazilia t. tzacatl*, and *Amozona ochrocephala*) are protected under Panamanian law. The following species were also observed and are listed in Appendix II of CITES: *Ramphastus sulfuratus*, *Brotogeris j. jugularis*, *Buteo brachyurus*, and *Amazona ochrocephala* (Moffatt & Nichol et al., 2004a).

Fifty-six bird species were observed during the transect surveys conducted near Pedro Miguel, Miraflores, and the 1939 locks excavation for the environmental evaluation of the new locks project (Louis Berger Group, Inc., 2004). Ten of the species were either listed in CITES or given a conservation ranking of Vulnerable or Endangered by the IUCN: *Dendrocygna autumnalis*; *Pandion haliaetus*; *Asturina nitida*; *Polyborus plancus*; *Brotogeris jugularis*; *Pionus menstruus*; *Phaethornis superciliosus*; *Thalurania colombica*; *Amazilia tzacatl*; *Chalybura buffoni*.

Mammals

Palo Seco Area

Eleven species of mammals were observed during the transect surveys conducted at Palo Seco as part of the Pacific Side Excavation & Dredging Materials Disposal Study, including four species of fructiferous bats (Moffatt & Nichol et al., 2004a). Five of the species observed are protected under Panamanian law: *Nasua narica* (white-nosed coati), *Procyon lotor* (northern raccoon), *Dasyprocta punctata* (Central American agouti), *Agouti paca* (paca), and *Dasypus novemcinctus* (nine-banded armadillo). A complete list of the mammals observed during the transect surveys is presented in Table 22

Table 22: Mammal Species Observed During Palo Seco Transect Surveys

Species	English Common Name	Spanish Common Name	Global Rank	National Rank
Didelphis marsupialis	Virginia opossum	Zorra común	G5	N5
Dasypus novemcinctus	Nine-banded armadillo	Armadillo de nueve bandas	G5	N5
Carollia castanea	Chestnut short-tailed bat	Murcielago frugivoro	G5	N5
Carollia perspicillata	Seba's short-tailed bat	Murcielago frugivoro	G5	N5
Artibeus jamaicensis	Jamaican fruit-eating bat	Murcielago frugivoro	G5	N5
Artibeus lituratus	Great fruit-eating bat	Murcielago frugivoro	G5	N5
Agouti paca	Paca	Conejo pintado	G5	N5
Dasyprocta punctata	Central American agouti	Ñeque	G5	N5
Sylvilagus brasiliensis	Forest rabbit	Muleto	G5	N5
Nasua narica	White-nosed coati	Gato solo	G5	N5
Procyon lotor	Northern raccoon	Mapache-gato manglatero	G5	N5

Howard AFB Area

Numerous species of mammals were observed at Howard Air Force Base. The largest number of species (31) was observed in mixed semi-deciduous forest, while the fewest number of species was observed in swamp areas. Seven species protected by

Panamanian law were observed at Howard AFB: *Saguinas geoffroyi* (Geoffroy's tamarin or mono tití); *Nasua narica*; *Procyon lotor*; Lontra longicaudis (American river otter or el gato de agua); *Hydrochaeris hydrochaeris* (capybara or poncho); *Aotus lemurinus* (mono de noche or western night monkey); and *Felis yaguarondi* (jaguarundi). *Liomys adspersus* (Panamanian spiny pocket mouse), an endemic species, was found in deciduous forest, and mixed, tall, and low semi-deciduous forest areas of Howard AFB (Arden & Price, 2001).

Miraflores Area

Ten species of mammals were observed at site T7 and 9 species were observed at T8. Four of these species are protected by Panamanian law (*Nasua narica*, *Dasyprocta punctata*, *Dayspus novemcintus*, and *Procyon lotor*). *Nasua narica*, *Dasyprocta punctata*, and *Procyon lotor* are also listed as Vulnerable by the IUCN (Moffatt & Nichol et al., 2004a).

Transect surveys were also conducted in the vicinity of Pedro Miguel and the 1939 locks excavation as part of the evaluation of the new locks. Five additional protected species were observed during the surveys: *Saguinas oedipus geoffroyi*; *Herpailurus yaguarondi* (jaguarundi or tigrillo congo); *Odocoileus virginianus* (white-tailed deer or venado cola blanca); *Agouti paca* (paca or conejo pintado); *Hydrochaeris hydrochaeris* (capybara or poncho). All of these species are protected under Panamanian law. *Odocoileus virginianus* and *Agouti paca* are listed as Vulnerable by the IUCN. *Saguinas oedipus geoffroyi*, *Herpailurus yaguarondi*, and *Hydrochaeris hydrochaeris* are listed as Endangered by the IUCN. *Saguinas oedipus geoffroyi* and *Herpailurus yaguarondi* are also listed on Appendix I of CITES (Louis Berger Group, Inc., 2004).

Protected, Rare, or Commercially Important Species

Rare and Protected Species

Palo Seco Area

Five species of plants with international conservation rankings or that are protected by Panamanian law are known to exist in the Palo Seco area. *Swietenia macrophylla* is protected under Panamanian law and is listed as Vulnerable by the IUCN. *Pachira quinata* is also listed as Vulnerable by the IUCN. The orchids *Catasetum viridiflavum*, *Vanilla, planifolia*, and *Brasavola nodosa* are listed in CITES Appendix I (Moffatt & Nichol et al., 2004a). Several species of mangrove also exist in the Palo Seco area; all species of mangrove are protected under Panamanian law.

The American crocodile, boa constrictor, and green iguana are known to exist in the Palo Seco area. These three species are protected by Panamanian law and listed in

CITES. In addition, the American crocodile is also listed as Vulnerable by the IUCN (Moffatt & Nichol et al., 2004a).

The rufous-tailed hummingbird and the yellow-headed caracara were observed during the Palo Seco transect surveys. These species are both listed in CITES Appendix II. The gray-headed chachalaca, a game bird protected by Panamanian law, was also observed during the transect surveys (Moffatt & Nichol et al., 2004a). The pale-vented pigeon, another species protected by Panamanian laws was observed in the vicinity of the southern entrance to the canal during the Biological Inventory (ANCON and University of Panama, 1993).

Five species of mammals protected by Panamanian law are known to exist in the Palo Seco area: *Nasua narico*, *Procyon lotor*, *Dasyprocta punctata*, *Agouti paca*, and *Dasypus novemcinctus* (Moffatt & Nichol et al., 2004a).

Miraflores Area

Six species of plants with international conservation rankings or that are protected by Panamanian law are known to exist in the Miraflores area. *Cederela odorata*, *Pachira quinata*, and *Dahlbergia retusa* are listed as Vulnerable by the IUCN. *Dahlbergia retusa* is also protected under Panamanian law. The orchids *Notylia pentachne*, *Oeceoclades maculata*, and *Oncidium stipulatum* are listed in CITES Appendix II (Moffatt & Nichol et al., 2004a). Also, at least two species of mangrove are known to exist near the 1939 locks excavation; all species of mangrove are protected under Panamanian law.

The *Crocodylus acutus*, *boa constrictor*, *Caiman crocodilus*, *Iguana iguana*, and *Trachemys venusta* are known to exist in the Miraflores/Pedro Miguel area. *Crocodylus acutus*, *Caiman crocdilus*, *Iguana iguana*, and *Boa constrictor* are protected by Panamanian law and listed in CITES. In addition, the American crocodile is also listed as Vulnerable by the IUCN (Moffatt & Nichol et al., 2004a; Louis Berger Group, Inc., 2004). *Trachemys venusta* is listed in CITES.

Four species of birds were observed during the Miraflores transect surveys that are protected under Panamanian law: *Ortalis cinereiceps*, *Brotogeris j. jugularis*, *Amazilia t. tzacatl*, and *Amozona ochrocephala. Ramphastus sulfuratus* and *Buteo brachyurus* were also observed. *Ramphastus sulfuratus*, *Brotogeris j. jugularis*, *Buteo brachyurus*, and *Amozona ochrocephala* are listed in Appendix II of CITES (Moffatt & Nichol et al., 2004a).

Nine species of mammals protected by Panamanian law are known to exist in the Miraflores/Pedro Miguel/1939 locks excavation area: *Saguinas oedipus geoffroyi*; *Nasua narico*; *Procyon lotor*; *Herpailurus yaguarondi*, *Odocoileus virginianus*; *Agouti paca*; *Hydrochaeris hydrochaeris*; Dasyprocta punctata; *Dasypus novemcinctus* (Moffatt & Nichol et al., 2004a; Louis Berger Group, Inc., 2004). *Odocoileus virginianus, Nasua*

narica, *Dasyprocta punctata*, *Procyon lotor* and *Agouti paca* are listed as Vulnerable by the IUCN. . *Saguinas oedipus geoffroyi*, *Herpailurus yaguarondi*, and *Hydrochaeris hydrochaeris* are listed as Endangered by the IUCN. *Saguinas oedipus geoffroyi* and *Herpailurus yaguarondi* are also listed on Appendix I of CITES (Louis Berger Group, Inc., 2004).

Commercially Important Species

Palo Seco Area

Twenty–three species of economically important plants were observed in the Palo Seco area during the transect surveys (Moffatt & Nichol et al., 2004a). Species observed include *Pachira quinata*, *Tabeuia rosea*, *Xylopia frutescens*, *Apeiba tibourbou*, *Ceceropia obtusifolia*, *Ochroma pyramidale*, *Swietenia macrophylla*, *Guarea glabra*, *Luehea seemanii*, and *Enterolobium cyclocarpum* (Moffatt & Nichol et al., 2004a).

Miraflores Area

Fifty-seven (57) and 17 economically important plant species were observed during the transect surveys at T7 and T8, respectively. Economically important species observed include *Anacardium excelsium*, *Cederela odorata*, *Cordia alliodora*, *Andira inemis*, *Carludovica palmata*, *Phoebe cinnamomifolia*, *Miconia argentea*, *Pochota quinata*, *Lennea viridifolia*, *Bambusa* ap., *Hyparrhenia rufa*, *Panicum maximum*, *Persea americana*, *Pseudosamanea guachapple*, *Enterolobium cyclocarpum*, *Erythrina fusca*, *Cassia moschata*, *Muntingia calabura*, *Bursera simaruba*, *Pseudobomax sepenatum*, *Spondias mombin*, and *Sterculia apetala*.

Socio-Economic, Cultural, and Archaeological Environment

Introduction

The following sections describe the social-economic aspects and archeological/cultural environments associated with within the Direct Impact Areas (DIA) and Indirect Impact Areas (IIA) associated with the preliminary study related to the Container Terminal and rail/access road development at Palo Seco Peninsula (Project). Due to the preliminary nature of this study, no direct contacts were made with the community leaders or local residents. The data presented in the following sections was obtained from previous studies conducted as part of the Island Development and Disposal Studies at the Pacific Entrance of the Panama Canal and other published information as cited. The data compiled in the on the Island Study was reported to have been obtained from public sources such as the Comptroller of the Republic of Panama. A site visit to these communities that are likely to benefit or impacted from the proposed project was made to verify the data previously collected in the previous studies and to update the information, if applicable.

Jurisdictional Background

The site of the Proposed Container Terminal is in an area that is within the patrimony of the ACP, adjacent to the Pacific entrance to the Panama Canal and just east of the former Howard Air Force Base. The location of the Terminal is very near to the maintained entrance to the Panama Canal Pacific entrance in an area that is routinely maintained and dredged to allow the passage of vessels crossing the Canal. The land use of the Palo Seco area has been formerly utilized as a US military based that housed Howard Air Force Base in an area that covers 3,707 acres, Rodman Naval Station and other military bases such as Kobbe, Cocoli and Farfan. As such much of the land use east of Howard Naval Base has been restricted from development for security reasons. The presence of steep hills along the shoreline and marsh/wetland systems and low lying areas east of Howard has also contributed the lack of development of the area. Howard Air Force Base is currently undergoing re-development. The base has residential infrastructure from the time the United States operated a military complex. Although these residences are no longer in use, the redevelopment efforts at the base will be considered along with several nearby communities that lie west of Howard Air Force Base. These small communities that lie 8 to 12 km west of Howard may experience benefits from the overall development at Palo Seco from such projects as the Kobbe Beach Resort, the proposed Container Terminal as well a continued redevelopment of Howard Air Force Base and the Amador Causeway. Based on the valuation of the Project the following communities lie closer enough to the Project site that may be potentially affected:

- Amador Causeway
- Howard Air Force Base/Kobbe
- Vacamonte

- Veracruz
- La Boca
- Cocolí
- Fort Clayton
- Pedro Miguel
- Paraiso

Social Characteristics of Panama

Although the above communities have specific social characteristics these communities share certain social conditions that are common to all of Panama. The social characteristics that affect these communities can be viewed in the context of the existing social conditions for the entire Republic as described below.

Education

General basic education in Panamá is free and mandatory for the first 9 years. However, children do not always attend school due to traditional attitudes, financial considerations of the family, lack of transportation, and insufficient government resources to enforce the requirement (CIDA, 2004). The lack of education is more predominant in areas outside the main cities of Panamá and Colón within the interior areas of Panama.

According to the UNDP, there are 20 public and private universities attended by 57 percent of the urban non-poor. Only 2.7 percent of the poor and 0.8 percent of the extreme poor have access to a higher education.

In 1997, the estimated adult illiteracy rate for the total population was 8.2 percent for men and 9.5 percent for women. The total illiteracy rate has improved in 2000. The rate improved to 7.5 percent for men and 8.7 percent for women (UN 2004). Illiteracy among indigenous groups is almost 50 percent, compared with 10 percent among the population as a whole (U.S. Department of State, 2004).

The average years of education in the year 2000 were 8.37 years for men and 8.74 years for women (UNDP, 2003). The percentage of the urban population aged between 13 and 19 who attended school was 77 percent for women and 74 percent for men in 1999 (UN, 2004). In 1999, the 25 to 59 years old population had an average of 10.4 years of education in urban areas, whereas the same age group in rural areas had an average of 7.1 years of education (CIDA, 2004). In the same year, the average years of education of the economically active population (15 years old and over) in urban areas were 10.6 years, which are 11.5 years for women and 10.1 years for men. In rural areas, the number of years of education decreases to an average of 7.1 years, which are 9.0 years for women and 6.5 years for men.

Health

Many factors contribute to the overall health of a population. In Panamá many of the indicators associated with the health of the population can be attributed to economic status, location, access to basic services and infrastructure. Based on studies conducted by the Pan American Health Organization in 2001 a profile of Panamá has been reported with highlights of their findings reported in the following sections. The epidemiological monitoring system of Panamá is organized at the local, regional, and central level. The diseases monitored are those included in the International Health Regulations, as well as outbreaks and epidemics, especially measles, rubella, botulism, encephalitis, viral meningitis, food poisoning, and other types of poisoning. Vector-borne diseases are the responsibility of a specific surveillance subsystem.

Several institutions are responsible for the management of water resources, wastewater, and solid waste. These responsibilities of the Institute for Water Resources and the Institute of National Water Supply and Sewerage Systems have initiated the preparation of comprehensive integrated plans for joint surveillance. Several environmental standards have commenced such as wastewater quality standards.

Larger municipalities such as Panamá and San Miguelito are responsible for the management of the solid waste. Waste from the district of Panamá including the project area is transported to the Cerro Patacón sanitary landfill for disposal.

The environmental risks generated by the use of growing quantities of chemical substances has been recognized as an increasing concern which has led to the establishment of the Environmental Planning Unit and the Environmental Health Bureau of the Ministry of Health in 1995. The priority is to conduct research and training projects that will make it possible to reduce or eliminate environmental health risks.

Other environmental laws have been passed to limit emissions from automobiles, and improving indoor air quality in public buildings by prohibiting smoking.

Heath Care Services

Panamá has 251 health centers, 449 sub centers, and 63 hospitals as recorded in 2003. In total, there are 763 sites providing services of varying degrees of complexity, 9 percent of which are concentrated in Panamá Province.

The Ministry of Health carried out 5.6 million health service activities in 1995, which included medical services (71.2 percent), oral health services (14.8 percent), nursing services (10.2 percent), and services provided by technical personnel (3.8 percent). Of this total, 10.7 percent were provided in the national hospitals. Of the 3.98 million outpatient

consultations, 15.7 percent were classified as emergencies and 5.9 percent were performed by specialists.

The Social Security Fund provided 4.65 million consultations in 1996 (31 percent more than in 1992). Of the total consultations in 1996, 12.5 percent were for uninsured individuals. The Fund handled 15,946 births, 18.7 percent of them by caesarean section.

Life Expectancy

As a population, the life expectancy in Panamá at birth rose from 70.1 years in 1980 to 72.7 in 1990 and 74.4 in 2000 for the entire country. For urban areas, the life expectancy is 75.1 years, and in rural areas, 71.5. For women it was 75.4 years; and for men, 71.0 years. The death rate in 2004 was estimated 6.39 deaths per 1,000 people with an estimated 8,938 deaths for 2004. The leading causes of death were malignant tumors (19 percent), cerebrovascular disease (11 percent), accidental injuries and violence (10 percent), myocardial infarction and other ischemic heart disease (10 percent). These five causes accounted for 51 percent of all deaths.

Health of Children

The infant mortality rate per 1,000 live births under the age of 5 years was 25 in 2002. In a 1994 study by the Ministry of Planning and Economic Policy, the infant mortality rate among the indigenous population was 84.1 per 1,000. The leading causes were accidental injuries, other forms of violence, intestinal disorders, and pneumonia. The Prevalence of Malnutrition Survey that health institutions conducted in 1994 showed that 5.2 percent of the population under 5 years of age was suffering from moderate chronic malnutrition (below normal height-for-age) and 3.4 percent from serious chronic malnutrition.

Among the 1,134 deaths in 1993 for children under 1 year of age, registered with medical certification, the leading cause of death was disorders originating during the perinatal period (9.1 per 1,000), followed by congenital abnormalities (4.1), pneumonia (1.3), intestinal infections (0.8), and protein-calorie malnutrition (0.6).

Health of Adults and the Elderly

The 15–60 age group represents 59.1 percent of the country's population. The mortality rate for this group was 5.1per 1,000 in 2004. The subgroup with ages ranging from 20 to 44 years, the leading causes of death were accidental injuries, suicides, homicides and other forms of violence, malignant neoplasms, cerebrovascular disease, acute myocardial infarction, and other ischemic heart disease. In the group aged 45 to 59, the leading cause of death was cardiovascular disease, followed by cancer, accidental injuries and other forms of violence, and ischemic heart disease.

Economic Profile of Panama

Panamá's economy is based primarily on the services sector. The currency of Panamá is Balboa which is equivalent in value to the U.S. dollar. Important economic areas in the country are the Panamá Canal, banking, the Colón Free Trade Zone, insurance, container ports, flagship registry, and tourism. Panamá's chief exports include bananas, sugar, shrimp, other tropical fruits and coffee.

According to preliminary data from the Contraloria General de la Republica de Panama, the gross domestic product (GDP) of Panamá was $13 billion (U.S.) in 2004. The ratio of gross domestic investment to GDP for the same time period was estimated at 27.6 and the ratio of exports of goods and services to GDP was 29.0. The ratio of Panamá's total debt to the GDP was 67.5 in 2002, while the ratio of total debt service to exports was 32.9. In 2002, Panamá owed $8,298 million (U.S.) for total debt outstanding and disbursed and $1,677 million for total debt service (World Bank, 2003).

Panamá's economy is highly dependent on world trade trends and is vulnerable to fluctuations in the global economy due to the strategic importance of the Panamá Canal, shipping, and port services. Panamá's economy enjoyed an annual average real domestic product growth rate of 5.1 percent throughout the 1990s. In FY2004 transits of ocean going commercial vessels were reported to be 12,506, representing an increase of almost 7% over 2003, while Canal cargo tonnage volumes increased from 188.27 to 200.19 million long tons over the same period, a 6.3 percent increase, to the previous year[1].

Imports and re-export activity at the Colón Free Trade Zone decreased in 2002, along with tonnage of major export commodities such as bananas (-5.2 percent) and shrimp (-16.5 percent). Panamá's real GDP growth fell from 2.5 percent in 2000 to 0.3 percent in 2001, but rose to approximately 0.8 percent in 2002 (EIA, 2003) and 5.6% in 2004 (Contraloria General de la Republica de Panama)

Employment

According to 2001 data, the labor force in Panamá comprised 1.1 million workers, with a shortage of skilled labor and a surplus of unskilled labor (CIA, 2003). The average annual growth of the labor force in Panamá during the years 1996-2002 was 1.8 percent (World Bank, 2003). Data from 2002 indicates that the unemployment rate was approximately 16 percent (CIA, 2003). In 1999 the adult economic activity rate in Panamá was 43 percent for women and 80 percent for men, with women making up 35 percent of the total labor force (INC, 2002). According to data from 1995, 61.2 percent of the labor force was employed in the

[1] Panama Canal Traffic, Fiscal Years 2002 though 2004. ACP Corporate Planning & Marketing Division.

services industry, 20.8 percent were employed in the agricultural sector, and 18 percent were employed by industry (CIA, 2003).

Poverty

In 2002, the Gross National Income per capita (Atlas method) in Panamá was estimated at $4,010.00 (World Bank, 2003). Data from 2002 indicates that approximately 37-40 percent of the population lives in poverty, including almost 18.8 percent that live in extreme poverty (EIA, 2003; U.S. State Dept, 2003). These figures are similar to data from 2000 that showed approximately 40.5 percent of the population living in poverty, with 26.5 percent of the population in living in extreme poverty (INC, 2002). Indigenous people suffer the most from poverty, with approximately 69.4 percent of that population living in extreme poverty in 2000 (INC, 2002).

According to World Bank assessments, poverty and extreme poverty are concentrated in Panamá's countryside. Rural poverty is higher in relative and absolute terms, with 788,000 rural residents living in poverty (almost three-quarters of the nation's poor). However, approximately 15 percent of the urban population lives in poverty. Close to 900,000 people, or 40 percent of the urban poor, live in the Panamá City-San Miguelito area (World Bank, 1999).

Economic Activities

Panamá's economy is based on a well-developed service sector that accounted for 77 percent of the GDP in 2002. Other important sectors include industry and agriculture, which accounted for 16 percent and 6.9 percent, respectively, of the GDP in 2002 (World Bank, 2003).

Agriculture

Agricultural activities accounted for 6.9 percent of Panamá's GDP in 2002 (World Bank, 2003). Average annual growth of the agricultural sector declined in 2002, to -0.2 percent from 0.8 percent in 2001 (World Bank, 2003). Data from 1995 indicate that approximately 20.8 percent of the labor force was employed in the agricultural sector (CIA, 2003). Panamá's main agricultural products include bananas and other fruit, corn, rice, sugar, coffee, shrimp, timber, vegetables, and livestock (U.S. State Dept., 2003).

Industry

Industrial activities accounted for 16 percent of Panamá's GDP in 2002, with 6.9 percent of the GDP generated by manufacturing (World Bank, 2003). Average annual growth of industry was 0.3 percent in 2002, up from -5.0 percent in 2001 (World Bank, 2003). Average annual growth of manufacturing was 0.3 percent in 2002, up from -5.6 percent in 2001 (World Bank 2003). Panamá exported approximately $1,218 million (U.S.) of manufactured products in 2002 (World Bank, 2003). Data from 1995 indicate that approximately 18 percent of the labor force is employed by industry (CIA, 2003). Panamá's main industries include construction, petroleum

refining, brewing, production of cement and other construction materials, and sugar milling (CIA, 2003).

Services

The service sector accounted for approximately 77 percent of Panamá's GDP in 2002 (World Bank, 2003). Average annual growth of the service sector was 1.0 percent in 2002, a decrease from 1.6 percent in 2001 (World Bank, 2003). Data from 1995 indicate that approximately 61.2 percent of the labor force was employed by the service sector (CIA, 2003). Services provided include operation of the Panamá Canal and the Colón Free Trade Zone, banking, insurance, container ports, and tourism (CIA, 2003).

The Panamá Canal handled approximately 4 percent of global maritime trade throughout the 1990s (ACP, 2000 in Niesten and Reid, 2001). Between 13,000 and 14,000 vessels traverse the Canal per year (Niesten and Reid, 2001). Approximately two thirds of Panamá's port activities comprise the transfer of containers between ships (transshipment) and approximately $600 million (U.S.) was invested in transshipment infrastructure development between 1995 and 2000 (Bounds 2000 in Niesten and Reid, 2001). In 1998, operations at Colón handled 1.12 million TEUs, more than any other port in Latin America, except Buenos Aires (Bounds, 2000 in Niesten and Reid, 2001). However, Canal transits and tonnage declined 2.3 percent and 2.8 percent, respectively, in 2002 over 2001 (EIA, 2003).

Tourism is also becoming an important part of Panamá's economy. On June 14, 1994, Panamá adopted Public Law Number 8, which offers tax incentives to encourage tourism within the country (ARI 2004). Approximately 402,000 tourists visited Panamá in 1997 (Nationmaster, 2004). According to statistics released by the Instituto Panameño de Tourismo (IPAT), over 800,000 visitors came to Panamá in 2002 and contributed over 678 million balboas to the economy (IPAT, 2004). Scientific research also contributes significantly to Panamá's economy. The STRI research station, which was established on Barro Colorado Island in 1924, is the most extensively studied tropical forest in the world. STRI employs more than 150 Panamánian staff and spends more than $20 million (U.S.) annually in Panamá. Additional funds are spent by the more than 400 scientific researchers who visit STRI each year, by researchers affiliated with foreign universities, and by conservation groups. The estimated overall economic contribution from international sources for scientific investigations is estimated to exceed $45 million (U.S.), annually (PIF, 1996).

Project Social Characteristics

Amador Causeway

The Amador Causeway is located outside of Panama City within the Providence of Panama at the south-eastern tip of the Pacific entrance to the Panama Canal south of the Bridge of Americas. The Causeway was built to provide shelter to ships entering the Panama Canal.

The causeway connects the mainland to three small islands, Naos, Perico, and Flamenco and is considered one of the desirable tourist destinations in Panama.

The northern part of the Causeway which is part of the mainland houses an international hotel that includes a golf course, restaurants and the Balboa Yacht Club, and a convention center and several restaurants. The Frank O. Gehry Museum of Biodiversity is currently under construction on the north end of the Causeway at the mainland. Investments in Causeway have exceeded B/32 million out of a B/60 million investments associated with the first phase of development. Investments projected for the next 20 years are anticipated to be around B/400 million based on the Strategic Plan for Tourist Development of Amador, 1996.

The Causeway extending from the mainland to Flamenco Island is designed as a pedestrian greenbelt with well maintained landscaped areas, paved walkways. The Causeway roadway is a narrow single lane paved road with no shoulders.

Naos Island is the first island in the Causeway that houses the Smithsonian Tropical Research institute marine laboratories and the Marine Exhibition Center.

Perico and Flamenco islands are the next islands traveling south on the Causeway. Perico faces Panama Bay and houses several restaurants. Flamenco Island houses several restaurants and will house a new cruise port and shopping facility. At present, cruise ships anchor just off the Causeway and passengers are shuttled back and forth. The proposed Cruise ship terminal will contain boutiques/stores and commercial offices once it is completed.

Figure 7: General View of Amador Causeway

Source: Island Travel Tours

The Causeway is used widely during the weekends by the local population which has resulted in heavy congestion to vehicular traffic. Studies are underway to evaluate the construction of a

mono-rail or some other form of transportation to the end of the causeway to reduce the number of automobiles

Population and Housing

The Amador Causeway is located within the Corregimiento de Ancon which encompasses an area that covers 664.5 square kilometers and which was at one time controlled by the United States military. The general population of the area indicates that the population of the Corregimiento has grown from 11,518 to 11,169 between the 1990 and 2000 census. The population density of the Corregimiento consists of 16.8 inhabitants per square kilometer with 80% located within urban areas. The distribution of the populated urban areas include the locations of Albrook, Alto de Diablo, Amador, Ancon, Balboa, Corozal, Curundu, Curundu Heights, El Chorillo, La Boca and Los Rios.

The characteristics of the Ancon Area include the following indicators.

Table 23: Population Characteristics of Ancon Corregimiento

Population Characteristics	Value
Average members per household	2.2
Population under 15 years of age, (%)	23.2
Population above 15 to 64 years of age, (%)	69.9
Population over 65 years of age, (%)	6.9
Number of males per 100 females	115.2
Average age of population	33
Male head of household, (%)	75
Female head of household, (%)	25
Birth rate per female	1.9

Source: National Panamanian Comptroller, 2000

The socio demographics of the area as presented in the table above indicate that the majority of the population is between 15 and 64 years of age with an average age of 33. The majority of the population between the age of 15 and 64 provide a large economically active pool of inhabitants. The 2000 census indicates that the population demographics consist of 55.6% males to 44.4% females with a male index of 115.2 males to each 100 females.

The 2000 census indicates that the 53.7 % of the population greater than 10 years of age are economically active and 46.3 % are not economically active. Of the population that claims to be economically active 85.4% are employed and 14.6 % are unemployed. The economically active population is employed as professionals, scientist and other professionals (18%); office employees (17.2%); sales and services not classified in other groups (14.4%), service industry and sales (12.3%); members of government (10.2%); mid-level technical and professionals (8.6%); and other occupations (19.3%). The medium wages of the employed populations is B/565 with males making B/551 and females B/581

The housing characteristics as provided in the 2000 Census indicate 5,149 residences with an average of 2.2 persons pre residence. The distribution of residences included 78% individual units, 20.5% apartments, 0.5 % rooms in homes in the vicinity, 0.6 % communes and 0.4% homeless.

Table 24: Characteristics of Households-2000 census

Characteristics	Number of Homes
Total of Occupied Homes	2,612
Dirt Floors	180
Without potable water	209
Without sanitary service	52
Without electricity	235
Wood powered cooking	131
Without television	313
Without Radio	261
Without phone	705

Source: National Panamanian Comptroller, 2000

Infrastructure and Services

The Amador Causeway and other main roads such as the Bridge of the Americas and the roadway leading to Howard Air Force Base represent the closest roadways that provide access to important areas of commercial, tourism and residential areas. The causeway provides access to various hotels, restaurants, recreational and commercial establishments other interior

paved roads provide excellent access to the interior of the country and into Howard Air Force Base.

Education in the area close to the project site consist of private schools such as the Chinese-Panamanian School, The Slaves of the Heart of Maria, the Mathematic Academy, public schools such as Republic of Japan the National Institute of Fermin Nadeau.

Potable water is available and distributed efficiently throughout the establishments in the Causeway and the Corregimiento. The hotels and commercial establishments are connected to sanitary sewer line.

The majority of inhabitants in the Corregimiento as well as most Panamanians are members of the Catholic religion and practice in various churches located throughout the area. Other religious groups in the area consist of Evangelist Churches, Jehovah's Witness and Seventh Day Adventist.

Palo Seco Long Term Retirement Hospital.

Known for many years as the local hospital for victims of leprosy, the Palo Seco Hospital located on the shoreline is now used as a long term care facility for elderly patients of limited resources. The wooden buildings are reported to be in poor condition, and it is understood that plans are in hand to move patients to another building located within the Howard AFB area.

The hospital is connected to the main highway by a narrow two lane road that is suitable for smaller vehicles.

Howard Air Force-Kobbe Beach

The Palo Seco area includes the former US military complex of Howard Air Force Base, along with the neighboring Fort Kobbe and the Farfan residential zone, were turned over to the Panamanian government in late 1999 as part of a treaty that will transfer all canal operations to Panama. Howard Air force Base covers 3,707 acres and is located in the Pacific sector just 45 minutes from Panama City. Rodman Naval Station and other military bases such as Kobbe, Cocoli and Farfan lie north of Howard and make up the rest of the former military land use for the area. The former Rodman Naval Station has a port facility with three docks and 87 housing units, warehouses, office buildings and other supporting facilities over a 600 acre site.

Figure 8: Howard Air Force Base Facing North

Source: Global Security Organization, 2005

The projected uses for Howard include industrial zones, residential communities, and urban developments. The Dell Computer Customer Calling Center is one of many proposed uses of the existing buildings located at the Base. Other planned industrial operations are currently in the planning stages such as a leather processing facility. The Kobbe Beach Resort currently under construction represents the first major tourist development in the area.

The existing infrastructure at Howard including an airport with a landing strip of approximately 2,591 meters, large enough to handle international cargo planes and a well developed road and highway systems within and near the base, commercial and residential buildings, fuel storage tanks, water and sanitary systems and a state-of-the-art fiber optic telecommunications system increase the potential use of Howard for a multimodal transport centre. The development of a Container Terminal with an associated rail/access road can be considered a mutually beneficial use for both development project and the future of this area as industrial, commercial and tourist area.

The Kobbe Beach Resort is located in a cove south of the proposed project on the western bank of the Panama Canal in an area well shielded by coastal vegetation. The proposed Beach resort is being constructed in an area that was a popular beach destination for the US military. The tourist complex being developed by Empresas Bern and anticipated to be completed in late 2005 will consist of US 12 million investments in the overall master development of the former Howard Air Force Base. Once completed the resort containing 300 rooms will be managed by the Intercontinental Hotel chain.

Source: Golder Associates 2005

Figure 9: Kobbe Beach Resort Cove Facing North

Overall development of the Kobbe as well as Howard Air Force Base is no longer overseen by Authority of Interoceanic Region (ARI) but rather a new agency, Special Economic Agency for Pacific Panama (AAEEPP). The intentions of this agency are to develop the area as a mixed-use land combining commercial, tourists and urban activities.

Veracruz/Bique Bay/Vacamonte

The communities that lie west of the Project site and Howard Air Force Base include the small fishing settlement of Bique Beach, and the communities of Veracruz and Vacamonte. All three communities are located in the Arraijan District within the Province of Panama along the shoreline of the Pacific Ocean.

Population and Housing

The populations of Bique, Veracruz and Vacamonte as of the 2000 census are presented in Table 25. The general population of the Bique Bay area indicates that the population of the community has grown from 261 to 350 between the 1990 and 2000 census. Veracruz

community population shows considerable growth in population between the 1990 and 2000 census of 6,744 to 14,936 inhabitants with a growth in houses for the same period growing from 37 to 6,425. The Veracruz community comprises of 89.2% of the population of the county of Veracruz. The population increase in Veracruz has been fairly constant with birthrates from 1996 to 2000 fluctuating between 428 to 489 per year. Vacamonte's growth has been very similar with a population of 25,281 according to the 2000 census.

Table 25: Population Characteristics of Nearby Communities

Population Characteristics	Bique Bay	Veracruz	Vacamonte
Population	350	14,936	25,281
Housing	86	3,232	6,425
Average members per household	4.10	4.5	3.9
Population under 15 years of age (%)	43	33.9	34.1
Population above 15 - 64 years of age (%)	54.9	61	64.6
Population over 65 years of age (%)	3.1	4.1	2.3
Number of males per 100 females	112.1	106.8	92.8
Average age of population	19.0	23	26
Male head of household, (%)	86.1	77.1	77.4
Female head of household, (%)	14	29	22.6
Birth rate per female	3.5	2.3	1.8

Source: National Panamanian Comptroller, 2000

The socio demographics of the area as presented in Table 25 indicate that the majority of the population is between 15 and 64 years of age with an average age of ranging between 19 and 26 years of age. The majority of the population between the age of 15 and 64 provide a large economically active pool of inhabitants. The 2000 census indicates that the population demographics consist of 51.7% males to 48.3% females with a male index of 106.2 males to each 100 females for Veracruz. The distribution of inhabitants of Vacamonte consists of 44.9% males to 55.1% females with a 92.8 male index.

The 2000 census indicates that the 10.4% of the population economically active is unemployed in Veracruz while Bique Beach has and unemployment rate of 17.4% and Vacamonte has 11.2% unemployed.

The housing characteristics as provided in the 2000 Census indicate that Vacamonte with the largest population of the three nearby communities also has the lowest average persons per household of 3.9. Veracruz the second largest community has 4.5 average persons per household and Bique Bay has 4.10.

The characteristics of the homes in these three communities indicates that Veracruz growth in residences has increased by 92% from 1990 to 2000 and of these homes the number that have dirt floors have grown from 38 to 272 a 600% increase. Other noticeable lack of services are the number of homes without potable water or sanitary services. The characteristics of households in Bique Bay from the 1990 to the 2000 census remain essentially the same with some areas of improvement in the availability of potable water, sanitary services and electricity. Vacamonte has experience such a rapid growth between the 1990 and 2000 census that very little comparison can be made. As a percentage of the overall number of households the percentage of homes with the lack of basic services is quite low compared to the other communities in the area. The number of homes Vacamonte with dirt floors (0.4%), without potable water (0.2%) and without sanitary services (0.08%) are considerably lower than those in Veracruz where the same indicators consist of dirt floor (7.7%), lack of potable water (2.5%) and lack of sanitary services (2.15%).

Table 26: Characteristics of Household, 1990 and 200 Census

Characteristics	Bique Bay		Veracruz		Vacamonte	
	1990	2000	1990	2000	1990	2000
Total Number of Houses	60	86	1,839	3,522	37	6,425
Dirt Floors	19	21	38	272	0	25
Without potable water	27	2	6	88	0	13
Without sanitary service	13	10	34	76	0	5
Without electricity	14	6	176	94	0	20
Wood powered cooking	17	11	48	43	0	3
Without television	0	28	323	381	0	1
Without Radio	28	25	326	520	2	106
Without phone	22	86	1,231	1,834	34	490

Coal fired cooking	57	85	2	2	0	3,177

Source: National Panamanian Comptroller, 2000

Economic Profile of Nearby Communities

Bique Bay is mostly a fishing community involved in artesian fishing and processing shrimp in Vacamonte Port. Other sources of employment consist of women employed as domestic employees in nearby villages, as well as temporary and permanent employment in Panama City, Arraijan, La Chorrera and Vista Alegre.

The majority of the population of Veracruz is employed in the public and private sectors in areas of fishing, mining and excavation, manufacturing, service industry (hotels, restaurants), transportation, construction, and social and health services. Approximately 134 companies operate in Veracruz and employ 239 employees that generate and income of B/12.3 million per year. According to the 200 census the above activities employ 52% of the total employment of the area.

Fishing is another important economic in the area. Several companies provide services to the fishing economy such as Veracruz International shipyard (ship repairs); Advance Marine Propulsion Systems (equipment sales) and Pesquera Taboguilla S.A. (fish flour processing). In addition local artesian fishing takes place in the area with an average monthly production of 8,400 pounds of fish and an associated income of B/5,200.

Vacamonte City has 252 reported companies operating in the port area engaged in exporting and processing of shrimp, poultry and pork. White and red shrimp are processed for exportation to the United Sates. Mexico, Venezuela and Spain.

The Vacamonte port employs 5,220 which include fishing fleet crews which comprise of 20% of those employed, temporary daily workers that make up 20 to 40% of the work force.

The Port of Vacamonte has 57 companies that range from micro to small firms. Two-hundred and fifty (250) shrimp vessels operate from the port. These vessels fish in deep water as well as in the San Miguel Gulf and from Los Santos to Darien. The catch is processed locally for export and local consumption.

Infrastructure and Services

Existing infrastructure between communities vary considerably. Bique, the smallest community has limited access to educational systems and limited number of available primary grades. Student in grades higher than the third grade must travel to other nearby communities. Services such as electricity are provided by the national system for all communities but Bique has less than 7% of the households with this service. Sanitary services varies but mostly

provided though the use of on-site latrines. Bique relies on the use of the ocean as a means for fishing their main source of income. Nearby roadways serve as the main access to economic, social and cultural resources. The larger communities such as Vacamonte and Veracruz have access to such services as telephone, cable, electricity, sanitary sewage, educational, transportation and educational system and roadways and highways.

La Boca

La Boca is located outside of Panama City in the entrance to the Panama Canal, north of the Bridge of Americas. La Boca connects the Amador Causeway with Balboa Community.

Population and Housing

The total population of La Boca was 217 individuals at the time of the 2000 Census, which represents only 55% the population since 1990 (392 individuals in 1990). The average age of the population is 36 years. The percentage of the population under 15 years old is 19.4 percent. The largest percentage of the population is individuals between 15 and 64 years of age (72.8 percent). Individuals 65 years or older made up 7.83 percent of the population at the time of the 2000 Census.

The illiteracy rate at La Boca is 0 percent and the unemployment rate is 10.35 percent. The average monthly income of employed individuals is 1,390.60/B. The average monthly household income is 2,625.00/B. The housing characteristics as provided in the 2000 Census indicate 68 residences with an average of 3.2 persons pre residence. The 100% of homes in La Boca have potable water and sanitary services.

Infrastructure and Services

La Boca has access to such services as telephone, cable, electricity, sanitary sewage, educational, transportation and educational system and roadways and highways

Cocoli

No statistical data has been reported in the latest 2000 census as a populated area population. Cocoli was an important community of about 2000 inhabitants and employed more than 300 civil and federal positions of the United States Government in the former Canal Zone. Currently the area does not have residents but it does have some activities that are linked with ACP and some private companies.

The center of Cocoli has several houses from the former Canal Zone that are slated to be preserved. These residents have historical significance and are considered to be potential tourist attractions. Adjacent to Cocolí is the old naval base marine barracks and several houses and buildings that provide lodging. Several projects are under study in the area and consist of a multi-center Isthmian Mall consisting of a variety of stores, restaurants similar to the existing Multicentro or Multiplaza. Another project proposed in the year 2001 consists of the

construction of a cruise liner port, low-density resorts, a multi-use stadium, and a light rail system connecting Cocoli with Howard/Kobbe and City of Panama.

Figure 10: Aerial Photograph of Cocoli

Source: Golder Associates

Fort Clayton

Fort Clayton was once one of the most important US Army military installations located at the Pacific entrance to the Panama Canal. During the peak of its operation, it accommodated 20,000 US military and civilian personnel including family members. Fort Clayton's 2,180 acres hosted the U.S. Army Southern Command. The base also contained 1,392 homes, dormitories for 1,754, schools for dependents and several recreational facilities. At the present time Fort Clayton houses numerous high to middle class houses, including the United States Embassy.

Figure 11: Fort Clayton

Source: United States Army, 2004

Population and Housing

The total population of Fort Clayton as recorded in the 2000 Census was 105 individuals, which represents only 26% the population of the 1990 Census (410 individuals in 1990). The average age of the population is 33 years. The percentage of the population under 15 years old is 26.7 percent. The largest percentage of the population is individuals between 15 and 64 years of age (69.5 percent). Individuals 65 years or older made up 3.8 percent of the population at the time of the 2000 Census.

The illiteracy rate at Fort Clayton is 0 percent and the unemployment rate is 7.5 percent. The average monthly income of employed individuals is 3,600.00/B. The average monthly household income is 4,500.00/B. The housing characteristics as provided in the 2000 Census indicate 31 residences with an average of 3.4 persons pre residence. The 100% of homes have potable water and sanitary services.

Infrastructure and Services

Fort Clayton has access to such services as telephone, cable, electricity, sanitary sewage, educational, transportation and educational system and roadways and highways

Pedro Miguel

Population and Housing

The total population of Pedro Miguel was 543 individuals at the time of the 2000 Census, which represents a loss in population since 1990 (810 individuals in 1990 compared to 543 individuals in 2000). The average age of the population is 41 years. The percentage of the population under 15 years of age is 16 percent. The largest percentage of the population is individuals between 15 and 64 years of age (63.7 percent). Individuals 65 years or older made up 20.3 percent of the population at the time of the 2000 Census.

The illiteracy rate at Pedro Miguel is 0.43 percent and the unemployment rate is 20.3 percent. The average monthly income of employed individuals is 489.70/B. The average monthly household income is 1,017.00/B, while average monthly income per capita is 535.26/B.

The housing characteristics as provided in the 2000 Census indicate 175 residences with an average of 3.0 persons pre residence. The 100% of homes in Pedro Miguel have potable water and sanitary services. The number of homes in Pedro Miguel without television (4.0%), without Radio (5.7%), and without phone(8.6%).

Infrastructure and Services

Pedro Miguel has access to such services as telephone, cable, electricity, sanitary sewage, educational, transportation and educational system and roadways and highways.

Paraiso

Paraiso, one of the oldest settlements in the Canal Zone that dates back to the first settlements used by the French Canal Company in 1882 located north of the Pedro Miguel Locks on the western side of the Pacific entrance. The community was founded on dredged material excavated from the construction of the Canal. Currently it is one of the fastest growing communities on the Pacific side of the Canal. At least twice within the past 15 years it has been abandoned and revived.(CZBrats, 2005)

Figure 12: Looking north up the Culebra Cut from Cerro Luisa. The town of Paraiso is in the foreground.

Source: Norms page, internet, 2005

Population and Housing

The total population of Paraiso was 1,087 individuals at the time of the 2000 Census. This represents a slight decrease from 1990 (1,095 individuals in 1990 compared to 1,087 individuals in 2000). The average age of the population is 29 years. Individuals between the ages of 15 and 64 years make up the largest percentage of the population (66.3%), followed by those under 15 years (22.5%), and individuals 65 years or older (11.2%)

The illiteracy rate at Paraiso is 1.08 percent and the average unemployment rate is 22.1 percent. The average monthly income of employed individuals is 383.20/B. The average monthly household income is 771.40/B and the average monthly income per capita is 406.00/B

The housing characteristics as provided in the 2000 Census indicate 283 residences with an average of 3.0 persons pre residence. The 100% of homes in Paraiso have potable water and

sanitary services. The number of homes in Paraiso without television is 1.8 percent, without Radio is 7.8 percent, and without phone service is 20.1 percent.

Infrastructure and Services

Paraiso has access to such services as telephone, cable, electricity, sanitary sewage, educational, transportation and educational system and roadways and highways

Historical & Cultural Resources

The Isthmus of Panama links the natural environments and cultures of North and South America. For millennia, the isthmus has served as a migration corridor for fauna and a transmission corridor for cultural ideas. Human occupation of Panama dates back to at least 10,000 years ago, but it is likely that human migrated through Panama much earlier than we now have records for. Panama currently a full record of human occupation from the Paleoindian Period through modern times (Norr, 1996).

Prehistoric, pre-Colombian, and colonial archaeological sites have been discovered in Panama, including some larger sites associated with prehistoric chiefdoms on the Pacific slope. One of the most notable finds was at Venado Beach, formerly part of Fort Kobbe. Refuse beds and burials were unearthed during land clearing activities conducted by the U.S. Military. A total of 369 bodies were recorded at the Venado Beach burial grounds. Burials consisted of individual and grouped graves. Of particular interest is the fact that many of the individuals buried at Venado appeared to be victims of suicide, human sacrifice, or ritual mutilation (Lothrop, 1954). Burial urns and elaborate gold jewelry were found with some of the bodies. The grotesque Coclé style jewelry depicted monstrous objects with both human and animal attributes. Many of the jewelry pieces found at the Venado burial site are believed to be trade pieces that were produced elsewhere and brought to the Venado region (Lothrop, 1956). The Venado Beach site has been given a radiocarbon date of 227-60 A.D. from a typical burial urn at the site (Deevey, et al., 157 in Bull, 1965).

Another important prehistoric site was discovered at Farfan Beach during excavation of a gun position during the 1940s. A refuse deposit midden was uncovered that contained fire-cracked rocks and soil, as well as large quantities of sherds. The pottery discovered at the Farfan midden fall into three distinct categories: dishes, bowls, and bottles. Two burial urns were also discovered but they show no signs of use. Sherds, shells (conch and scallop), stone artifacts (manos, a celt, and a sharpening stone), and burial urns were located in disturbed soil. Human bone fragments were found inside one of the urns. The age of the site and the length of occupation were undetermined (Marshall, 1949).

An archaeological discovery was also made at Palo Seco. This is often called the Engineer's Hill site. The site was first excavated in 1980 and was excavated again in 1981. The site was a

fairly large habituation with a large accumulation of shells, ceramics, and stone materials. The stone tools found include a mano, “nutting stones”, an elongated stone that appeared to be an axe, and flake tools. Sherds of labial flanged globular and necked globular vessels were found as well as two fragments of Spanish majolica. The cultural material examined from the site appears to be within Phase IV as defined by Dr. Richard Cooke, dated between 150 and 450 A.D. (Aguilú, 1980; Yanguez, 1981).

In spite of the important finds in the Palo Seco region, no systematic surveys have been conducted there. Undiscovered or unrecorded archaeological remains are likely to exist in the area. The submerged areas of the coastal shelf may also be archaeologically significant since some 50 km of former dry land along the southern shore of Panama Bay has been inundated since the end of the Pleistocene era by rising sea levels (Moffat & Nichol et al., 2004b). However, this inundated zone is so vast that the small potentially affected areas offshore are unlikely to contain uniquely significant sites that would merit the extraordinary effort needed to properly excavate them.

Visual Landscape

The potential for visual impacts associated with the Project depends upon two primary factors:

- the visual character and quality of views or vistas that may be obstructed by structures (or lack of structures)
- the reduction in forest or vegetation along the shoreline of Palo Seco, and the degree of viewer exposure and sensitivity from Amador Causeway.

The visual character is related to the existing characteristics in the immediate area of proposed container terminal. Viewer exposure is related to the number of viewers, the distance between the viewer and the obstruction or reduction in vegetation cover, the view direction, areas from which the landscape can be viewed and the visual impacts associated with light and noise generated from the proposed development.

The existing visual character of the area is primarily undeveloped and densely vegetated along the coastline with the exception of the hospital located at the shoreline of the proposed location of the project. The project lies in an area that is designated as with the industrial activities associated with the operation of the Panamá Canal at the Pacific entrance, and commercial and tourist establishments along Amador Corridor. The proposed project will result in the creation of an artificial island located near the shoreline to avoid the reduction of certain trees, shrub or other vegetation that currently make up the shoreline. The visual appearance associated with the project will require a detailed assessment during subsequent studies. The assessment should quantify the level of visual impact likely to be experienced from an envelope of visual receptors within the proposed project. The large scale of infrastructure associated with a container port including cranes, vessels, and storage container units, as well as lights and noise

associated with the operation will result in various degrees of adverse visual impacts. The visual envelope will extend predominantly across the Amador Causeway which will require computer modeling of the project, using simulated conditions of various equipment in the most obtrusive positions.

Fauna Found in the Panama Canal Watershed With International Conservation Rankings

(from Appendix F of Volume 1 of the

Panamá Canal Gaillard Cut Widening Feasibility Study 1987, PMCC Report 1989, Biological Inventory Report 1993, Condit et al. 2001, and InfoNatura, 2004)

Class	Scientific Name	English Common Name	Spanish Common Name	CITES Status	IUCN Status	Endemic to Panamá
Mammalia	*Tamandua mexicana*	Northern Tamandua	Oso Hormiguero Común	3		
Mammalia	*Dasypus novemcinctus*	Nine-banded armadillo	Armadillo Narizón Común		LR	
Mammalia	*Dasyrprocta punctata*	Central American agouti	Ñeque	3		
Mammalia	*Speothos venaticus*	Bush dog	Perro de Monte	1	VU	
Mammalia	*Urocyon cinereoargenteus*	Grey fox	Zorro Gris		LR	
Mammalia	*Lontra longicaudis*	Neotropical River Otter	Lobo de Agua	1	DD	
Mammalia	*Nasua narica*	White-nosed coati	Cozumbo	3		
Mammalia	*Panthera onca*	Jaguar	Tigre, Jaguar	1	NT	

Mammalia	*Leopardus pardalis*	Ocelot	Tigrillo	1	LR	
Mammalia	*L. wiedii*	Margay	Tigrillo de Cola Larga	1	LR	
Mammalia	*Herpailurus yaguarondi*	Jaguarundi	Yaguarundi	1	LR	
Mammalia	*Puma concolor*	Puma	Puma	2	LR	
Mammalia	*Trichechus manatus*	West Indian Manatee	Manatí	1	VU	
Mammalia	*Tapirus bairdii*	Baird's Tapir	Danta	1	VU	
Mammalia	*Tayassu pecari*	White-lipped peccary	Chancho de Monte	2		
Mammalia	*Pecari. tajacu*	Collared peccary	Javelina	2	LR	
Mammalia	*Mazama americana*	Red brocket deer	Corzuela Roja	DD		
Mammalia	*Alouatta palliata*	Golden-mantled howling monkey	Mono Congo	1		
Mammalia	*Ateles geoffroyi*	Geoffroy's spider monkey	Mono arana colorado	2		
Mammalia	*Saguinus geoffroyi*	Geoffroy's tamarin	Tití de Chocó	1		
Mammalia	*Aotus trivirgatus*	Night monkey	Musmuqui	2		
Mammalia	*Aotus lemurinus*	Lemurine night monkey	Mono Nocturno Subtropical	2	VU	
Mammalia	*Cebus capucinus*	White-faced capuchin	Mono Capuchino	2		

Aves	*Dendrocygna viduata*	White-faced whistling duck	Pato de Cara Blanca	3		
Aves	*Cairina moschata*	Muscovy duck	Pato real	3		
Aves	*Elanus leucurus*	White-tailed kite	Milano Cola Blanca	2		
Aves	*Elanoides forficatus*	Swallow-tailed kite	Milano Tijereta	2		
Aves	*Leptodon cayanensis*	Gray-headed kite	Gavilán Cabeza Gris	2		
Aves	*Chondrohierax uncinatus*	Hook-billed kite	Gavilán Pico Gancho	2		
Aves	*Harpagus bidentatus*	Double-toothed kite	Gavilán Bidentado	2		
Aves	*Ictinia plumbea*	Plumbeous kite	Milano Plomizo	2		
Aves	*Accipiter superciliosus*	Tiny hawk	Gavilán Chiquito	2		
Aves	*Buteo magnirostris*	Roadside hawk	Aguililla Caminera	2		
Aves	*B. jamaicensis*	Red-tailed hawk	Aguililla Cola Roja	2		
Aves	*B. albonotatus*	Zone-tailed hawk	Gavilán Negro	2		
Aves	*Buteogallus anthracinus*	Common black-hawk	Gavilán Cangrejero	2		
Aves	*Harpia harpyja*	Harpy eagle	Harpía	1	NT	
Aves	*Spizaetus tyrannus*	Black hawk eagle	Águila Crestada Negra	2		
Aves	*Herpetotheres*	Laughing	Halcón Guaco	2		

	cachinnans	falcon				
Aves	*Micrastur ruficollis*	Barred-forest falcon	Halcón-Selvático Barrado	2		
Aves	*M. semitorquatus*	Collared-forest falcon	Halcón Collarejo	2		
Aves	*M. mirandollei*	Slaty-backed forest falcon	Halcón Dorsigris	2		
Aves	*Milvago chimachima*	Yellow-headed Caracara	Chimachima	2		
Aves	*Falco peregrinus*	Peregrine Falcon	Halcón Peregrino	1		
Aves	*Brotogeris jugularis*	Orange-chinned parakeet	Perico Ala Amarilla	2		
Aves	*Pionus menstruus*	Blue-headed parrot	Loro Cabeciazul	2		
Aves	*Amazona autumnalis*	Red-lored parrot	Loro Cachete Amarillo	2		
Aves	*A. farinosa*	Mealy parrot	Loro Corona Azul	2		
Aves	*A. ochrocephala*	Yellow-crowned parrot	Loro Coroniamarillo	2		
Aves	*Ara macao*	Scarlet macaw	Guacamaya Roja	1		
Aves	*A. chloropterus*	Red and green macaw	Guacamayo Rojo Verde	2		
Aves	*A. severa*	Chestnut-	Guacamaya	2		

		fronted macaw	Frenticastaña			
Aves	*Lophostrix cristata*	Crested owl	Buho Cuerno Blanco	2		
Aves	*Pulsatrix perspicillata*	Spectacled owl	Buho de Anteojos	2		
Aves	*Strix virgata*	Mottled owl	Buho Café	2		
Aves	*S. nigrolineata*	Black and white owl	Buho Blanquinegro	2		
Aves	*Tyto alba*	Barn owl	Lechuza de Campanario	2		
Aves	*Dendrocygna autumnalis*	Black-bellied whistling duck	Sirirí Vientre Negro	3		
Aves	*Penelope purpurascens*	Crested guan	Pava Cojolita	3		
Aves	*Crax rubra*	Great Curassow	Hocofaisán	3	NT	
Amphibia	*Atelopus zeteki*	Golden frog	Rana dorado	1	E	YES
Amphibia	*Atelopus limosus*		Sapo Limisa		NT	YES
Amphibia	*Dendrobates auratus*	Poison dart frog		2	LC	
Amphibia	*Phyllobates lugubris*	Lovely poison frog		2		
Reptilia	*Oscaecilia ochrocephala*				LC	YES
Reptilia	*Crocodylus acutus*	American crocodile	Lagarto aguja	1	VU	
Reptilia	*Caiman crocodilus* ssp. *fuscus*	Brown caiman	Babilla	2		

Reptilia	*Iguana iguana*	Green iguana	Iguana verde	2		
Reptilia	*Boa constrictor*	Boa constrictor	Boa constrictor	2		

CITES Status

Appendix 1 - Species are rare or endangered, and trade will not be permitted for primarily commercial purposes.

Appendix 2 - Species are not rare or endangered at present, but could become so if trade is not regulated.

Appendix 3 - Species are not endangered, but are managed by the listing nation.

IUCN Status

CR - critically endangered; a calculated probability of extinction during the next 10 years of >50%

DD - data deficient; there in inadequate information to make a direct, or indirect, assessment of its risk of extinction.

EN - endangered; calculated probability of extinction during the next 20 years of >20%

LC - does not qualify as critically endangered, endangered, vulnerable, or near threatened (2001)

LR – does not satisfy the categories of critically endangered, endangered, or vulnerable (1996).

NT - is close to qualifying for critically endangered, endangered, or vulnerable status

VU - vulnerable; calculated probability of extinction during the next 100 years is >10%

APPENDIX C - WAVES & HYDRODYNAMIC MODELING

Wave & Protection Assessment

Wave studies were connected for the first Artificial Island project by Moffatt & Nichol and also by JETRO. In both studies, the wave climate in the region of the potential island construction due to Pacific Ocean waves was evaluated to determine wave protection requirements and potential ship motion characteristics for marine terminal options. This analysis involved the development and evaluation of the offshore metocean data and the transformation of the offshore wave climate to the study region.

An overview of the results of the evaluation is presented in this section and the reader is referred to Appendix F of the Artificial Island Study (2003) for a more complete discussion on the offshore and near shore wave climates.

Wave Hindcasts

Methodology

A 31 year wave hindcast was obtained from Oceanweather Inc., covering the period from early 1970 through the end of the year 2000. The hindcast process involves the collection of historical wind and wave data from a number of locations and the transfer of the wave data to a given site, based on wind data, bathymetry and physical characteristics of the study zone.

The hindcast used Oceanweather's Global Reanalysis of Ocean Waves (GROW) model to produce a time series of wave parameters at a location just offshore of the entrance to the Gulf of Panama. The global oceans covered in the GROW model are divided into a 0.625 by 1.25 degree latitude/longitude grid with wave and wind fields archived every three hours. In order to determine the offshore deepwater wave condition, the hindcast wave data were obtained for GROW2000 model grid point 30275, located at 6.875° latitude and 280.0° longitude, just offshore of the Gulf of Panama as shown in Figure 13 The model output included a time series of significant wave height, wave direction, and wave period every three hours for the entire 31 year period (1970-2000). This point was selected because it is located in an area that captures the wave climate from the predominant directions expected to impact the site.

Figure 13: Location of Deep Water Wave Model Grid Point

To allow for more direct analyses, the raw wave hindcast data were summarized by counting the number of occurrences of particular events within defined bins, or specific ranges of values. The wave data were grouped in 0.25 meter bins, the wave period data in 2 second bins, and the wave direction data in 5 degree bins. The frequency of occurrence of specific events was summarized monthly and annually. The monthly data consisted of the total occurrences of a particular event during a given month over the 31-year time series. The annual data were for all occurrences of a particular event over the entire 31-year time series. By grouping the data this way, it was possible to calculate percent occurrence and percent exceedance values for the different wave conditions.

Joint frequency tables are provided in Appendix F-Part A of the Artificial Island Study for the whole period of hindcast for the following pairs of variables:

- Significant wave height (Hs) by peak wave period (Tp)
- Peak wave period (Tp) by mean wave direction (degrees clockwise from North)
- Significant wave height (Hs) by mean wave direction

Offshore Wave Climate

As seen in Figure 13, wave energy can only reach the entrance to the Gulf of Panama from a restricted direction due to the geometric shape of the Gulf itself and the surrounding geography. The only significant wave energy that could have affected the Artificial Island area was from a window extending from south to west-southwest (180°–247.5°). For this project, protection is

further increased by the presence of the Amador Causeway and the shadow effect of Taboga and Taboguilla Islands.

The offshore fetch to the south is limited by the west coast of Ecuador which blocks some of the large swells that originate near the Antarctic. The Azuero Peninsular at the western edge of the entrance to the Gulf of Panama limits wave energy from the northwest to west.

The Pearl islands and other islands within the Gulf and the geometric configuration of Panama Bay also provide additional shelter from offshore waves. Consequently, any waves at the site generated from these restricted directions will primarily be the result of local winds, likely resulting in shorter period waves of limited height and energy.

Significant Wave Height

Figure 14 shows the percent occurrence of significant wave height monthly and annually. The graph illustrates that most significant wave heights are between 0.5 and 2.5 meters. Predominant wave heights are centered around 1.00 -1.25 m for the months of December to April and 1.50 -1.75 meters for the months of July to November.

Figure 14: Percent Occurrence of Significant Wave Height

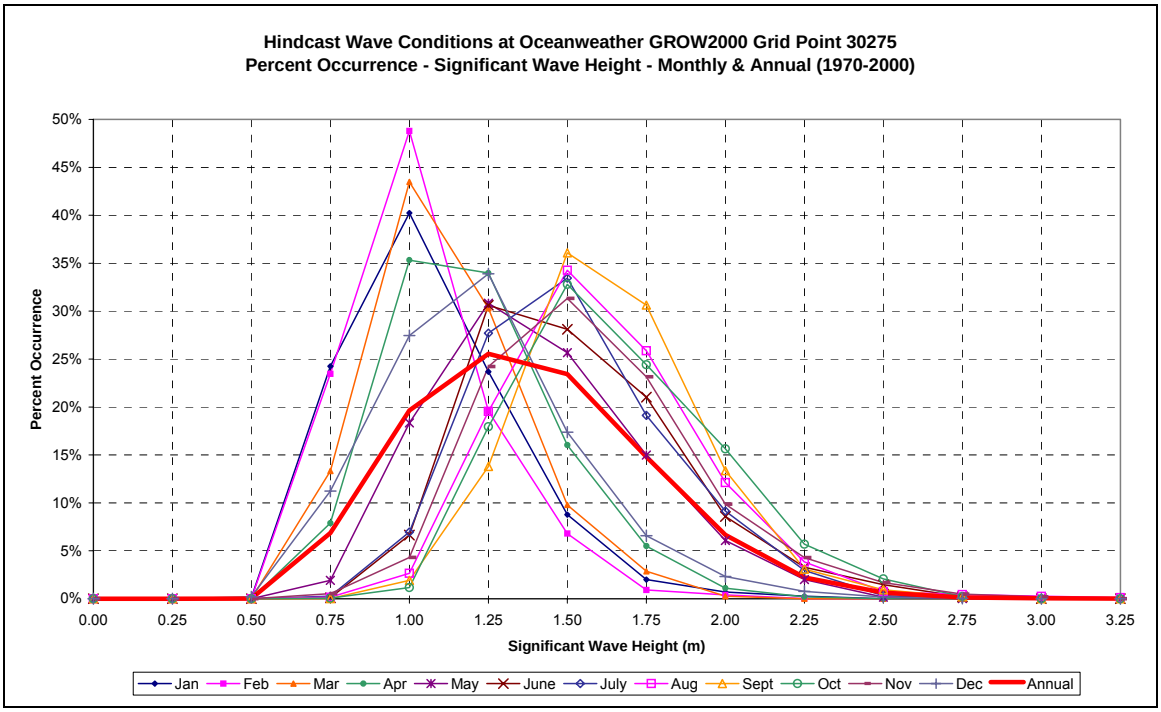
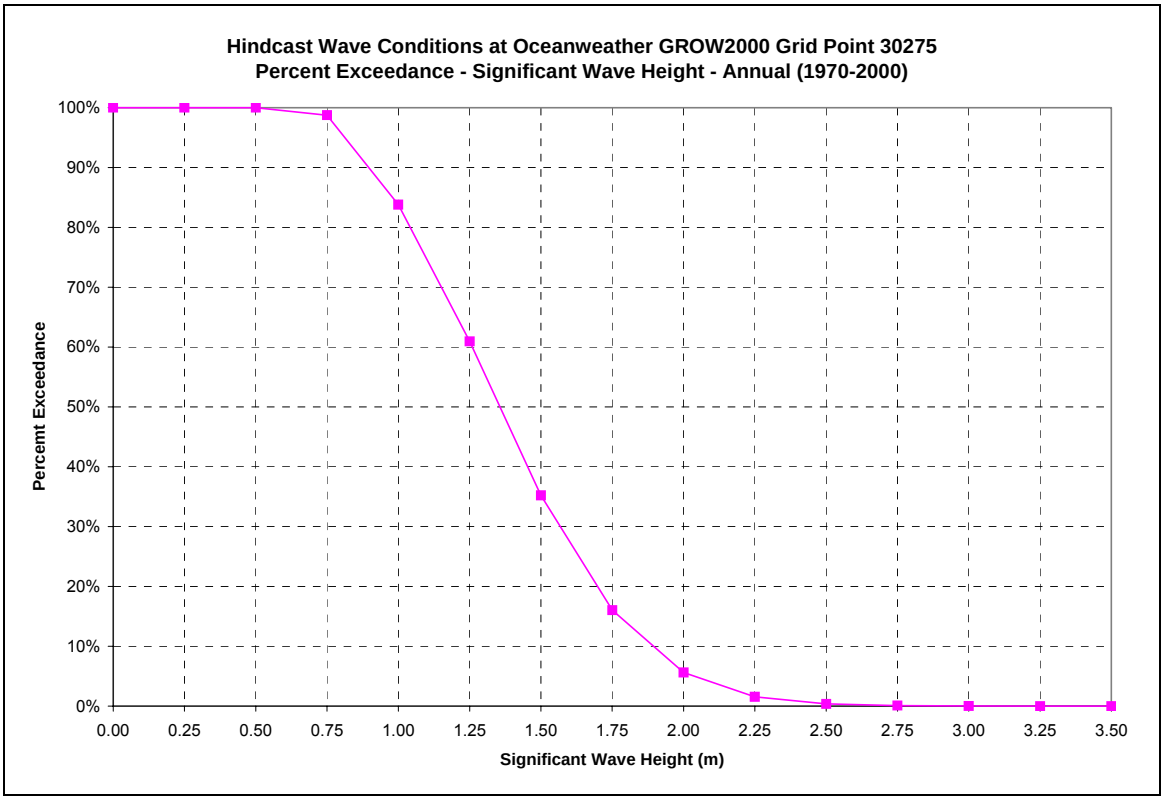


Figure 15 provides the deepwater wave exceedance curve for significant wave heights. From the figure, it can be seen that the offshore wave climate is relatively mild, with significant wave heights rarely exceeding 2 meters.

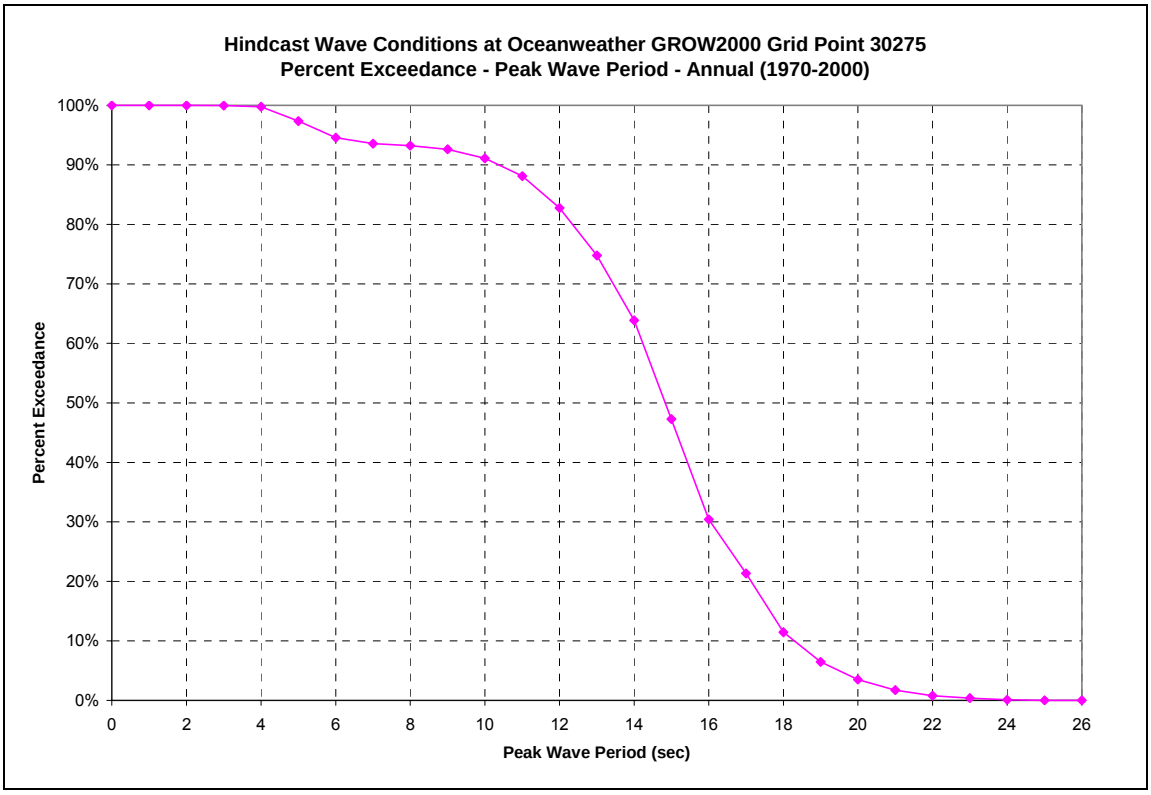
Figure 15: Percent Exceedance of Significant Wave Height



Wave Period

Figure 16 illustrates the percent exceedance of wave periods within the 31-year hindcast record. From the graph, it can be seen that over 80% of the peak offshore waves are of periods between 10 and 18 seconds.

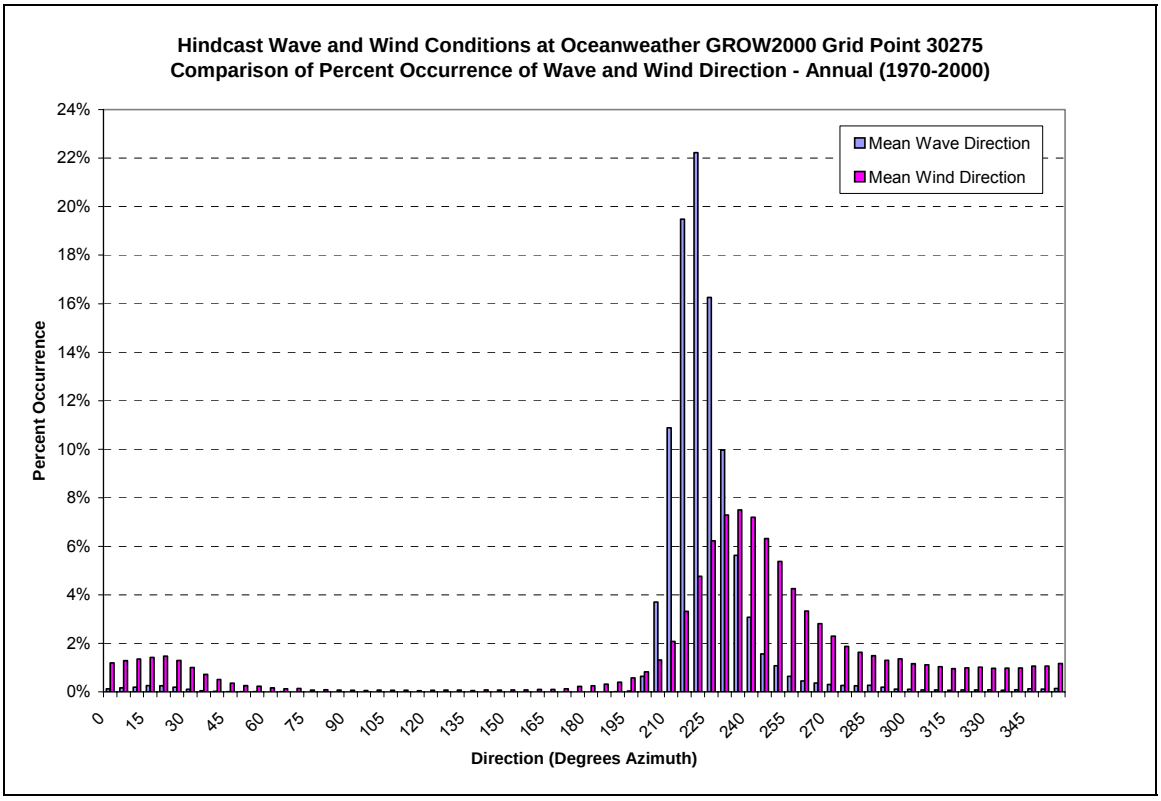
Figure 16: Percent Exceedance of Peak Wave Period



Wave and Wind Direction

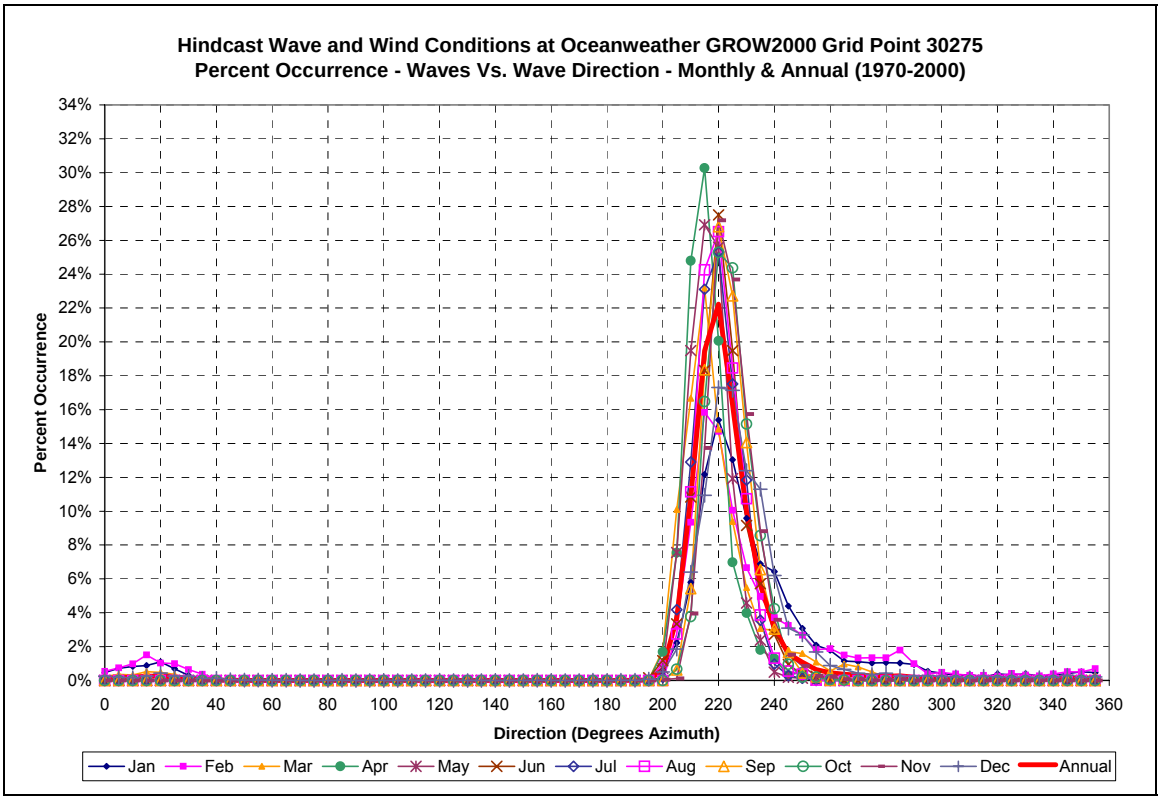
The relatively small range of offshore wave directions, limited by the geographic configuration of Central and South America, is clearly illustrated in Figure 17. Most waves arrive at the entrance to the Gulf of Panama from 200 to 250 degrees. The offshore hindcast wind field is slightly shifted from the mean wave directions and is more distributed. The wind is not constrained by the land configuration in the same manner as waves.

Figure 17: Percent Occurrence of Waves and Wind by Direction



The percent occurrences of waves by mean wave directions are graphed for monthly and annual conditions in Figure 18. This graph reveals little seasonal variation in the offshore wave direction.

Figure 18: Percent Occurrence of Waves vs. Wave Direction



Tides

Tidal ranges for stations within the Gulf of Panama were obtained from the British Admiralty Tide Tables and are presented in Table 27. The overall tidal range within the Gulf is approximately 4 to 5 meters.

Table 27: Astronomical Tide Level Characteristics within the Gulf of Panama

Location	LAT N	LONG W	Mean High Water Springs (MHWS)	Mean High Water Neap (MHWN)	Mean Sea Level (MSL)	Mean Low Water Neap (MLWN)	Mean Low Water Spring (MLWS)
Rio Chepo*	8°59’	79°07’W	4.8	3.9	2.5	1.2	0.2
Balboa*	8°57’	79°34’W	4.9	3.8	2.6	1.1	-0.1
Punta Garachine	8°05’	78°25’W	4.2	3.3	2.2	1.1	0.2
San Telmo Bay	8°18’	78°54’W	4.2	3.3	2.1	1.1	0.2
Bahia Pina	7°34’	78°11’W	4.1	3.2	2.1	1.1	0.2
Punta Malla	7°28’	80°00’W	3.3	2.4	1.7	0.9	0.1

*Permanent Tidal stations closest to project region

Tide levels referred to Chart Datum (m).

For this study, the wave transformation model was run at both MHWS and MLWS, with the high and low tidal elevations taken to be 4.8 meters and 0.2 meters respectively.

Extremal Wave Analysis

Return periods of 2, 5, 10, 20, 50 and 100 years were computed for significant wave height. The extreme analysis shown in Table 28 was based on annual maximum significant wave heights for the 31 year hindcast record and used a Type I (Gumble) distribution approach.

Table 28: Return Periods and Wave Heights

Return Period (years)	Significant Wave Height (m)
2	2.6
5	2.8
10	3.0
20	3.2
50	3.4
100	3.6

Wave Transformation Analysis

Methodology

As deepwater waves propagate toward shore and into shallower water, they are modified both in direction and height, due to interaction with the sea floor. It is important to quantify these transformation effects so that a deepwater wave climate may be adapted to describe the nearshore climate at the site of interest. A wave model was required to transfer the offshore wave climate to the proposed vicinity of the artificial island. Regional grids were developed to take waves of various periods from deepwater to the near-shore project region. Given the added protection and orientation of the berth faces for this latest project, it can be assumed that the adoption of the values from the original project represents an extremely conservative approach to the new location.

The Danish Hydraulic Institute, MIKE21 Parabolic Mild-Slope Model (PMS) was used for this study. This model is a parabolic linear refraction / diffraction model that takes into account the effects of refraction and shoaling due to varying depth, diffraction along the perpendicular to the predominant wave direction and energy dissipation due to bottom friction and wave breaking. It is based on a parabolic approximation to the elliptic mild-slope equation governing the refraction, shoaling, and diffraction of linear waves propagating over a gently sloping bathymetry.

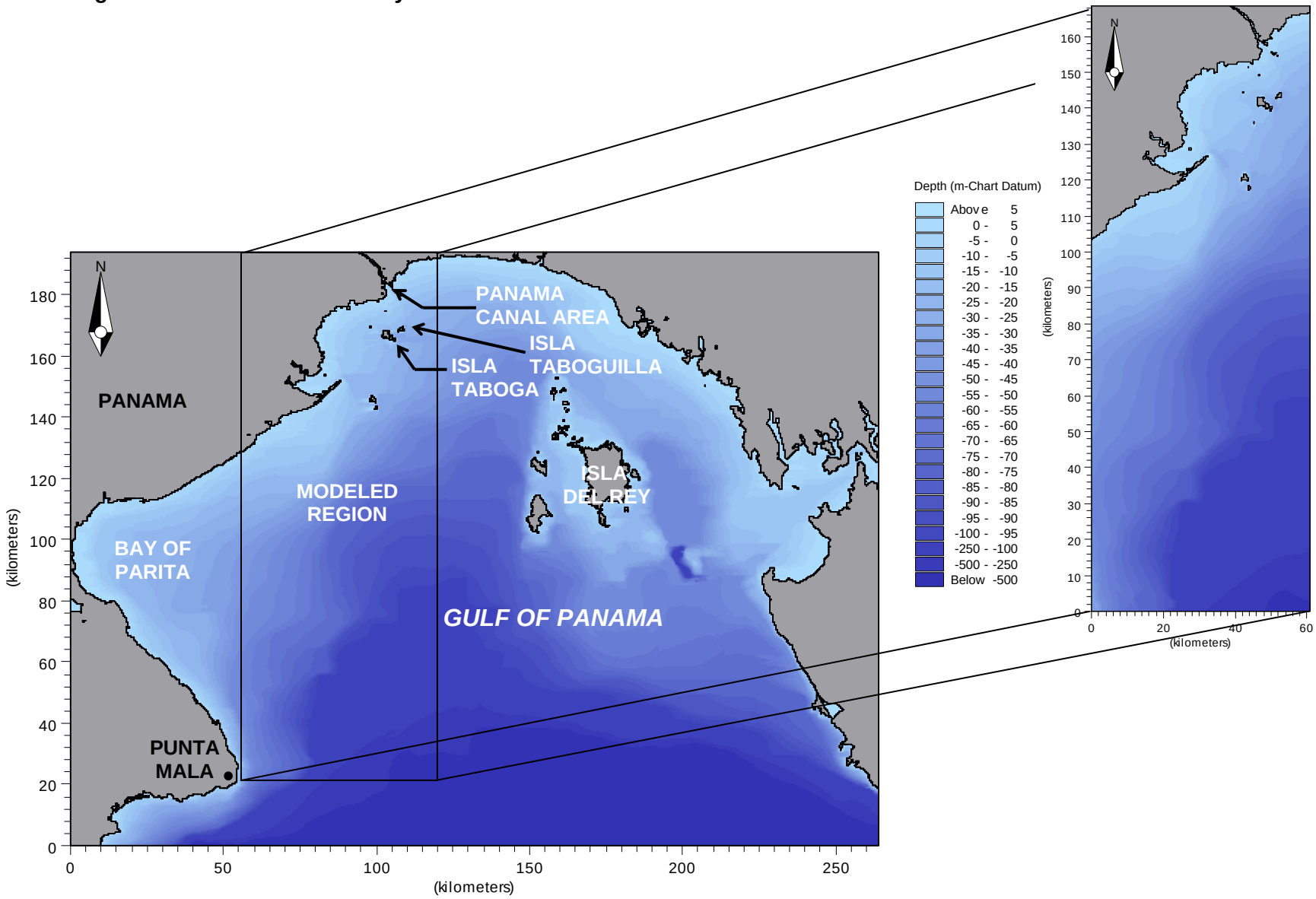
Bathymetry

The bathymetry data for the inshore wave analysis was obtained from nautical charts (Admiralty – Chart 1929: “Gulf of Panama” and Chart 1401: “Approaches to the Panama Canal”) and the

hydrographic survey of the study region carried out in 2003[2]. Current data with higher resolution of the bathymetric information in the study region, especially near the site where the water depths are shallower and wave interaction with the seafloor is increased, provides improved results for wave transformation calculations. The bathymetry for the Gulf of Panama and study region was digitized from this data. All vertical data was referenced to Chart Datum, approximately Mean Low Water Springs (MLWS). From the bathymetry of the Gulf, a smaller model region was extracted as shown in Figure 19.

[2] ACP – January 2003

Figure 19: Inshore Wave Study Limits



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Modeling Approach

In order to transform the deepwater waves to the nearshore wave climate at the site of interest, the offshore waves were divided into representative period-direction pairs. Each pair was propagated and transformed to calculate the wave climate within the study region. Refraction, shoaling, and diffraction were solved numerically over the model area by digitizing the bathymetry into an x-y grid and solving the governing equations at each grid point

The main output data are integral wave parameters such as wave height, peak wave period, and mean wave direction. A normalized unit incident wave, specified by wave period and direction, was modeled for each period-direction component. Grid spacing was selected to provide adequate resolution of the bathymetry and the waves within reasonable computer storage and processing requirements.

Modeled Wave Conditions

Wave model runs were performed for water depths corresponding to Mean Low Water Spring (MLWS) and Mean High Water Spring (MHWS), taken as 0.2 m and 4.8 m, respectively, above bathymetry datum (chart sounding datum). Based on the previous offshore wave climate analysis, wave periods from 6 to 20 seconds and wave directions from 200 to 240 degrees were chosen for the wave transformation model runs.

Unit wave heights were modeled for each wave period-direction pair with wave periods taken every 2 seconds and with a directional interval of 5 degrees. In order to provide relatively smooth model results and to more closely represent the natural variation of actual wave conditions, JONSWAP spectra with minor frequency and directional spreads were used to represent the offshore boundary wave conditions.

Modeling Region

As shown in Figure 19, the bathymetry grid for the modeling region was approximately 60 by 168 kilometers. From the larger Gulf of Panama bathymetry grid, a computational grid with uniform spacing in both the x and y-directions of 30 x 30 meters was interpolated and used to calculate transformation of the waves with periods of 14 to 20 seconds. This provided a minimum of 10 grid points per wavelength in deepwater and adequate resolution as the wavelengths are reduced in shallower water. The 12-second models were run using the bathymetry grid with a higher resolution of 20 X 20 meter grid spacing.

Figure 20 shows the initial model grids and the reduced bathymetry grids for the 6-10 second model runs, relative to the original modeling region. The length of the model grid was chosen based on diffraction behavior and the wave angle with respect to Punta Mala. For the shorter period waves, the grid was shortened a point in line with the shielding afforded by Punta Mala and where the water was still deep with respect to the wavelength (no refraction), thus allowing the offshore wave conditions to be representative at the boundary.

Figure 20: Existing Bathymetry for Reduced Modeling Grids

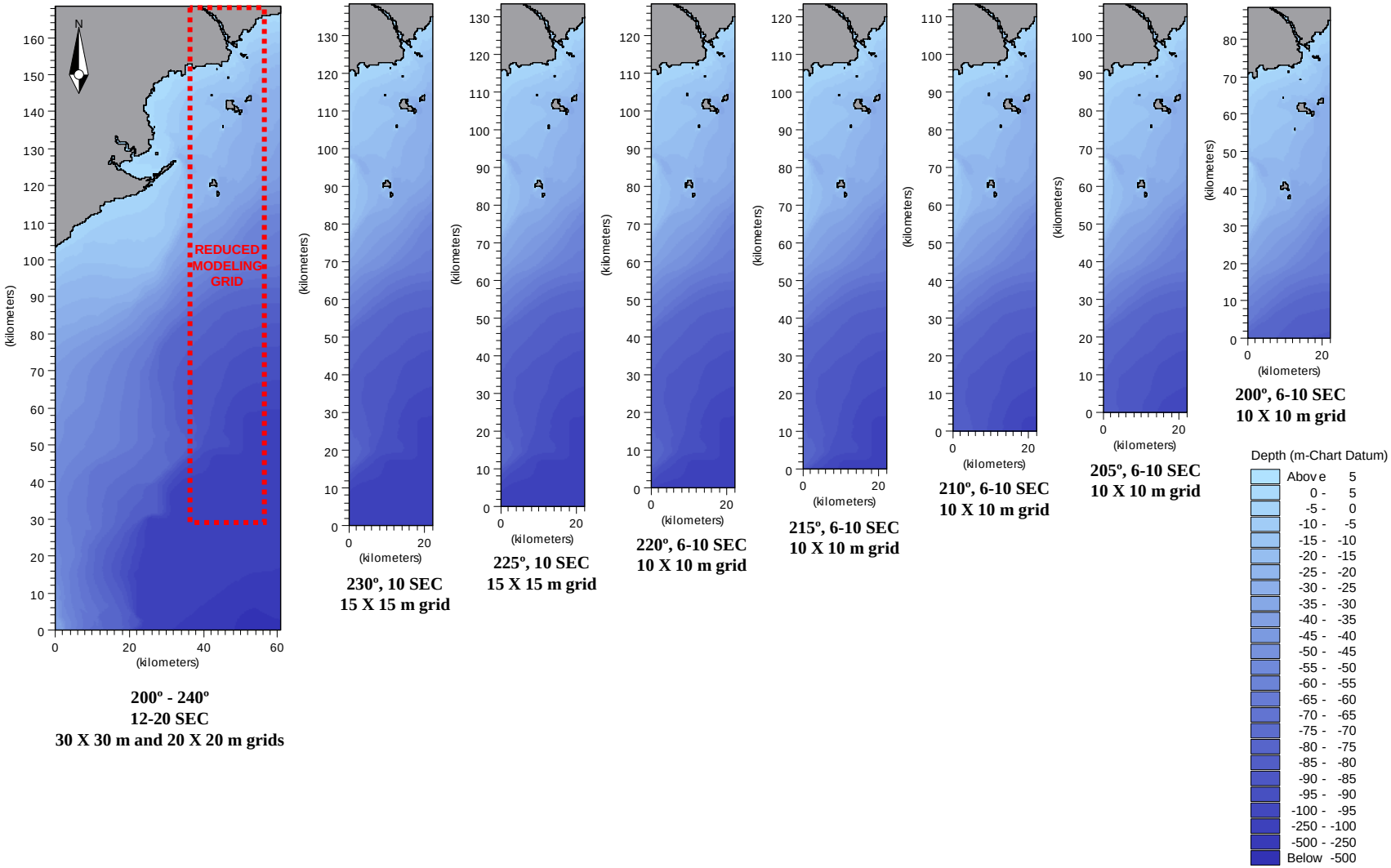

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Table 29 lists the grid size used for the entire matrix of model runs. As shown in the table, some of the steeper angle model runs were eliminated. Based on the PMS results for the 12-20 second waves, it was found that the steeper directions did not result in significant energy reaching the proposed site. In the event that less than 1% of the offshore wave height remained near the site for the 12-second model runs, all lower period model runs were eliminated (e.g. 235°- 240 °). The 6-8 second model runs were likewise eliminated for the 225° -230° directions, based on the 10-second wave results.

Table 29: Grid size used for Wave Model runs

Wave Direction (degrees)	Wave Period (sec)							
	6	8	10	12	14	16	18	20
200	10 m	10 m	10 m	20 m	30 m	30 m	30 m	30 m
205	10 m	10 m	10 m	20 m	30 m	30 m	30 m	30 m
210	10 m	10 m	10 m	20 m	30 m	30 m	30 m	30 m
215	10 m	10 m	10 m	20 m	30 m	30 m	30 m	30 m
220	10 m	10 m	10 m	20 m	30 m	30 m	30 m	30 m
225			15 m	20 m	30 m	30 m	30 m	30 m
230			15 m	20 m	30 m	30 m	30 m	30 m
235				20 m	30 m	30 m	30 m	30 m
240				20 m	30 m	30 m	30 m	30 m

Model Results & Discussion

The typical wave climate due to ocean waves in the area of the proposed artificial islands is relatively mild with the geometry of the Gulf of Panama and South America limiting the directions of waves entering the region. The 100-year return period significant wave height was computed to be 0.7 meters with a 17 second period. These long period swell waves generated by storms in the Pacific occasionally reach the area. However, long period waves can cause considerable movement of a vessel at an unprotected or partially protected berth. This in turn can lead to accelerated fender damage, inefficient or restricted cargo operations and other operational difficulties. The near-shore islands of Isla Taboga and Taboguilla will provide significant protection for container vessel operations at this site.

Locally-Generated Waves

Following the analysis of the ocean waves that would impact the Artificial Island sites, an evaluation of locally-generated waves was performed to assess how wind waves generated within the Bahia de Panama would dictate design conditions. While the original island sites were exposed to relatively long fetches over deep water to the east and southwest, the new location is protected by the Amador Causeway and not subject to waves generated in the Bay of Panama. Consequently, the impacts of locally generated waves are not a significant concern at the new location.

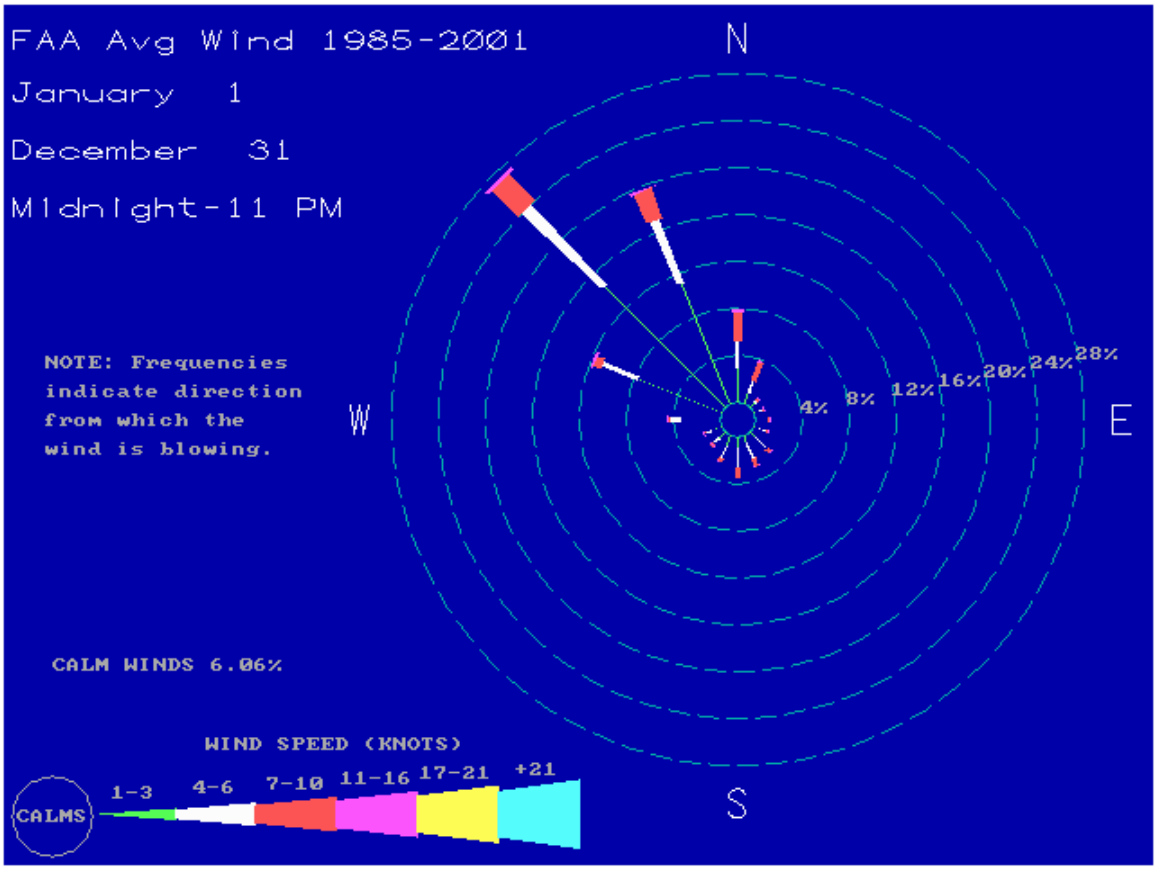
Wind Speed and Direction

Wind speed and direction data were obtained from the Balboa FAA records for the period 1985 through 2001. These data were then used to hindcast the locally-generated waves that would impact the various island locations. The hourly average wind data are presented in Table 30 as a frequency distribution and Figure 21 presents a wind rose graph developed from the same data. The data are presented for sixteen directions and six wind speed ranges, and show that almost 67 percent (66.93) of the winds that have been recorded over the 17-year record most winds are from the WNW to N directions. The records also show that maximum hourly average wind speeds from any direction are generally less than 16 knots, with slightly less than one percent (0.94%) of the recorded winds in the 11 to 16 knot range, which is typical of the tropical coastal conditions.

Table 30: Balboa FAA Hourly Ave. Wind Data 1985-2001, Frequency Distribution

Direction	Speed (knots)						
	1-3	4-6	7-10	11-16	17 - 21	> 21	Total
N	0.029856	0.022474	0.024823	0.001899	0.000000	0.000000	0.079052
NNE	0.010375	0.010932	0.016032	0.001429	0.000000	0.000000	0.038768
NE	0.005805	0.003006	0.001335	0.000081	0.000000	0.000000	0.010227
ENE	0.005999	0.002704	0.000497	0.000013	0.000000	0.000000	0.009214
E	0.007207	0.004402	0.000986	0.000027	0.000000	0.000000	0.012623
ESE	0.005456	0.006422	0.001604	0.000027	0.000000	0.000000	0.013509
SE	0.006402	0.013730	0.003550	0.000040	0.000000	0.000000	0.023722
SSE	0.006342	0.014730	0.006134	0.000047	0.000000	0.000000	0.027252
S	0.009590	0.016898	0.007261	0.000067	0.000000	0.000000	0.033815
SSW	0.010133	0.011079	0.002946	0.000054	0.000000	0.000000	0.024212
SW	0.007778	0.006228	0.001765	0.000060	0.000000	0.000000	0.015831
WSW	0.010314	0.004765	0.000778	0.000047	0.000000	0.000000	0.015904
W	0.035003	0.008147	0.001758	0.000107	0.000000	0.000000	0.045015
WNW	0.078072	0.031366	0.007194	0.000705	0.000000	0.000000	0.117336
NW	0.145850	0.094554	0.031332	0.003664	0.000000	0.000000	0.275400
NNW	0.110874	0.058712	0.026863	0.001087	0.000000	0.000000	0.197536
Total	0.485055	0.310148	0.134858	0.009355	0.000000	0.000000	
FREQUENCY of CALM WINDS = 0.060584							

Figure 21: Balboa FAA Hourly Average Wind Data 1985-2001 Frequency Distribution Wind Rose



Wave Hindcast Computations

Using the above data, wind-generated wave calculations were completed for the southwest and east directions. In accordance with procedures recommended by the U.S. Army Corps of Engineers (USACE), Coastal Engineering Manual (CEM) (USACE 2001), a radially averaged fetch distance was computed for the two directions (70 km from east and 24 km from southwest as stated above). Wave conditions were hindcast along these fetch directions for the maximum hourly average winds observed over the period of record. Water levels were evaluated using MHWS over the average water depths within the radial fetch window. Average water depth to the east is about 30 m; to the southwest about 12 m. Waves were hindcast for a 16 knot (8 m/s) wind speed using methods published in the CEM.

Hindcast results are presented in Table 31for significant wave height (H_s), maximum wave height ($H_{2\%}$), and peak spectral wave period (T_p), respectively. Hindcast results predicted significant wave heights of about 1.0 m from the east and 0.6 m from the southwest. These wave heights are comparable to those from the Pacific Ocean that have been reduced due to protection from the islands as shown in the wave modeling discussed above.

These waves could impact operations on the west face of the island in the event that additional berths are constructed at the rear and south faces of the Container Terminal.

Table 31: Locally-generated Significant Wave Heights (m), Maximum Wave Heights ($H_{2\%}$), and Peak Spectral Wave Periods (sec)

Wave Direction	H_S	$H_{2\%}$	T_P
East	1.0	1.8	4.1
Southwest	0.6	1.1	3.1

Conclusions

The wave analyses carried out for the Artificial Island Study showed two separate sets of dynamics controlling the wave conditions within the study area. Panama Bay is well protected from ocean swells generated in the Pacific Ocean, which limits the expected 100 year significant wave height at the island site to 0.70 m from the south or south west, with a 17 second period. Locally generated wind waves are higher at 1.0 m from the east, with a 4.1 second period, but the site is well protected by the Amador Causeway.

According to the wind data used for this analysis, the 1.8 m maximum wind generated wave from the south and southwest is of very short duration. The new location for the Container port is much better protected than the original Artificial Island concept, but the potential for a short duration storm with long period regular waves from the Pacific and the high tidal range at Panama could cause significant damage to inadequately protected faces of the island in a short period of time.

In general terms, any wave period in excess of 7 seconds is considered to be “long” and possibly problematic from a ship motion standpoint. Given the high level of protection afforded by Taboga and Taboguilla to the south and the Amador Causeway to the east of the project site, it is not expected that long period waves will be a significant concern for vessels at the main berth face.

However, as a cautionary measure, it is strongly recommended that a wave gauge with the capability to detect long period waves should be installed for at least a 12 month period at the project site before final design work is commenced on the project. This gauge may be either bottom mounted or a wave rider style with capabilities for automatic transfer of data to a receiving station plus a storage capacity within the unit itself.

Hydrodynamic Model Update

Introduction

This analysis of the hydrodynamic conditions at the proposed project location is an extension of the work done as part of the Feasibility Study for the Construction of an Artificial Island at the Pacific Entrance to the Panama Canal, presented in the Panama Bay Existing Conditions Hydrodynamic Model draft report (ECHM 2002) submitted to ACP by Moffatt & Nichol in November 2002 and the Panama Bay Island Alternative P1-A Assessment of Impacts on Existing Hydrodynamic and Water Quality Conditions draft report (P1-A_AIEHWQC 2003) submitted to ACP by Moffatt & Nichol in January 2003.

Model Description

The hydrodynamic model for this study was developed using the Delft3D modeling system. The model used in this study is based on the local model developed and presented in ECHM 2002 and also applied in P1-A_AIEHWQC 2003. The numerical model grid was originally developed to study the hydrodynamic impacts of an island alternative located north of Isla Taboga, therefore the highest model resolution (130 m) was defined in that location. On the other hand, because the new project site is located near the Farfan Peninsula better model resolution is required at the project area and also at the canal entrance. A refined grid (50 m) has been developed that covers the project area and the canal entrance.**Error! Reference source not found.**, shows the refined model grid coverage in the new model setup together with the extent of the existing local model grid.

Figure 22 shows a detailed view of the model grid and bathymetry at the project area. This refined grid has a dynamic coupling with the local model grid used in the previous studies. Open boundaries, wind forcing and other model parameters are the same described in ECHM 2002.

Model bathymetry from sources described in ECHM 2002 have been supplemented with ACP in 2003 and a channel survey in the Pacific entrance area, carried out by APC in early 2005.

Figure 22: Hydrodynamic Model Grid

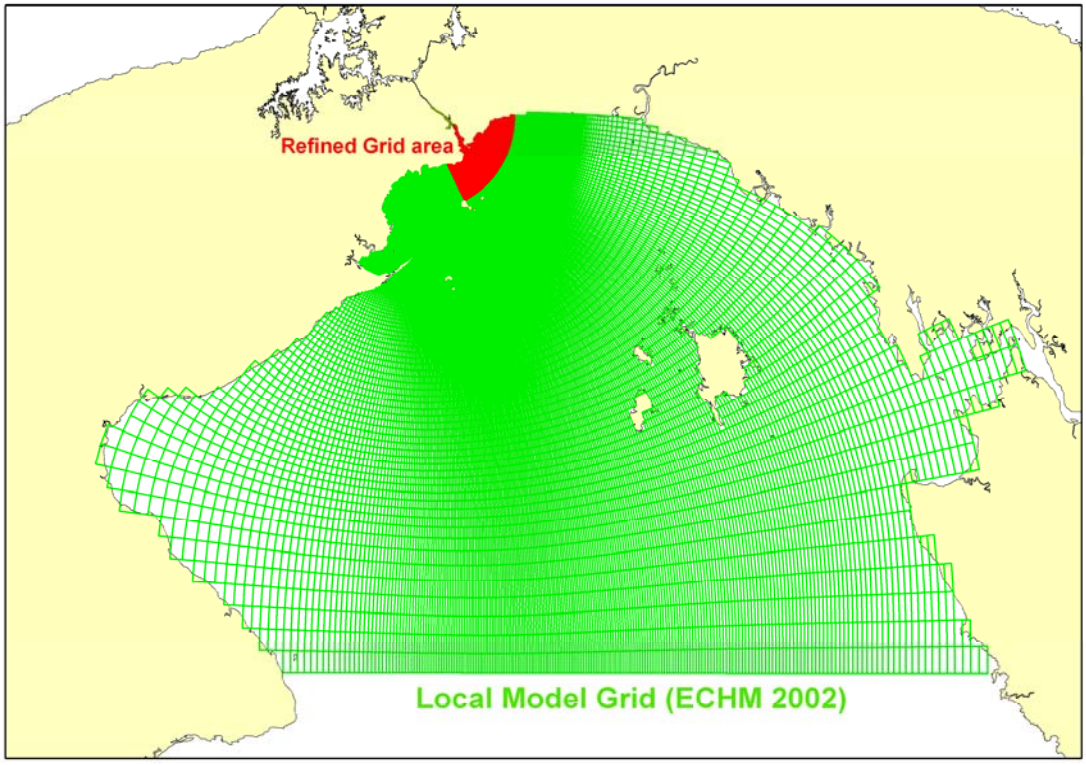
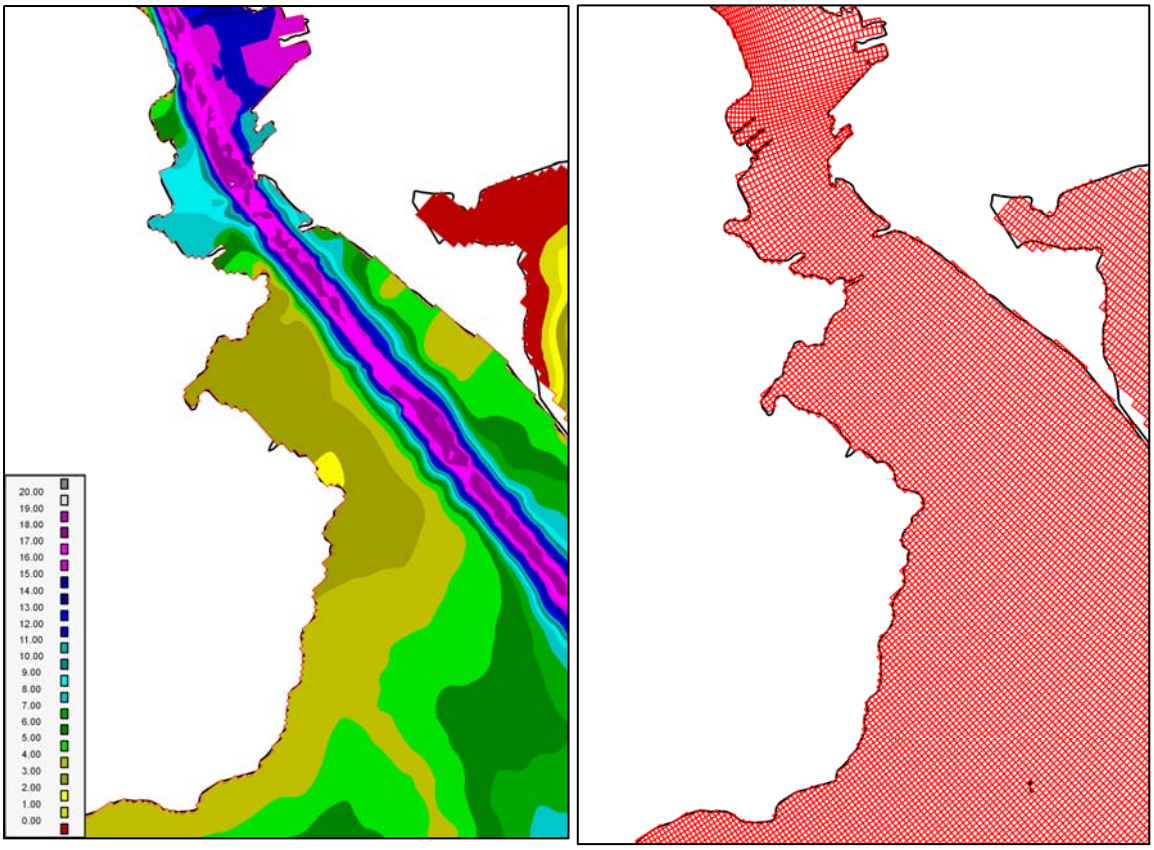


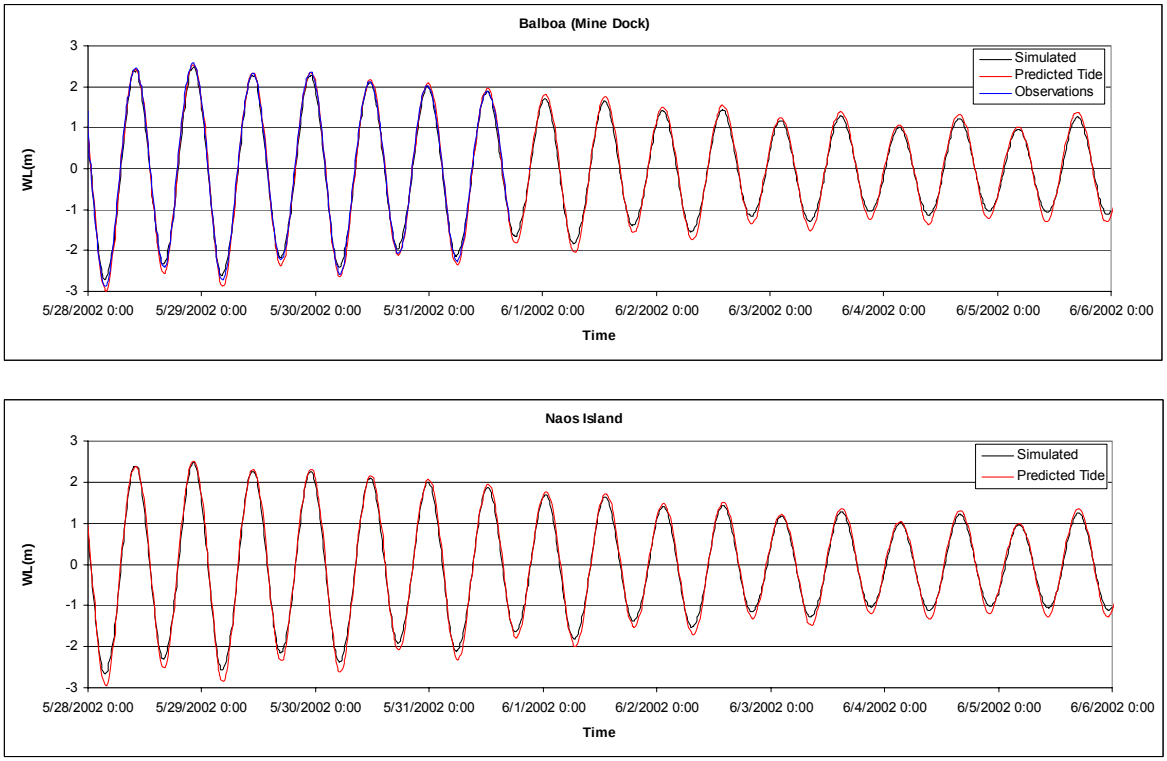
Figure 23: Detail model bathymetry (Left) and grid (Right) in the vicinity of the project area and entrance channel



Model Verification

The local model presented in ECHM2002 was calibrated and verified using water level and currents data collected by ACP during the summer of 2002. In order to verify the validity of the refined model grid and bathymetry, model results at Balboa/Mine Dock and Naos Island were compared to observations (at Balboa only) and predicted tides. Time series of water levels are presented in Figure 24. Root Mean Square (RMS) of the differences and the correlation between observed and modeled water levels at Balboa for the period 5/28/2002 to 6/1/2002 are respectively 0.128 m and 0.998.

Figure 24: Observed water levels, predicted tides and model predicted water levels at Balboa and Naos Island

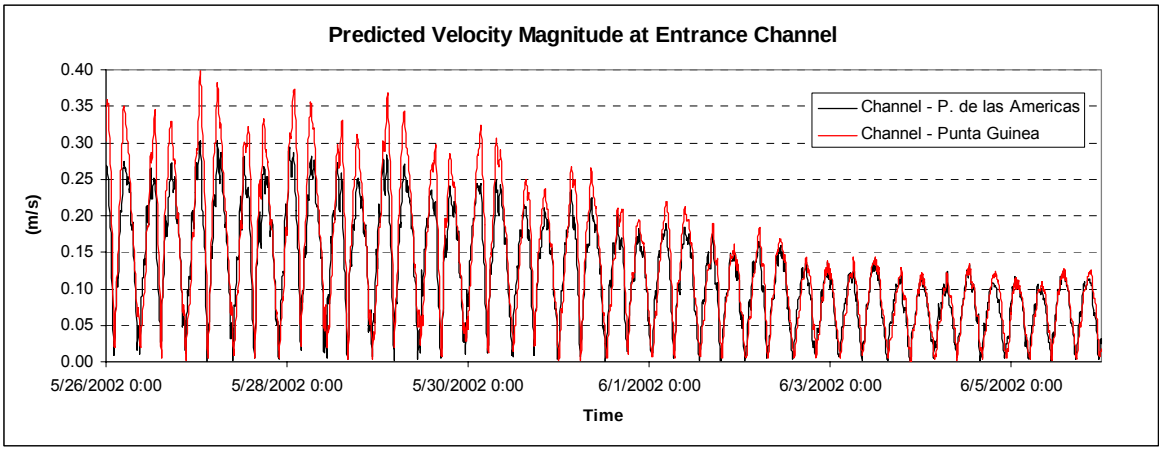


In addition, during the fall of 2002 ACP collected current data along two alignments (Puente de las Americas and Punta Guinea) at the canal entrance during the four stages of the tide and during spring and neap tides. At the Puente de las Americas alignment observed maximum depth average ebb and flood velocities at the channel vary between 0.2 and 0.4 m/s during spring tide and 0.2 to 0.3 m/s during neap tide. At the Punta Guinea's alignment observed maximum depth average ebb and flood velocities at the channel vary between 0.25 and 0.45 m/s during spring tide and 0.2 to 0.3 m/s during neap tide.

The simulation period used in this study (05/25/02 to 06/06/02), which is the same used previously in ECHM2002, covers a spring/neap cycle similar to the one observed in November 2002, when the current measurements were collected. Tidal amplitudes during the spring tide on 05/27/02 and neap tide on 06/02/02 were very similar to the spring and neap tides when the measurements were collected. On those dates, the model predicts at the channel near Punta Guinea maximum velocities of 0.3-0.4 m/s during spring tide and 0.15-0.2 m/s during neap tide. At the Puente de las Americas alignment the maximum velocities predicted by the model are

0.25-0.3 m/s during spring tide and 0.15-0.18 during neap tide. Figure 25 presents time series of the model predicted velocities at the entrance channel approximately at the location where observations were collected.

Figure 25: Model predicted velocity magnitude at the entrance channel



It has to be noted that model predicted peak discharges across a section located at the Puente de las Americas are in the order of 1,500 m^3/s during spring tide and about 800 m^3/s during neap tide. These values are much higher than the normal operation discharges through the locks, therefore discharges through the locks have not been included in the model since there influence is expected to be very small.

Hydrodynamic impact assessment

Comparison of model results for existing conditions and for the proposed island location were carried out for spring and neap tides at the four stages of the tide (low water, peak flood, high water and peak ebb). The same 14-day period (5/25/02 to 06/06/02) used in ECHM2002 was simulated, which includes spring and neap tides. **Error! Reference source not found.** to **Error! Reference source not found.** present flow patterns from the existing condition model during spring and neap tides and for the four stages of the tide. In addition, those figures also show the differences in the magnitude of the velocities between the with-project and the existing conditions simulations.

The effects of the island on the flow patterns are localized in the vicinity of the project. For most of the tidal stages it is observed an increase of velocities at the south and south-east and north-west tips of the island and at the pass between the island and the shore. Maximum observed current magnitude under with project condition at the tip of the island is in the order of 0.3-0.35 m/s at Peak Flood and Peak Ebb during Spring Tide. These areas of higher velocities may require special provision for scour protection, although in order quantify these effects a more detailed study would be necessary.

A reduction in the magnitude of the currents is observed mainly at the west side of the island (and to a minor degree north east of the island) due to the blocking effect of the project to southwest and northeast moving currents. The largest reduction is observed during Peak Ebb at Spring Tide extending from the island west to Punta Bruja. Area west and northeast of the Island will be relatively quiescent and prone to increased sedimentation as a combination of the possible wave sheltering (specially the northeast area) and the current reduction.

The increase in current magnitude at the navigation channel and area between the artificial island and the Amador Causeway is between 2.5-5 cm/s during Peak Flood and Peak Ebb at Spring tide, when the current magnitudes are maximum (0.35-0.4 m/s). During the other tidal stages, changes at the navigation channel are less than 2.5 cm/s.

In general, the largest changes in flow patterns are observed during Peak Flood and Peak Ebb situations. These changes (less than 5-10 cm/s in magnitude) are limited to the area surrounding the project. In addition, the flows through the area where the island is located are dominated by the tidal exchange and little influence of the coastal current is observed since this area is sheltered of this westward moving current by the Amador causeway.

Figure 26: Flow patterns during PEAK FLOOD SPRING TIDE (2002/05/27 06:00) under existing and with project conditions. Bottom: flow magnitude differences (with project – existing conditions)

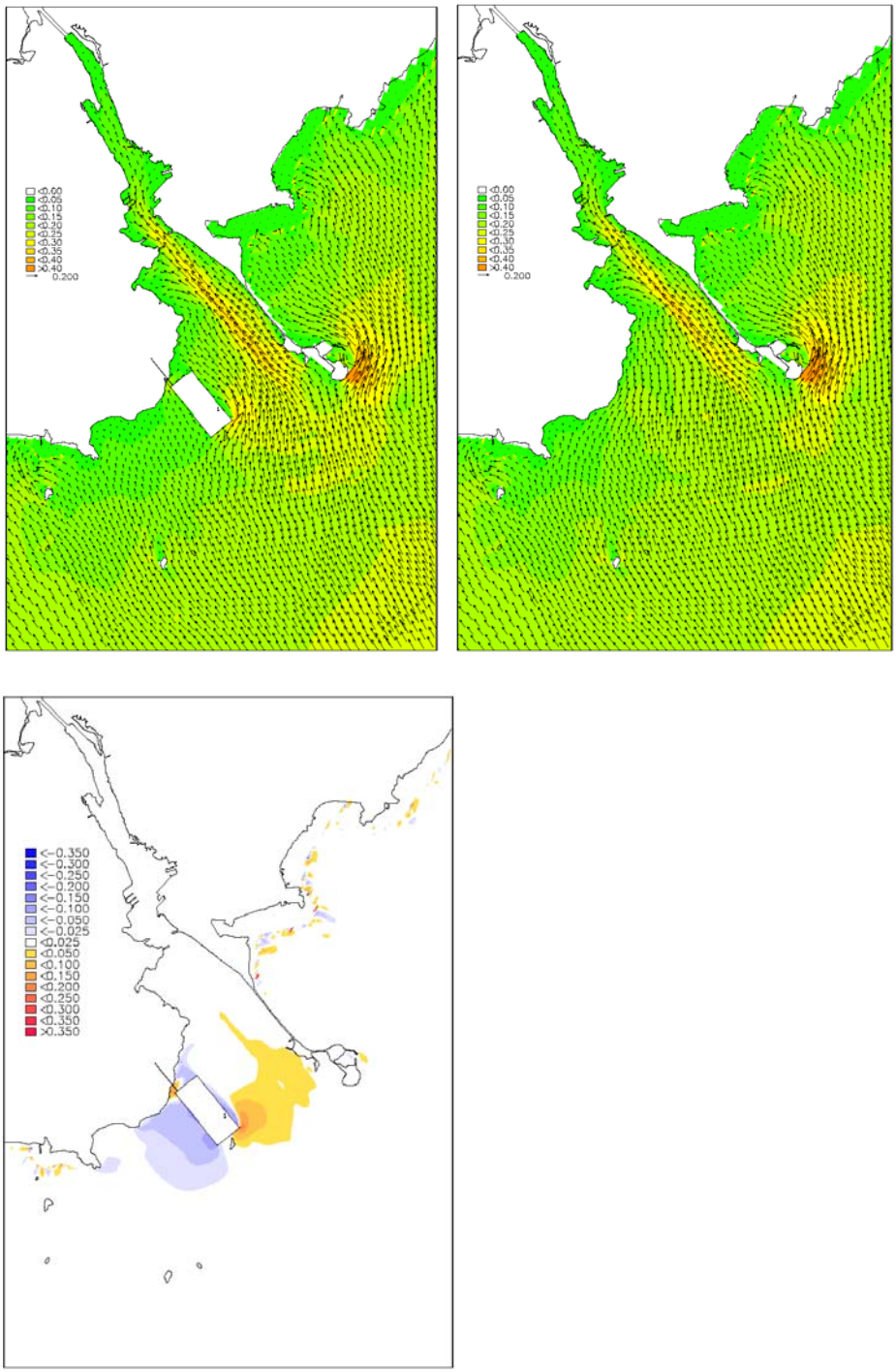


Figure 27: Flow patterns during PEAK EBB SPRING TIDE (2002/05/27 12:00) under existing and with project conditions. Bottom: flow magnitude differences (with project – existing conditions)

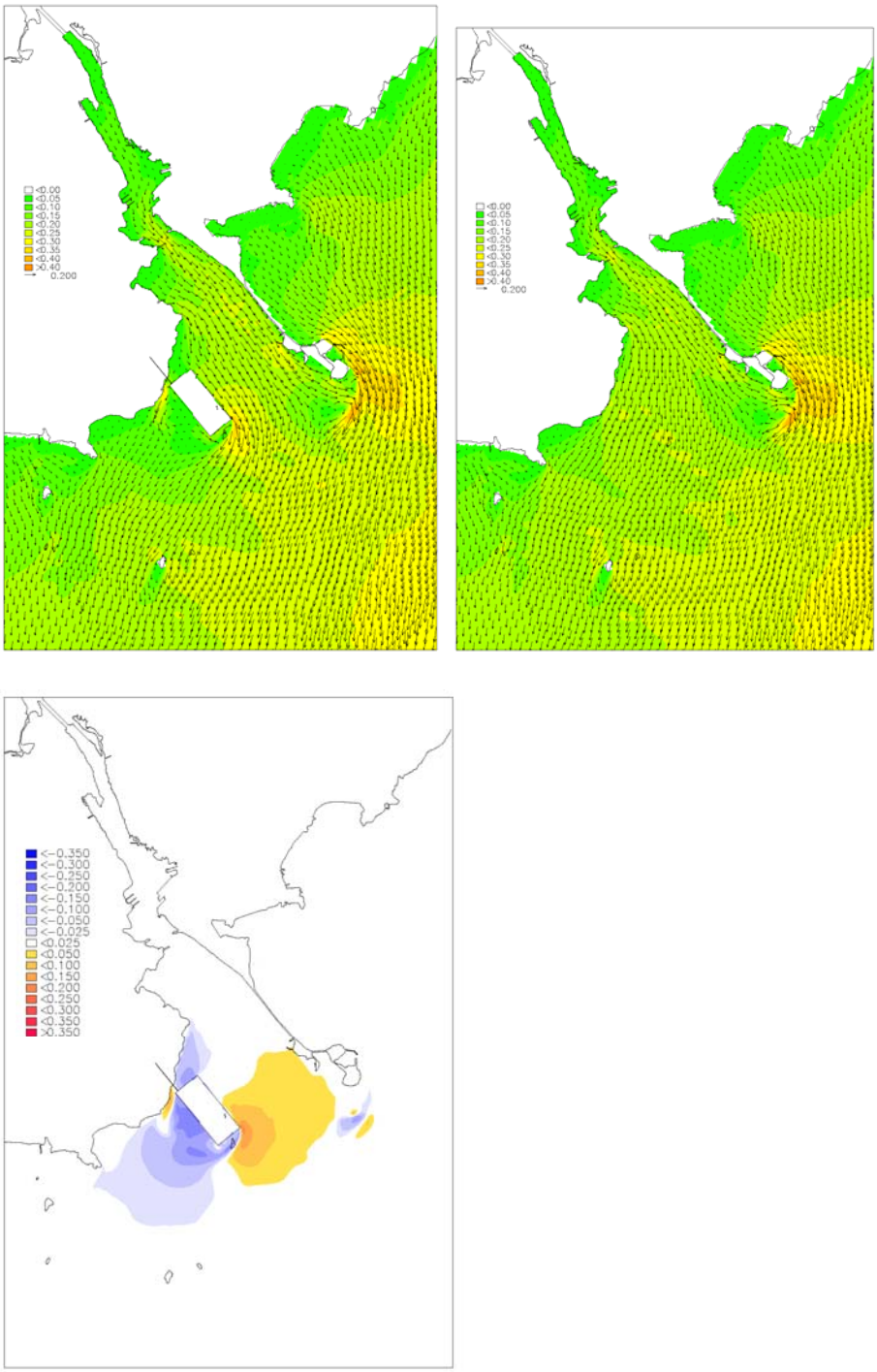


Figure 28: Flow patterns during LOW WATER SPRING TIDE (2002/05/27 03:00) under existing and with project conditions. Bottom: flow magnitude differences (with project – existing conditions)

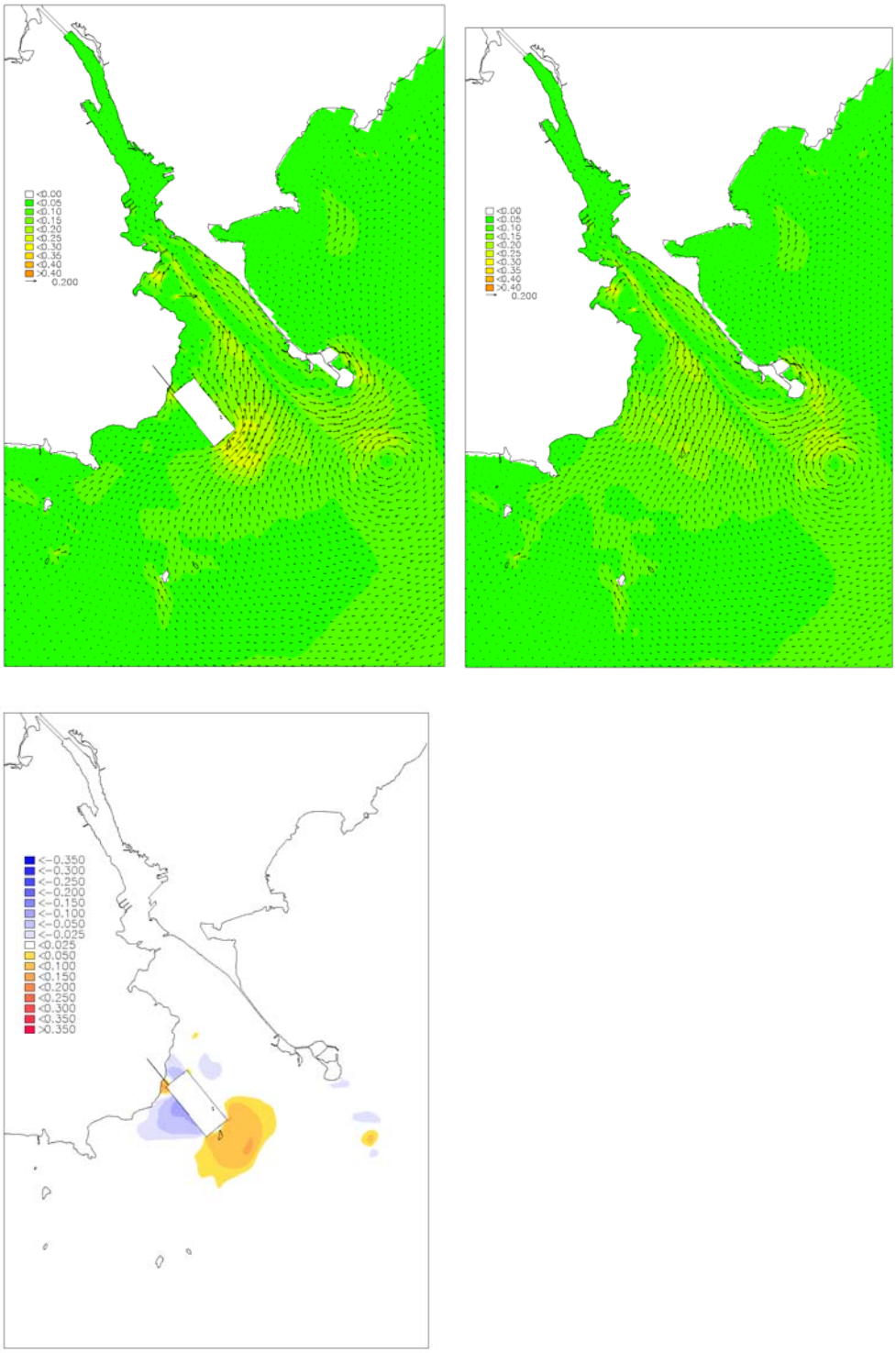


Figure 29: Flow patterns during HIGH WATER SPRING TIDE (2002/05/27 09:00) under existing and with project conditions. Bottom: flow magnitude differences (with project – existing conditions)

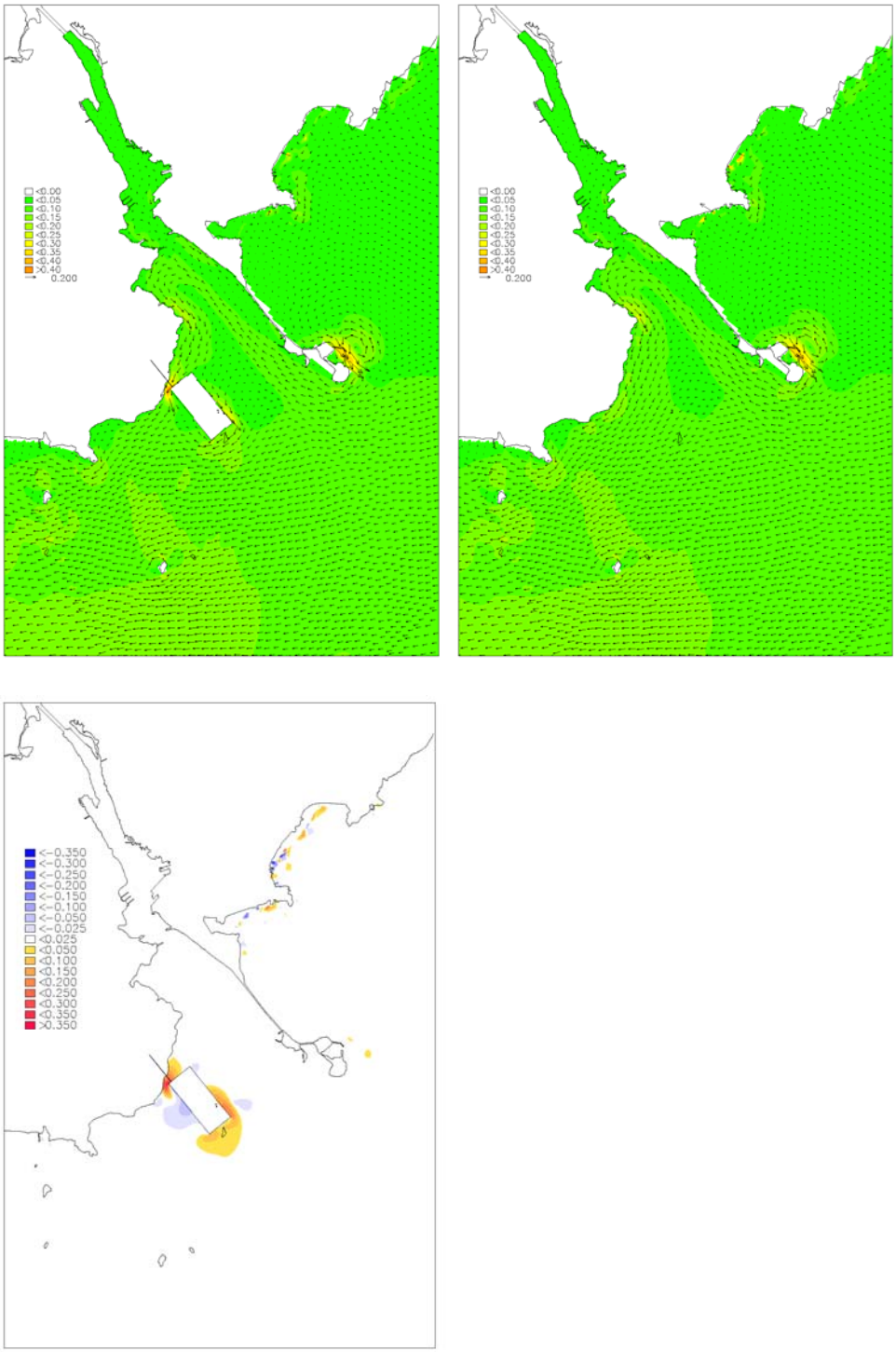


Figure 30: Flow patterns during PEAK FLOOD NEAP TIDE (2002/06/04 13:00) under existing and with project conditions. Bottom: flow magnitude differences (with project – existing conditions)

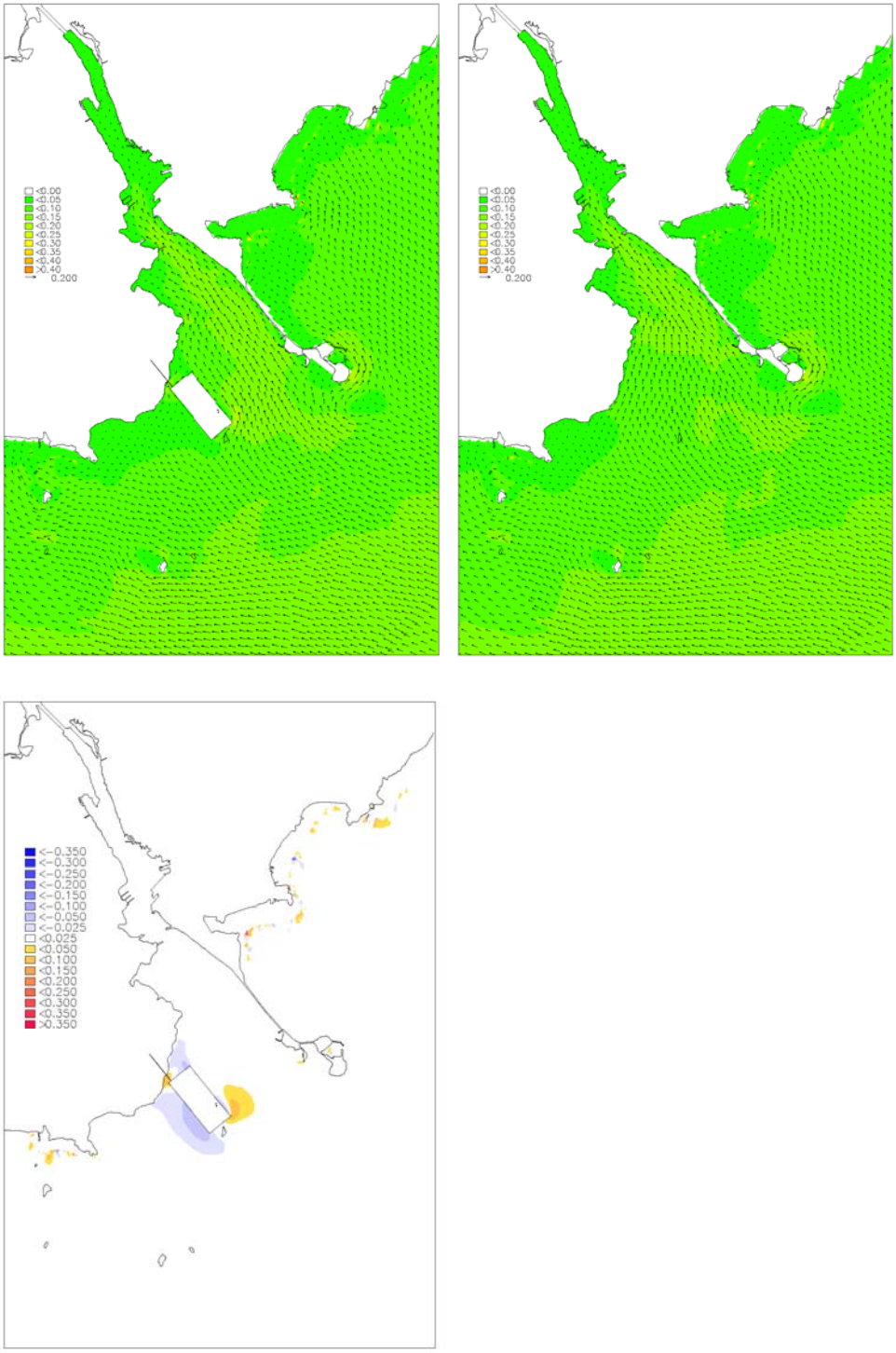


Figure 31: Flow patterns during PEAK EBB NEAP TIDE (2002/06/04 18:00) under existing and with project conditions. Bottom: flow magnitude differences (with project – existing conditions)

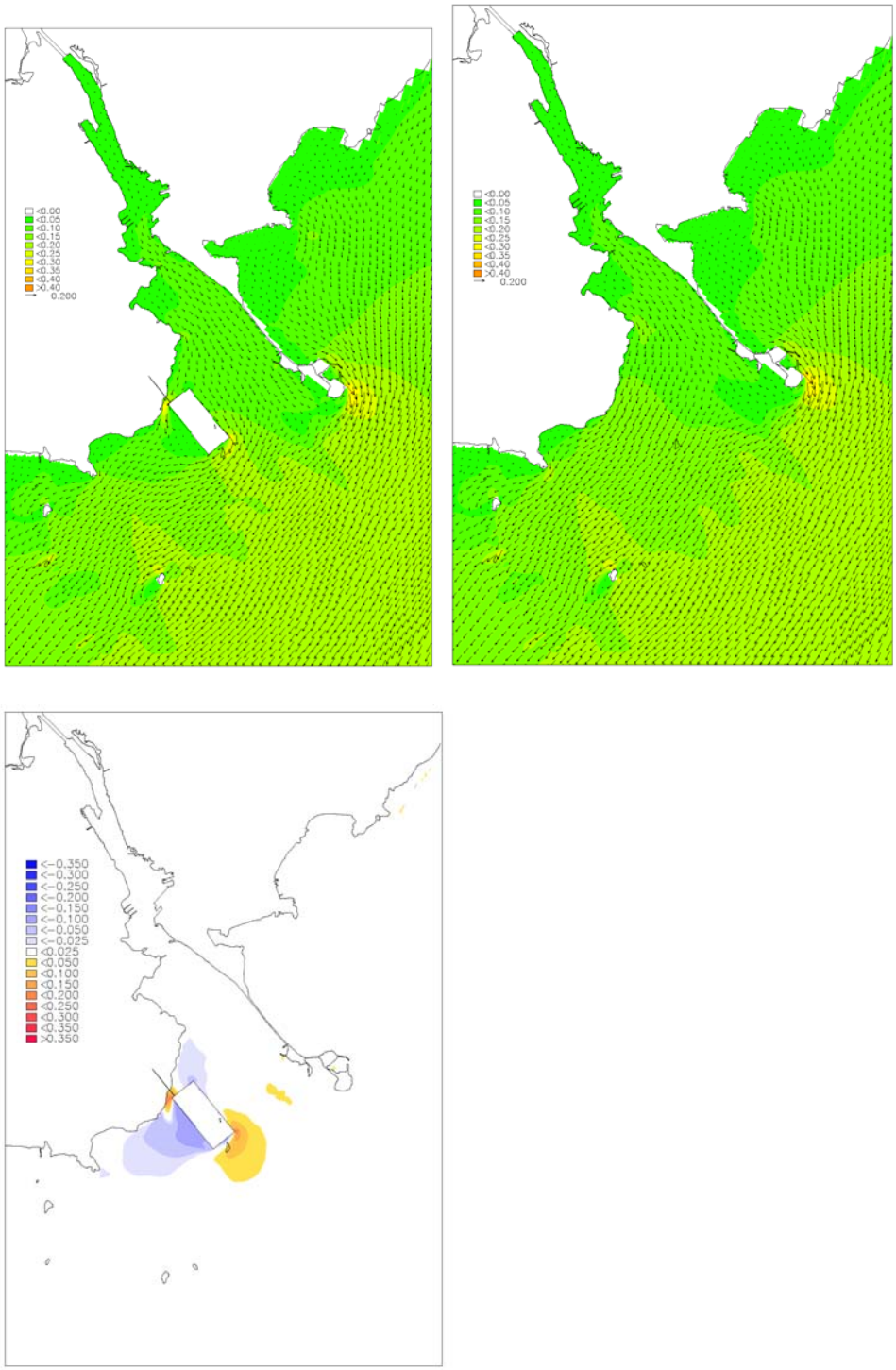


Figure 32: Flow patterns during LOW WATER NEAP TIDE (2002/06/04 11:00) under existing and with project conditions. Bottom: flow magnitude differences (with project – existing conditions)

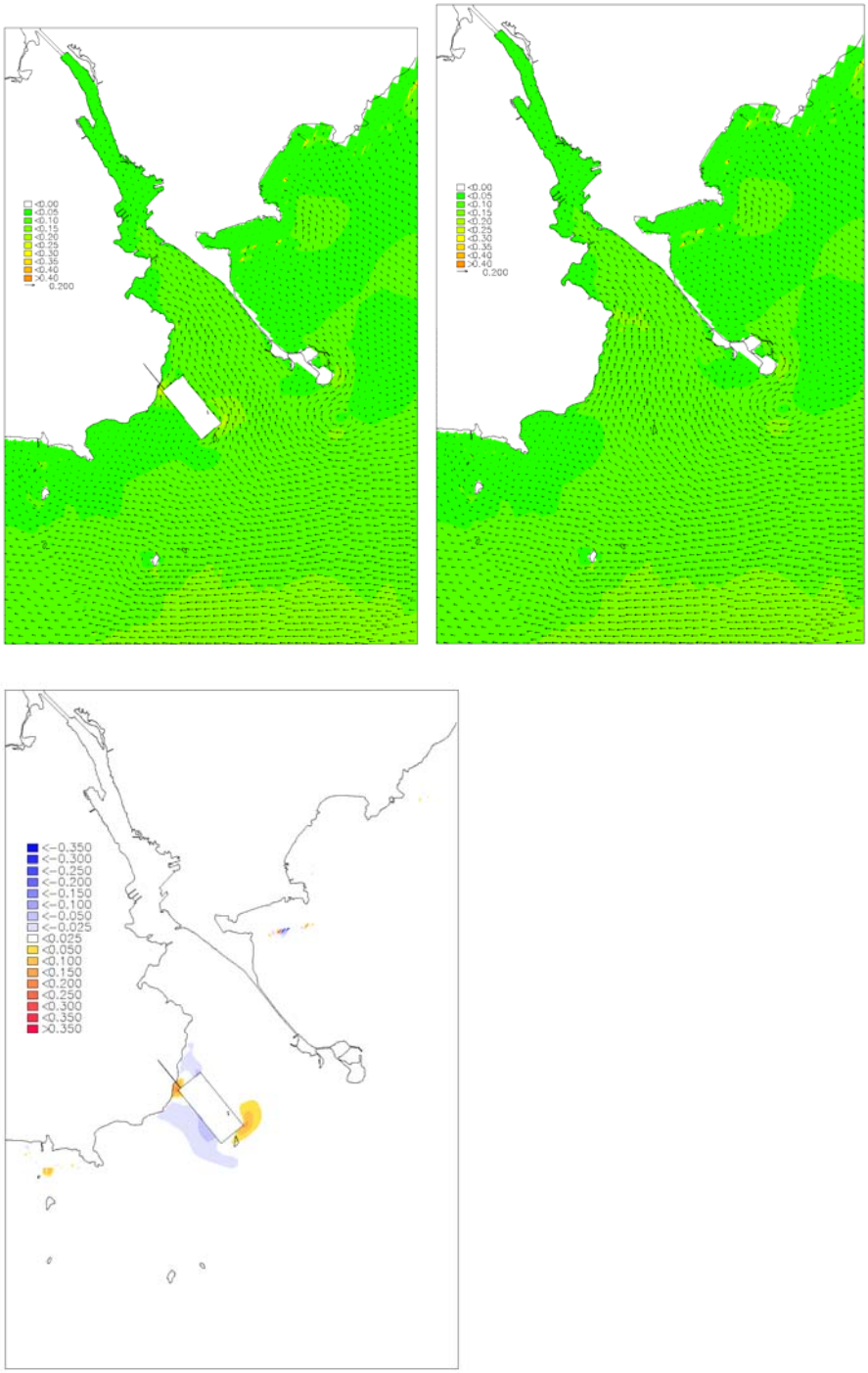
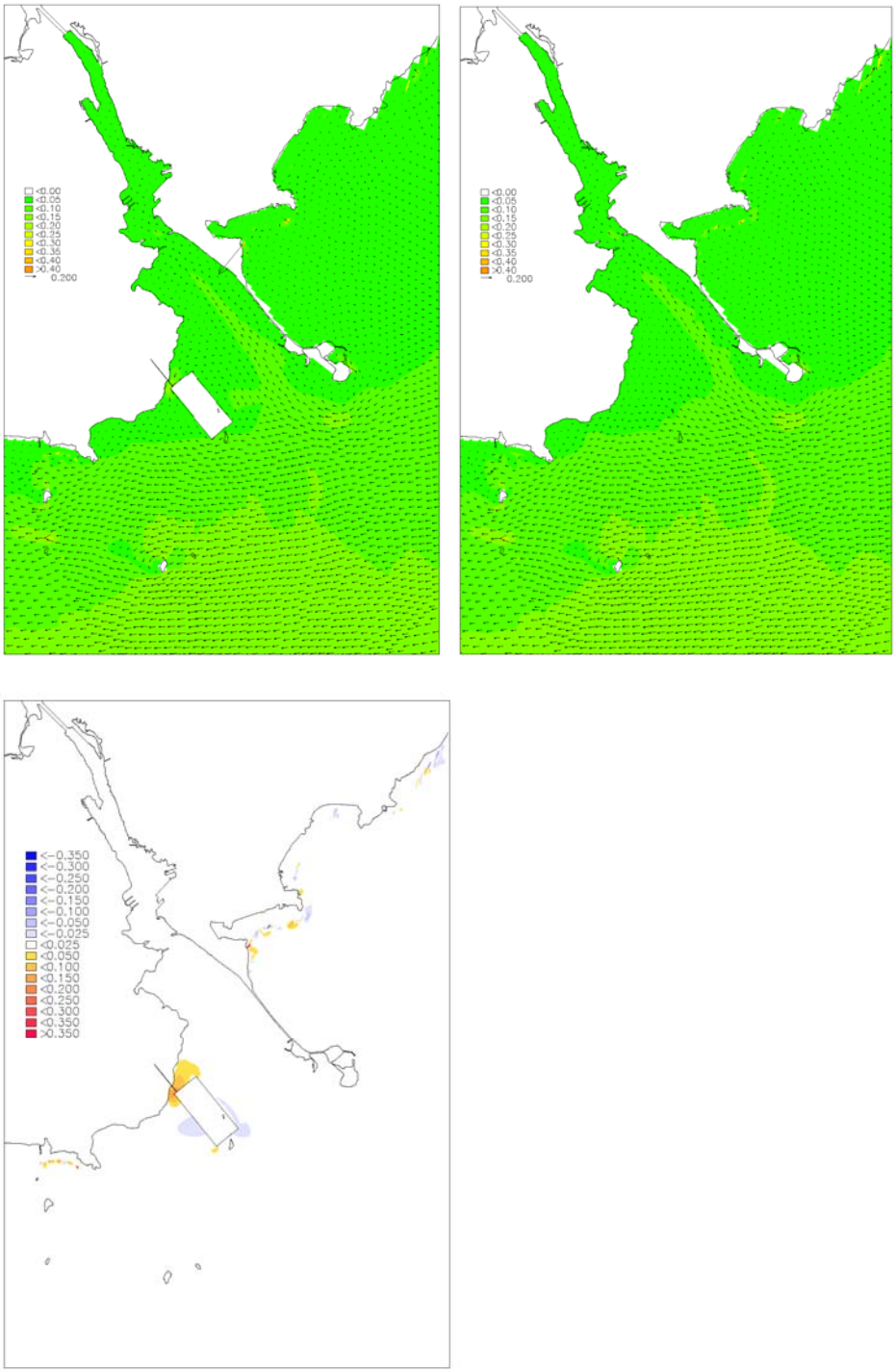


Figure 33: Flow patterns during HIGH WATER NEAP TIDE (2002/06/04 15:00) under existing and with project conditions. Bottom: flow magnitude differences (with project – existing conditions)



Conclusions

Based on the model results the hydrodynamic impacts of the proposed new island south of the Palo Seco area are summarized below:

Changes in the hydrodynamic regime of Panama Bay

Results from the numerical simulations, however, indicate that the construction of the artificial island will not have an effect on the general hydrodynamic patterns of Panama Bay. Effects on the currents will be limited to areas in the immediate vicinity of the project. The separation of the island from the shoreline by a distance of at least 200 m will assist the circulation of the water flows along the Palo Seco/Farfan Shoreline area.

Impacts on Coastal Resources

The artificial island does not produce any change in the flow patterns in the vicinity of Isla Otoque and the areas where coral growth can still be found. Comparison of velocities predicted by the hydrodynamic model showed that after the island construction changes of these variables at the vicinity of isla Otoque are negligible.

Impacts on Beaches and Western coastline

The coastal current is not affected by the island construction. Only the shoreline located just west of the project could be prone to increased sedimentation and concentration of any substance carried by the water that reaches this area. In addition, the shoreline located near the northwest tip of the artificial island could experience some loss of the sand pockets and exposure of the rock faces due to the higher velocities through that narrow area.

Sedimentation in the Panama Canal access channel

Model results suggest that velocities will increase slightly during Spring Tide in the area of the entrance channel due to the island construction. This then indicates that the impact of the project will be a decrease in sedimentation of the Canal Pacific Entrance.

APPENDIX D - MARINE STRUCTURES DESIGN CRITERIA & STANDARDS

Design References, Standards, and Codes

The following codes, references, and standards are recommended as a basis for the analysis and design of the container terminal berth:

Primary Codes for Design

- American Concrete Institute, *Building Code Requirements for Structural Concrete and Commentary, (ACI 318-05), 2005*
- American Institute of Steel Construction (AISC), *Manual of Steel Construction, 9th Edition, 1989*
- American Association of State Highway and Transportation Officials, *Standard Specifications for Highway Bridges*, (AASHTO HB-17, 2003)
- ANSI/ASCE-7-98, Standard, *Minimum Design Loads for Buildings and Other Structures, 1998*
- Military Handbook – *Piers and Wharves* (MIL-HDBK1025/1)

Information and Reference Documents

- American Association of State Highway and Transportation Officials (AASHTO), *Standard Specifications for Highway Bridges, 1996* (Reference Document).
- Military Handbook, *Piers and Wharves* (MIL-HDBK-1025/1) (Reference Document).
- Military Handbook, *Dockside Utilities for Ship Service* (MIL-HDBK-1025/2) (Reference Document).
- Naval Facilities Engineering Command (NAVFAC) Design Manual, *Fixed Moorings* (DM 26.4) (Reference Document).
- Naval Facilities Engineering Command (NAVFAC) Design Manual, *Mooring Design Physical and Empirical Data* (DM 26.6) (Reference Document).

Design Loads

The following design criteria and loading conditions are developed to be consistent with the state-of-the-art facility requirements for a Super Post-Panamax container terminal.

Vertical Design Loads

Uniform Load:

- 57.5 kN/m2 (1200 psf) minimum uniform live load distributed to produce maximum stress, with the load removed 3 m (10 feet) either side of crane rails when combined with concentrated loads from cranes, trucks, and other equipment. Only HS25-44 load -or alternate 19.2 kN/m2 (400 psf) load- shall be applied outboard of the shipside crane rail.
- Foundation piles designed for 46.0 kN/m2 (960 psf) minimum uniform live load (a 20 percent reduction) in accordance with accepted engineering practice. Foundation piles are also to be evaluated with respect to concentrated loading conditions.

Container Crane Loads

(loads indicated are load per wheel, with 1.4 m wheel spacing):

	Seaside	Landside
a. Case I – Operating Condition	969.7 kN (218.0 kips)	630.3 kN (141.7 kips)
b. Case II – Overload Condition	1149.4 kN (258.4 kips)	764.2 kN (171.8 kips)
c. Case III – Stowed Condition	1010.2 kN (227.1 kips)	845.2 kN (190.0 kips)

d. Case IV – Uplift Condition (Per Corner)

Seaside	Landside
-4136.8 kN (-930.0 kips)	-889.6 kN (200 kips)

Truck loading

In accordance with AASHTO Standard Specifications for Highway Bridges for an HS 25-44 truck or equivalent loading. Total of three axles: front axle load 44.5 kN (10 kips), two rear axles are 177.9 kN (40 kips) each for a total load of 400.3 kN (90 kips). Vehicle impact added according to AASHTO requirements)

Taylor Machine Works TEC-950L Container Handler:

a) 422.6 kN (95 kip) capacity at 610 mm (48-inch) load center.

b) Front axle load 1269.5 kN (285.4 kips) including 30% impact with corresponding rear axle load of 90.7 kN (20.4 kips), with axles spaced at 5.7- m (18.75-foot) centers.

c) Tires 458 mm x 635 mm (18 in. x 25 in.) at 951.5 kN/m2 (138 psi) – four tires per front axle.

d) Out-to-out of outer tires 4880 mm (192 inches).

e) Center-to-center of inner tires 3774 mm (148.5 inches).

f) Tire contact area 0.19 m2 (300 square inches).

Lateral Design Loads

Vessel berthing force

Based on Super Post-Panamax ship criteria, with berthing energies calculated based on displacement, berthing velocity, and angle of approach. Accidental berthing energies to control the design of the dock fender system. Berthing energies calculated in accordance with MIL-HDBK-1025/1.

Container Crane Lateral Loads

Operating or Stowed Condition - Load Perpendicular to Rail (per wheel)

Seaside	Landside
166.8 kN (37.5 kips)	166.8 kN (37.5 kips)

Mooring forces

From breasting lines and spring lines based on ship criteria outlined herein, with a 33 percent allowable stress increase for mooring forces. Minimum mooring device working design capacity for bollard is 136.1 tonnes (150 tons) perpendicular to bollard.

The structure weight for seismic analysis and design will equal the dead load of the structure plus (the dead load of one container crane or 25 percent of the deck live load, whichever is greater).

Effective peak velocity-related acceleration shall be as required by applicable building codes, but in no case be less than 0.05 g.

Longitudinal Design Loads

a) Container Crane Longitudinal Loads

	Seaside	Landside
Stowed Condition (per rail)	1378.9 kN (310 kips)	1023.1 kN (230 kips)

b) Container crane stop force of 934.1 kN (210 kips) at each rail applied 1.2 m (4 feet) above top of rail. Value will be adjusted according to the crane manufacturers prescribed design data.

c) Mooring forces from spring lines of the fully laden controlling design vessel with a 22.4 meters per second (50 miles per hour) wind velocity.

d) Longitudinal component of berthing force from the controlling design vessel specified, with a 33 percent allowable stress increase for mooring forces only.

Load Combinations

a) Load combinations shall be in accordance with MIL-HDBK-1025/1, Paragraph 3.4 using load factor design procedures. The container handler load factors are considered as 1.3 (as allowed for crane outrigger loads) due to operating constraints of the equipment.

b) Steel structures are designed using service load (allowable stress) method. The service load approach is used for designing all foundations and for checking foundation stability.

c) Concrete structures for piers and wharves are proportioned using the load factor (ultimate strength) method; however, members are checked for serviceability and construction loads using the service load design approach.

APPENDIX E - COST MODELS AND COST ESTIMATES

Backup Calculations

Project Specifications - Truck Haul

Item	Unit	Qty	Price/Rate	Total	Comments
Cells requiring user input are highlighted thus:					
General Parameters					
Total Material to be Hauled	m3	**16,500,000**			
Time to transport material	year	1.50			
Working Days per Year	day/year	345			
Total Working Days	day	518			
Calculated Target Production	m3/day	**31,885**			
Working Hours per day	hr	20			
Equipment Parameters					
CAT 5230B Mass Excavator/Shovel (17m3 bucket)					Excavation site material removal - cost not included (production check)
Single Bucket Capacity	m3	17.0			
Bucket Fill Factor	no.	75%			
Factored Bucket Capacity	m3	12.75			
Bucket Cycle Time	sec	30.0			
Production Rate for Excavator	m3/hr	1530.0			Comparison: Harza Report, 2040m3/hr
Daily Loading Rate per Excavator	m3/day	30,600.00			
No. Excavators Required to maintain Target Rate	**no.**	**2.0**			
Hourly Loading Rate for 2 Excavator(s)	m3/hr	**3,060.0**			
CAT 994D Front End Loader (20m^3 Capacity)					Intermediate transfer to ensure continuous removal from excavation site
Single Bucket Capacity	m3	20.0			
Bucket Fill Factor	no.	70%			
Factored Bucket Capacity	m3	14			
Dig/Load Cycle Time	sec	30.0			
Production Rate for Loader	m3/hr	1680.0			
Daily Loading Rate per Loader	m3/day	33,600.00			
No. Loaders Required to maintain Target Rate	**no.**	**1.0**			
Hourly Loading Rate for 1 Loaders	**m3/hr**	**1,680.0**			
CAT 789C Off-Road Truck (105m3 Capacity)					
Truck Capacity (Max.)	m3	105			
Truck Capacity (Struck)	m3	73			
Total Truck Trips Required to Meet Target	no.	226,027			
Calculated truck trips per day	no.	437.0			
Max. load/unload time per truck *	hr	0.046			Note: logistics check
* Note: If this value is less than either calculated load or unload time below, then load/unload maximum is exceeded - increase time to completion					
Truck Transportation Cycle					
Average one-way distance (excavation site to shoreline stockpile)	km	16.0			Source: site plan
Average Truck Travel Speed		45			
Estimated Load Time	hr	0.024			1.4 minutes
Estimated Travel Time (Round Trip)	hr	0.711			Calculated round-trip distance of 32 km
Estimated Unload Time	hr	0.042			2.5 minutes
Total Cycle Time	**hr**	**0.78**			
Calculated Trips Per Truck per Day	no.	25.8			
No. 105m3 Trucks Required (long haul)	**no.**	**17.0**			
No. 41.5m3 Trucks Required (short haul < 1km)	**no.**	**3.0**			Arbitrary no. used to maintain continuous flow at transfer station
Equipment Costs					
CAT 789C Off-Road Truck (105m3 Capacity)					
Hourly Rate	$/hr		$ 442.00		
Daily Rate per truck	$/day		$ 10,608		24 pay hours per day
Daily Rate for 17 trucks	$/day	17	$ 180,337		
CAT 775E Off-Road Truck (41.5m^3 Capacity)					
Hourly Rate	$/hr		$ 336.97		
Daily Rate per truck	$/day		$ 8,087		24 pay hours per day
Daily Rate for 3 trucks	$/day	3.0	$ 24,262		
CAT 994D Front End Loader (20m^3 Capacity)					
Hourly Rate	$/hr		$ 634.18		
Daily Rate per loader	$/day		$ 15,220		24 pay hours per day
Daily Rate for 1 loader	$/day	1	$ 15,220		
Haul Roads					
Construction Cost per km	$/km		$3,000,000.00		
Daily maintenance cost of haul road	$/day		$10,000.00		2 graders + 2 water trucks

Transportation Costs

Item	Unit	Qty	Price/Rate	Total	Comments
Equipment					
105m3 Off-Road Trucks	day	517.5	$ 180,337	$ 93,324,302	
41.5m3 Off-Road Trucks	day	517.5	$ 24,262	$ 12,555,368	
20m3 Front End Loader	day	517.5	$ 15,220	$ 7,876,516	
Haul Roads					
Haul Road Construction	km	18.0	$ 3,000,000	$ 54,000,000	
Haul Road Bridge (Pan American Highway)	no.	1.0	$ 4,800,000	$ 4,800,000	
Haul Road Culverts	no.	22.0	$ 150,000	$ 3,300,000	
Haul Road Maintenance	day	517.5	$ 10,000	$ 5,175,000	

Total Cost - Material Transportation	**$181,031,186**
Unit cost of truck haul per m ^{3}	**$10.97**

Backup Calculations

Project Specifications - Train Haul

Item	Unit	Qty	Price/Rate	Total	Comments
Railway Construction Data					
Formation (Section) Length	m	14000			
No. main-line tracks (Standard Gauge - 1435mm)	no.	2			
Formation cut volume	m3	2700000			
Formation fill volume	m3	3000000			
Width at Base of Formation	m	30			Estimated average base width
Ballast Depth (top of tie to formation)	m	0.6			
Ballast Width	m	6			
Spacing of ties	m	0.6			
Wood tie dimensions					
width	m	0.2			
depth	m	0.15			
length	m	2.6			
volume	m3	0.078			
Annual Maintenance	$/year/km	$ 40,000			Factored from 1993/94 Westrail data
Quantity Calculations					
Total Track Length	m	38,000			Includes 10,000m for marshalling yard
Total no. ties	no.	63,333			
Ballast volume	m3	170,740			
Ballast mass @ 1.8 t/m3	t	307,332			

Construction Costs

Item	Unit	Qty	Price/Rate	Total	Comments
Track Laying on Formation					
Survey	Ha	280	$ 3,000.00	$ 840,000	200m Corridor to shoreline, guesstimate
Boreholes	ea	28	$ 2,400.00	$ 67,200	Assuming 20m deep @ $120 per metre ($35 per foot) - every 500m
Clearing and Stripping	Ha	42	$ 14,820.00	$ 622,440	Assume $6000 per Acre
Formation/Roadbed Earthworks	m3	5,700,000	$ 3.00	$ 17,100,000	Cut + Fill Volumes
Ballast	t	307,332	$ 30.00	$ 9,219,960	
Treated Wood Ties	ea	63,333	$ 58.00	$ 3,673,333	
Tie plates	ea	126,666	$ 8.60	$ 1,089,328	
132lb Rail	m	76,000	$ 62.50	$ 4,750,000	
Track spikes	ea	253,333	$ 5.50	$ 1,393,333	
Rail anchors	ea	126,667	$ 5.00	$ 633,333	Anchor pattern: 1 tie in 2
Turnout (#10)	ea	15	$ 25,000.00	$ 375,000	
Total Cost - Track on Formation				***$ 39,763,928***	
Unit Cost per km				***1,046,500***	

Item	Unit	Qty	Price/Rate	Total	Comments
Structures					
Bridges	ea	1	$ 3,500,000.00	$ 3,500,000	
Culvert - crossings		10			
Pipe (Class 5)	ea	40	$ 23,580.58	$ 943,223	Assume 30m long at each location using 4 x 1.8m (72") pipe
Headwall	ea	20	$ 4,703.60	$ 94,072	Assume 1.8m (72") dia pipe
Rail Crossings	ea	5	$ 5,500.00	$ 27,500	Assume 8m-wide roadway

Total Cost - Formation + Track Laying	**$ 39,763,928**
Total Cost - Railway Structures	**$ 4,564,795**
Total Cost - Railway Construction	**$ 44,328,723**

MATERIAL TRANSPORATION

Item	Unit	Qty	Price/Rate	Total	Comments
General Parameters					
Total Material to be Hauled	m3	**16,500,000**			
Time to transport material	year	1.4			
Working Days	day/year	345			
Total Working Days	day	483			
Calculated Target Production (total material/working days)	m3/day	**34,162**			
ACP Production Rate - Wet	m3/day	4,522			based on published average production rate of 30,000m3/week
ACP Production Rate - Dry	m3/day	22,609			based on published average production rate of 150,000m3/week
Working Hours per day	hr	24.0			

Equipment Parameters

CAT 5230B Mass Excavator/Shovel (17m3 bucket)				excavation production (costs not included)
Single Bucket Capacity	m3	17.0		
Bucket Fill Factor	no.	80%		
Factored Bucket Capacity	m3	13.6		
Bucket Cycle Time	sec	30.0		
Production Rate for Excavator	m3/hr	1632.0		Comparison: Harza Report, 2040m3/hr
Daily Loading Rate per Excavator	m3/day	39,168.00		
No. Excavators Required to maintain Target Rate	**no.**	**1.0**		
Hourly Loading Rate for 1 Excavators	**m3/hr**	**1,632.0**		
CAT 994D Front End Loader (20m^3 Capacity)				
Single Bucket Capacity	m3	20.0		
Bucket Fill Factor	no.	75%		
Factored Bucket Capacity	m3	15		
Dig/Load Cycle Time	sec	30.0		
Production Rate for Loader	m3/hr	1800.0		Comparison: Harza Report, 1200m3/hr
Daily Loading Rate per Loader	m3/day	43,200.00		
No. Loaders Required to maintain Target Rate	**no.**	**1.0**		
Hourly Loading Rate for 1 Loaders	**m3/hr**	**1,800.0**		
CAT 789C Off-Road Truck (105m3 Capacity)				
Truck Capacity (Max.)	m3	105.0		
Truck Capacity (Struck)	m3	73.0		
Total Truck Trips Required to Meet Target	no.	226,027		
Calculated truck trips per day	no.	468.0		
Max. load/unload time per truck *	hr	0.051		Note: logistics check, indicates maximum in order to maintain production

* Note: If this value is less than either calculated load or unload time below, then load/unload maximum is exceeded - increase time to completion

Trains				
Rail Car Capacity	m3	40		
Rail Cars Per Train	no.	50		
Locos per Train	no.	2		Ruling Grade @ 1.5%
Total Train Capacity	m3	2,000		
Train Trips Required Per Day to Meet Target	no.	17		To meet target, requires 2 tracks at unloading site
Max. load/unload time per train *	hr/train	1.404		Note: logistics check

* Note: If this value is less than either calculated load or unload time below, then load/unload maximum is exceeded - increase time to completion

Rail Transportation Cycle

Avg. track distance (material transfer to disposal site)	km	14.0		
Average Train Speed	km/hr	20		factors included for train movements and delays
Time to Load Train	hr	1.11		
Average Travel Time (Round Trip)	hr	1.40		
Time to Unload Train	hr	0.83		Dual-car dumpers, 2min per car per dumper
Total trip cycle time	**hr**	**3.34**		
No. trains loading/dumping simultaneously	no.	0.60		Indicates no. of trains loading/unloading to meet production target
Calculated Trips Per Train Per Day	no.	7.2		
No. of Train Consists Required	**no.**	**3.0**		
No. Rail Cars Required	**no.**	**150.0**		
No. Locos Required	**no.**	**6.0**		

Truck Transportation Cycle (Loading)

Average one-way distance (excavation to stockpile)	km	1.0		Source: site plan
Average Truck Travel Speed		45		
Estimated Load Time	hr	0.041		2.4 minutes
Estimated Travel Time (Round Trip)	hr	0.044		Calculated round-trip distance of 2 km
Estimated Unload Time	hr	0.017		1 minutes per truck
Total Cycle Time	**hr**	**0.10**		
Calculated Trips Per Truck per Day	no.	236.1		
No. 105m3 Trucks Required (short haul)	**no.**	**2.0**		

Truck Transportation Cycle (Unloading)

Average one-way distance (transfer station to island)	km	4.0		Source: site plan
Average Truck Travel Speed		45		
Estimated Load Time	hr	0.041		2.4 minutes
Estimated Travel Time (Round Trip)	hr	0.178		Calculated round-trip distance of 8 km
Estimated Unload Time	hr	0.017		1 minutes per truck
Total Cycle Time	**hr**	**0.24**		
Calculated Trips Per Truck per Day	no.	102.1		
No. 105m3 Trucks Required (short haul)	**no.**	**5.0**		

Equipment Costs

CAT 789C Off-Road Truck (105m3 Capacity)				
Hourly Rate	$/hr		$ 442.00	
Daily Rate per truck	$/day		$ 10,608	24 pay hours per day
Daily Rate for 7 trucks	$/day	7	$ 74,256	
CAT 775E Off-Road Truck (41.5m^3 Capacity)				
Hourly Rate	$/hr		$ 336.97	confirm rate
Daily Rate per truck	$/day		$ 8,087	24 pay hours
Daily Rate for 0 trucks	$/day	0.0	$ -	
CAT 994D Front End Loader (20m^3 Capacity)				
Hourly Rate	$/hr		$ 634.18	confirm rate
Daily Rate per loader	$/day		$ 15,220	24 pay hours
Daily Rate for 2 loaders	$/day	2.0	$ 30,441	
Rollingstock				
Locomotive - Purchase Cost	ea		$ 2,860,000	Research results
Locomotive - Salvage Value (@ 20%)	ea		$ 572,000	Research results
Side-dump rail car - Purchase Cost	ea		$ 104,000	Research results
Side-dump rail car - Salvage Value (@ 20%)	ea		$ 20,800	Research results
Locomotive operational cost	$/day/unit		$ 1,688	Research results
Locomotive maintenance cost	$/day/unit		$ 1,125	Research results
Rail car maintenance cost	$/day/unit		$ 120	Research results

Railway Operation and Maintenance Costs

Rollingstock						
Daily Operations Cost for 6 Locos	$/day	6	$ 10,125			
Daily Maintenance Cost for 6 Locos	$/day	6	$ 6,750			
Daily Maintenance Cost for 150 Rail Cars	$/day	150	$ 18,000			
Track						
No. Mainline Tracks	no.	2				
Daily maintenance cost	$/km/day	28	$ 150.00	$	4,200	

Haul Roads

Construction Cost per km	$/km		$2,000,000.00			
Maintenance Cost per km per day	$/km/day		$1,000.00			Grader and Water Truck
Daily maintenance cost for 5 km of haul road	$/day	5.0	$5,000.00			

Conveyors

Maintenance and operation	$/km		$4,000.00			includes power and belt maintenance
Daily cost for 5km of conveyor	$/day	5	$20,000.00			

Transportation Costs

Item	Unit	Qty	Price/Rate		Total	Comments
Railway Construction and Maintenance						
Railway Construction	LS	1	$ 44,328,723	$	44,328,723	
Track Maintenance	day	483	$ 4,200	$	2,028,600	
Haul Roads and Loading/Unloading Conveyors						
Haul Road Construction	km	5.0	$ 2,000,000	$	10,000,000	
Haul Road Maintenance	day	483	$ 5,000	$	2,415,000	
Conveyor maintenance and operation	day	483	$ 20,000	$	9,660,000	
Rollingstock Purchase Costs						
Locomotives	no.	8	$ 2,200,000	$	17,600,000	Includes backup loco(s)
Rail cars	no.	160	$ 104,000	$	16,640,000	Includes backup rail cars
Rollingstock Operating/Maintenance Costs						
Operational cost of locomotives	day	483	$ 10,125	$	4,890,375	
Maintenance cost of locomotives	day	483	$ 6,750	$	3,260,250	
Maintenance cost of rail cars	day	483	$ 18,000	$	8,694,000	
Rollingstock Salvage Value						
Locomotives	no.	8	$ 572,000	$	(4,576,000)	
Rail cars	no.	160	$ 20,800	$	(3,328,000)	
Equipment						
105m3 Truck(s)	no.	483	$ 74,256	$	35,865,810	
20m3 Front End Loader	no.	483	$ 30,441	$	14,702,829	
Conveyor/Railcar Loading System	no.	2	$ 6,000,000	$	12,000,000	Source: EDC report April 2003, 43,000,000/7 stations
Railcar dumper + stacker conveyor	no.	2	$ 3,375,000	$	6,750,000	Source: EDC report April 2003

Total Cost - Material Transportation	**$180,931,587**
Unit cost of transport per m^3	**$10.97**

Backup Calculations

Project Specifications - Truck and Scow Haul

Item	Unit	Qty	Price/Rate	Total	Comments
Cells requiring user input are highlighted thus:					
General Parameters					
Total Material to be Hauled by Truck (Third Locks Excavation)	m3	**16,500,000**			
Time to transport material by truck	year	1.80			
Working Days per Year	day/year	345			
Total Working Days - Third Locks Material	day	621			
Calculated Target Production - dry excavation	m3/day	**26,571**			
ACP Production Rate - Dry	m3/day	22,609			based on published average production rate of 150,000m3/week
Working Hours per day	hr	24			
Equipment Parameters					
4000m3 Scow					
Scow Capacity	m3	2,400			Assume 60% fill factor
Total scow trips required to move third locks material	no.	6,875			
Scow/Tug trips required per day - third locks	no.	11.07			
CAT 5230B Mass Excavator/Shovel (17m3 bucket)					Excavation site material removal - cost not included
Single Bucket Capacity	m3	17.0			
Bucket Fill Factor	no.	55%			
Factored Bucket Capacity	m3	9.35			
Bucket Cycle Time	sec	30.0			
Production Rate for Excavator	m3/hr	1122.0			Comparison: Harza Report, 1200m3/hr
Daily Loading Rate per Excavator	m3/day	26,928.00			
No. Excavators Required to maintain Target Rate	**no.**	**1.0**			
Hourly Loading Rate for 1 Excavator(s)	m3/hr	**1,122.0**			
CAT 994D Front End Loader (20m^3 Capacity)					Intermediate transfer to ensure continuous removal from excavation site
Single Bucket Capacity	m3	20.0			
Bucket Fill Factor	no.	70%			
Factored Bucket Capacity	m3	14			
Dig/Load Cycle Time	sec	45.0			
Production Rate for Loader	m3/hr	1120.0			Comparison: Harza Report, 1200m3/hr
Daily Loading Rate per Loader	m3/day	26,880.00			
No. Loaders Required to maintain Target Rate	**no.**	**1.0**			
Hourly Loading Rate for 1 Loaders	**m3/hr**	**1,120.0**			
CAT 789C Off-Road Truck (105m3 Capacity)					
Truck Capacity (Max.)	m3	105			
Truck Capacity (Struck)	m3	73			
Total Truck Trips Required to Meet Target	no.	226,027			
Calculated truck trips per day	no.	364.0			
Max. load/unload time per truck *	hr	0.066			Note: logistics check
* Note: If this value is less than either calculated load or unload time below, then load/unload maximum is exceeded - increase time to completion					
Truck Transportation Cycle					
Average one-way distance (excavation site to transfer station)	km	2.5			Source: site plan
Average Truck Travel Speed		30			
Estimated Load Time	hr	0.065			3.9 minutes
Estimated Travel Time (Round Trip)	hr	0.167			Calculated round-trip distance of 5 km
Estimated Unload Time	hr	0.050			3 minutes
Total Cycle Time	**hr**	**0.28**			
Calculated Trips Per Truck per Day	no.	85.2			
No. 105m3 Trucks Required (long haul)	**no.**	**5.0**			
No. 41.5m3 Trucks Required (short haul < 1km)	**no.**	**2.0**			Arbitrary no. used to maintain continuous flow at transfer station
Scow Transportation Cycle					Transfer to disposal
Average one-way distance (transfer station to disposal site)	km	10.0			Ref: site plan
Average Scow/Tug Travel Speed	km/hr	9			
Time to Load Scow	hr	1.00			
Average Travel Time (round Trip)	hr	2.22			
Time to Berth and Dump Scow	hr	0.50			
Total trip cycle time	**hr**	**3.72**			
Max scow trips per day (assuming 24 operating hours)	no.	6.44			
No. Scow(s) required	**no.**	**3.0**			
No. Tow Tug(s) required	**no.**	**3.0**			Tug estimate based on cycle time
Equipment Costs					
4000m3 scow					
Hourly Rate	$/hr		$ 208.38		
Daily Rate per Scow	$/day		$ 5,001		Source: Corps of Engineers, divide monthly cost by 30.4375
Total cost for 3 scow(s)	$/day	3	$ 15,004		
3000HP towing tug					
Hourly Rate	$/hr		$ 481.56		
Daily Rate per tug	$/day		$ 11,557		Source: Corps of Engineers, divide monthly cost by 30.4375
Total cost for 3 tow tug(s)	$/day	3	$ 34,672		
CAT 789C Off-Road Truck (105m3 Capacity)					
Hourly Rate	$/hr		$ 442.00		
Daily Rate per truck	$/day		$ 10,608		24 pay hours per day
Daily Rate for 5 trucks	$/day	5	$ 53,040		
CAT 775E Off-Road Truck (41.5m^3 Capacity)					
Hourly Rate	$/hr		$ 356.53		
Daily Rate per truck	$/day		$ 8,557		24 pay hours
Daily Rate for 2 trucks	$/day	2	$ 17,114		

CAT 994D Front End Loader (20m^3 Capacity)						
Hourly Rate	$/hr		$ 634.18			
Daily Rate per loader	$/day		$ 15,220			24 pay hours
Daily Rate for 1 loader	$/day	1	$ 15,220			
Haul Roads						
Construction Cost per km	$/km		$3,000,000.00			
Daily maintenance cost for 3.5 km of haul road	$/day	3.5	$5,000.00			grader + water truck
Conveyor System						
Barge Loader - Power Cost	kWh/day	15,000	$0.10	$	1,500	Source: EDC Material Handling Report - April 2003
Maintenance and operation	$/T		$0.20			

Transportation Costs

Item	Unit	Qty	Price/Rate	Total	Comments
Equipment					
105m3 Off-Road Trucks	day	621.0	$ 53,040	$ 32,937,989	
41.5m3 Off-Road Trucks	day	621.0	$ 17,114	$ 10,627,506	
20m3 Front End Loader	day	621.0	$ 15,220	$ 9,451,819	
3000m3 Scow	day	621.0	$ 15,004	$ 9,317,265	
3000HP Tug	day	621.0	$ 34,672	$ 21,531,618	
Barge Transfer Station					
Barge Loader	LS	1.0	$ 11,700,000	$ 11,700,000	
Barge Loader Operation and Maintenance	T	29,700,000	$ 0.20	$ 5,940,000	
Berth Structure	m2	2,000.0	$ 1,500	$ 3,000,000	
Haul Roads and Conveyor					
Haul Road Construction	km	3.5	$ 3,000,000	$ 10,500,000	
Haul Road Maintenance	day	621.0	$ 5,000	$ 3,105,000	

Total Cost - Material Transportation	**$118,111,197**
Unit cost of truck and scow haul per m^3	**$7.16**

Backup Calculations - Highway legal truck haul from Howard Quarry

Project Specifications - Truck Haul

Item	Unit	Qty	Price/Rate	Total	Comments
Cells requiring user input are highlighted thus:					
General Parameters					
Total Material to be Hauled	m3	**1,011,000**			Deduct for rock from dredging
Time to transport material	year	0.50			
Working Days per Year	day/year	320			
Total Working Days	day	160			
Calculated Target Production	m3/day	**6,319**			
Working Hours per day	hr	16			
Equipment Parameters					
CAT 5230B Mass Excavator/Shovel (17m3 bucket)					Excavation site material removal - cost not included (production check)
Single Bucket Capacity	m3	17.0			
Bucket Fill Factor	no.	75%			
Factored Bucket Capacity	m3	12.75			
Bucket Cycle Time	sec	30.0			
Production Rate for Excavator	m3/hr	1530.0			Comparison: Harza Report, 2040m3/hr
Daily Loading Rate per Excavator	m3/day	24,480.00			
No. Excavators Required to maintain Target Rate	**no.**	**1.0**			
Hourly Loading Rate for 1 Excavator(s)	m3/hr	**1,530.0**			
CAT 994D Front End Loader (20m^3 Capacity)					Intermediate transfer to ensure continuous production
Single Bucket Capacity	m3	20.0			
Bucket Fill Factor	no.	70%			
Factored Bucket Capacity	m3	14			
Dig/Load Cycle Time	sec	30.0			
Production Rate for Loader	m3/hr	1680.0			
Daily Loading Rate per Loader	m3/day	26,880.00			
No. Loaders Required to maintain Target Rate	**no.**	**1.0**			
Hourly Loading Rate for 1 Loaders	**m3/hr**	**1,680.0**			
Highway Legal Truck (35m3 Capacity)					
Truck Capacity (Max.)	m3	35			
Truck Capacity (Struck)	m3	25			
Total Truck Trips Required to Meet Target	no.	40,440			
Calculated truck trips per day	no.	253.0			
Max. load/unload time per truck *	hr	0.063			Note: logistics check
* Note: If this value is less than either calculated load or unload time below, then load/unload maximum is exceeded - increase time to completion					
Truck Transportation Cycle					
Average one-way distance (excavation site to dump location)	km	5.0			Source: site plan
Average Truck Travel Speed		30			
Estimated Load Time	hr	0.016			1 minutes
Estimated Travel Time (Round Trip)	hr	0.333			Calculated round-trip distance of 10 km
Estimated Unload Time	hr	0.083			5 minutes
Total Cycle Time	**hr**	**0.43**			
Calculated Trips Per Truck per Day	no.	37.0			
No. Trucks Required	**no.**	**7.0**			
	no.				Arbitrary no. used to maintain continuous flow at transfer station
Equipment Costs					
Highway legal Truck (35m3 Capacity)					
Hourly Rate	$/hr		$ 55.62		
Daily Rate per truck	$/day		$ 890		16 pay hours per day
Daily Rate for 7 trucks	$/day	7	$ 6,229		
CAT 994D Front End Loader (20m^3 Capacity)					
Hourly Rate	$/hr		$ 634.18		
Daily Rate per loader	$/day		$ 15,220		24 pay hours per day
Daily Rate for 1 loader	$/day	1	$ 15,220		
Haul Roads Use existing highway and construction dikes					
Construction Cost per km	$/km				
Daily maintenance cost of road	$/day		$500.00		Assume patching to existing road.

Transportation Costs

Item	Unit	Qty	Price/Rate	Total	Comments
Equipment					
35m3 Trucks	day	160.0	$ 6,229	$ 996,682	
20m3 Front End Loader	day	160.0	$ 15,220	$ 2,435,251	
Haul Roads					
Haul Road Construction	km	7.0	$ -	$ -	
Haul Road Bridge (Pan American Highway)	no.	1.0	$ 4,800,000		
Haul Road Culverts	no.	22.0	$ 150,000		
Haul Road Maintenance	day	160.0	$ 500	$ 80,000	

Total Cost - Material Transportation	**$3,511,933**
Unit cost of truck haul per m^3	**$3.47**

Note: Costs do not include drill and blast and work at quarry face

ANNUAL COST		2001 Costs	2005 Costs	2001 Costs	2005 Costs	2001 Costs	2005 Costs	2001 Costs	2005 Costs
Equipment Costs		CAT 789 Off-Road Truck	CAT 789 Off-Road Truck	CAT 775E Off-Road Truck	CAT 775E Off-Road Truck	CAT 5230 Front Shovel	CAT 5230 Front Shovel	CAT 994D Front End Loader	CAT 994D Front End Loader
Purchase Price		$ 1,550,000.00	$ 1,743,750.000	$ 1,000,000.00	$ 1,125,000.000	$ 3,210,000.00	$ 3,611,250.000	$ 2,500,000.00	$ 2,812,500.000
Salvage Value		$ 310,000.00	$ 348,750.00	$ 200,000.00	$ 225,000.00	$ 642,000.00	$ 722,250.00	$ 500,000.00	$ 562,500.00
Useful Life (years)		10	10	10	10	10	10	10	10
Revenue Hours per Year		3000	3000	3000	3000	3000	3000	3000	3000
Interest Rate		8%	8%	8%	8%	8%	8%	8%	8%
Annual Fixed Maintenance	10.0%	$ 155,000.00	$ 174,375.00	$ 100,000.00	$ 112,500.00	$ 321,000.00	$ 361,125.00	$ 250,000.00	$ 281,250.00
Annual Depreciation	12.0%	$ 186,000.00	$ 209,250.00	$ 120,000.00	$ 135,000.00	$ 385,200.00	$ 433,350.00	$ 300,000.00	$ 337,500.00
Annual Insurance	1.0%	$ 15,500.00	$ 17,437.50	$ 10,000.00	$ 11,250.00	$ 32,100.00	$ 36,112.50	$ 25,000.00	$ 28,125.00
Fuel Consumption Per Hour		45	45	40	40	50	50	50	50
Fuel Cost Per Gallon		$ 1.25	$ 2.30	$ 1.25	$ 2.30	$ 1.25	$ 2.30	$ 1.25	$ 2.30

HOURLY COST		2001 Costs	2005 Costs	2001 Costs	2005 Costs	2001 Costs	2005 Costs	2001 Costs	2005 Costs
Cost Type		CAT 789 Off-Road Truck	CAT 789 Off-Road Truck	CAT 789 Off-Road Truck	CAT 789 Off-Road Truck	CAT 5230 Front Shovel	CAT 5230 Front Shovel	CAT 994D Front End Loader	CAT 994D Front End Loader
Maintenance		$ 51.67	$ 58.13	$ 33.33	$ 37.50	$ 107.00	$ 120.38	$ 83.33	$ 93.75
Ownership		$ 62.00	$ 69.75	$ 40.00	$ 45.00	$ 128.40	$ 144.45	$ 100.00	$ 112.50
Insurance		$ 5.17	$ 5.81	$ 3.33	$ 3.75	$ 10.70	$ 12.04	$ 8.33	$ 9.38
Fuel		$ 56.25	$ 103.50	$ 50.00	$ 92.00	$ 62.50	$ 115.00	$ 62.50	$ 115.00
Lubricants									
@ 15% of Fuel Cost	15.0%	$ 8.44	$ 15.53	$ 7.50	$ 13.80	$ 9.38	$ 17.25	$ 9.38	$ 17.25
Variable Maintenance									
@ 50% of Fixed Maintenance	50.0%	$ 25.83	$ 29.06	$ 16.67	$ 18.75	$ 53.50	$ 60.19	$ 41.67	$ 46.88
Labor (Panamanian Rate)		$ 15.00	$ 16.88	$ 15.00	$ 16.88	$ 30.00	$ 33.75	$ 30.00	$ 33.75
Hourly Cost		$ 224.35	$ 298.65	$ 165.83	$ 227.68	$ 401.48	$ 503.05	$ 335.21	$ 428.50

ISLAND FEASIBILITY STUDY - PANAMA

ALTERNATIVE #3

Preliminary Estimate of Dredging and Reclamation Unit rates from CEDP model

	Activity	approximate Qty	Unit	Unit Price	Total
1	**Mobilization**	**1**	**ls**	**$8,269,221**	**$8,269,221**
2	**Access Dredging**	**4,050,000**	**m3**	**$5.54**	**$22,437,600**
2a	Entrance Channel - Pilot Cut (to -5m; Clam)	210,000	m3	$5.50	$1,155,000
2b	Island Perimeter (to -5m; Clam)	690,000	m3	$5.69	$3,926,100
2c	Entrance Channel - Balance (to -8m; Clam)	3,150,000	m3	$5.51	$17,356,500
3	**Island Construction**	**1,120,000**	**m2**	**$215.37**	**$241,213,020**
3a	Pre-Dredge Soft Sediments	7,587,000	m3	$5.32	$40,362,840
3b	Cofferdam Cells	1,600	Lm		$0
3c	Rock Dike	3,000	Lm	$7,373	$22,120,000
3ca	Armor Stone	225,000	m3	$20.00	$4,500,000
3cb	Underlayer Stone	144,000	m3	$15.00	$2,160,000
3cc	Core Stone	1,546,000	m3	$10.00	$15,460,000
3d	Berth Structure	1,600	Lm		$0
3e	Soft Mat'l Disposal / Fill Placement (Hopper)	22,347,000	m3	$6.09	$136,093,230
3f	Fill Placement (Hopper)	6,065,000	m3	$7.03	$42,636,950
4	**Rock Removal**	**1,800,000**	**m3**	**$37.29**	**$67,118,200**
4a	Dredging of Weathered Rock (Clam)	740,000	m3	$20.64	$15,273,600
4b	Drilling & Blasting Dense Rock (Drillboat)	530,000	m3	$77.64	$41,149,200
4c	Dredging Dense Rock (Clam)	530,000	m3	$20.18	$10,695,400
	TOTAL COST	**1,120,000**	**m2**	**$302.71**	**$339,038,041**

Note: Quantities are preliminary and subject to update as study proceeds

Estimated Cost - Berth Structure - Design Option 1

Item			Locations 1 & 2		Location 3	
Dimensions						
Length	m	1,600				
Width	m	53.13				
	Units	**Unit Price**	**Quantity**	**Cost**	**Quantity**	**Cost**
Cofferdam Cell				***$28,186,214***		***$30,700,444***
Flat Steel Sheet Piles	tonnes	$1,230	16,455	$20,239,397	17,922	$22,044,454
Corner Steel Fabrications	tonnes	$2,260	597	$1,348,900	650	$1,469,850
Coating Waterside Steel Sheet Pile	m^2	$25	99,907	$2,505,652	108,814	$2,729,038
Cofferdam Fill - Dredge from Borrow	m^3	$3.00	545,635	$1,636,906	594,280	$1,782,841
Cofferdam Fill - Transport	m^3	$1.50	545,635	$818,453	594,280	$891,420
Cofferdam Fill - Place Mechanically	m^3	$3.00	545,635	$1,636,906	594,280	$1,782,841
Piles				***$36,801,600***		***$44,520,850***
Furnish & Install PZ-27 Sheet Pile Deadman	tonnes	$1,320	1,280	$1,689,600	1,280	$1,689,600
Furnishing HP 14x89 Piles	m	$145	44,100	$6,394,500	56,350	$8,170,750
Handling & Driving HP 14x89 Piles	ea	$1,000	2,450	$2,450,000	2,450	$2,450,000
Field Splicing HP 14x89 Piles	ea	$500	2,450	$1,225,000	2,450	$1,225,000
Furnishing 36" x 1/2" Pipe Piles	m	$315	21,000	$6,615,000	25,200	$7,938,000
Drill & Socket Pipe Piles	m	$3,000	2,100	$6,300,000	3,150	$9,450,000
Handling & Driving 36" x 1/2" Pipe Piles	ea	$2,000	1,050	$2,100,000	1,050	$2,100,000
Concrete Fill for Pipe Piles	m^3	$700	13,800	$9,660,000	15,900	$11,130,000
Pipe Pile Test	ls	$50,000	1	$50,000	1	$50,000
Dynamic Pile Testing	ea	$1,750	90	$157,500	90	$157,500
Dynamic Pile Testing - Restrike	ea	$1,600	100	$160,000	100	$160,000
Deck				***$29,406,500***		***$28,309,000***
Concrete - Bent Caps	m^3	$1,150	4,990	$5,738,500	4,580	$5,267,000
Concrete - Waterside Crane Beam	m^3	$1,150	2,380	$2,737,000	2,380	$2,737,000
Concrete - Landside Crane Beam	m^3	$500	5,370	$2,685,000	5,370	$2,685,000
Concrete - Fascia Beam	m^3	$1,150	1,600	$1,840,000	1,600	$1,840,000
Concrete - Slab on Grade	m^3	$400	12,740	$5,096,000	13,200	$5,280,000
Concrete - Precast Deck Panels	m^2	$500	16,500	$8,250,000	15,400	$7,700,000
Concrete - Topping Slab & Bent Infill	m^3	$500	6,120	$3,060,000	5,600	$2,800,000
Vessel Associated Hardware				***$3,520,000***		***$3,520,000***
Panel Fenders	ea	$35,000	88	$3,080,000	88	$3,080,000
Mooring Bollards	ea	$5,000	88	$440,000	88	$440,000
Crane Rails				***$2,435,000***		***$2,435,000***
175# Crane Rail	m	$750	3,200	$2,400,000	3,200	$2,400,000
Crane Rail Expansion Joint	ea	$3,500	10	$35,000	10	$35,000
Associated Crane Items				***$4,295,560***		***$4,295,560***
Form & Cast Crane Cable Trench	m	$520	3,200	$1,664,000	3,200	$1,664,000
Super Panzerbelt P400	m	$550	3,200	$1,760,000	3,200	$1,760,000
Form & Cast Crane Cable Reel Vault	ea	$12,120	15	$181,800	15	$181,800
Form & Cast Utility Pits	ea	$1,580	10	$15,800	10	$15,800
Ductile Iron Utility Pit Frame & Cover	ea	$1,070	50	$53,500	50	$53,500
CIP Concrete Crane Stops	ea	$2,250	4	$9,000	4	$9,000
Crane Stowage Pin	ea	$1,530	42	$64,260	42	$64,260
Crane Storm Tie-Down	ea	$9,120	60	$547,200	60	$547,200
Miscellaneous :				***$884,000***		***$884,000***
Plastic Marine Lumber Curbing	m	$240	1600	$384,000	1600	$384,000
Cathodic Protection System	ls	$500,000	1	$500,000	1	$500,000
Civil/Infrastructure				***$2,769,000***		***$2,769,000***
Electrical/Communications Manhole	ea	$32,000	10	$320,000	10	$320,000
6-Way 4-Inch PVC Communications Ductbank	m	$230	1,600	$368,000	1,600	$368,000
8-Way 5-Inch PVC Electrical Ductbank	m	$330	1,600	$528,000	1,600	$528,000
75' Light Pole & Foundation	ea	$20,000	20	$400,000	20	$400,000
3-Inch Ductile Iron Pipe & Fittings (Potable)	m	$170	1,600	$272,000	1,600	$272,000
8-Inch Ductile Iron Pipe & Fittings (Potable)	m	$230	1,600	$368,000	1,600	$368,000
8-Inch Ductile Iron Pipe & Fittings (Fire)	m	$230	1,600	$368,000	1,600	$368,000
Fire Hydrant	ea	$3,500	20	$70,000	20	$70,000
Electric Work	ls	$75,000	1	$75,000	1	$75,000
Total				**$108,297,874**		**$117,433,854**
TOTAL				**$108,300,000**		**$117,400,000**
Cost per meter				**$67,687.50**		**$73,375.00**
Cost per square meter				**$1,274**		**$1,381**

Estimated Cost - Berth Structure - Design Option 2

Item			Locations 1 & 2		Location 3	
Dimensions						
Length	m	1,600				
Width	m	53.13				
	Units	**Unit Price**	**Quantity**	**Cost**	**Quantity**	**Cost**
Cofferdam Cell				***$35,804,143***		***$35,804,143***
Flat Steel Sheet Piles	tonnes	$1,230	20,123	$24,750,923	20,123	$24,750,923
Corner Steel Fabrications	tonnes	$2,260	730	$1,650,250	730	$1,650,250
Coating Waterside Steel Sheet Pile	m^2	$25	122,174	$3,064,118	122,174	$3,064,118
Cofferdam Fill - Dredge from Borrow	m^3	$5.00	667,248	$3,336,238	667,248	$3,336,238
Cofferdam Fill - Transport	m^3	$1.50	667,248	$1,000,871	667,248	$1,000,871
Cofferdam Fill - Place Mechanically	m^3	$3.00	667,248	$2,001,743	667,248	$2,001,743
Piles				***$23,054,100***		***$24,272,100***
Furnish & Install PZ-27 Sheet Pile Deadman	tonnes	$1,320	1,260	$1,663,200	1,260	$1,663,200
Furnishing HP 14x89 Piles	m	$145	44,120	$6,397,400	52,520	$7,615,400
Handling & Driving HP 14x89 Piles	ea	$1,000	2,190	$2,190,000	2,190	$2,190,000
Field Splicing HP 14x89 Piles	ea	$500	2,190	$1,095,000	2,190	$1,095,000
Furnishing 36" x 1/2" Pipe Piles	m	$315	14,800	$4,662,000	14,800	$4,662,000
Drill & Socket Pipe Piles	m	$3,000	1,150	$3,450,000	1,150	$3,450,000
Handling & Driving 36" x 1/2" Pipe Piles	ea	$2,000	575	$1,150,000	575	$1,150,000
Concrete Fill for Pipe Piles	m^3	$700	2,970	$2,079,000	2,970	$2,079,000
Pipe Pile Test	ls	$50,000	1	$50,000	1	$50,000
Dynamic Pile Testing	ea	$1,750	90	$157,500	90	$157,500
Dynamic Pile Testing - Restrike	ea	$1,600	100	$160,000	100	$160,000
Deck				***$17,755,167***		***$17,755,167***
Concrete - Bent Caps	m^3	$550	1,750	$962,500	1,750	$962,500
Concrete - Waterside Crane Beam	m^3	$650	4,500	$2,925,000	4,500	$2,925,000
Concrete - Landside Crane Beam	m^3	$533	5,370	$2,864,000	5,370	$2,864,000
Concrete - Fascia Beam	m^3	$767	1,600	$1,226,667	1,600	$1,226,667
Concrete - Slab on Grade	m^3	$345	17,800	$6,141,000	17,800	$6,141,000
Concrete - Precast Deck Panels	m^2	$500	5,760	$2,880,000	5,760	$2,880,000
Concrete - Topping Slab & Bent Infill	m^3	$350	2,160	$756,000	2,160	$756,000
Vessel Associated Hardware				***$3,520,000***		***$3,520,000***
Panel Fenders	ea	$35,000	88	$3,080,000	88	$3,080,000
Mooring Bollards	ea	$5,000	88	$440,000	88	$440,000
Crane Rails				***$2,435,000***		***$2,435,000***
175# Crane Rail	m	$750	3,200	$2,400,000	3,200	$2,400,000
Crane Rail Expansion Joint	ea	$3,500	10	$35,000	10	$35,000
Associated Crane Items				***$4,295,560***		***$4,295,560***
Form & Cast Crane Cable Trench	m	$520	3,200	$1,664,000	3,200	$1,664,000
Super Panzerbelt P400	m	$550	3,200	$1,760,000	3,200	$1,760,000
Form & Cast Crane Cable Reel Vault	ea	$12,120	15	$181,800	15	$181,800
Form & Cast Utility Pits	ea	$1,580	10	$15,800	10	$15,800
Ductile Iron Utility Pit Frame & Cover	ea	$1,070	50	$53,500	50	$53,500
CIP Concrete Crane Stops	ea	$2,250	4	$9,000	4	$9,000
Crane Stowage Pin	ea	$1,530	42	$64,260	42	$64,260
Crane Storm Tie-Down	ea	$9,120	60	$547,200	60	$547,200
Miscellaneous :				***$884,000***		***$884,000***
Plastic Marine Lumber Curbing	m	$240	1600	$384,000	1600	$384,000
Cathodic Protection System	ls	$500,000	1	$500,000	1	$500,000
Civil/Infrastructure				***$2,769,000***		***$2,769,000***
Electrical/Communications Manhole	ea	$32,000	10	$320,000	10	$320,000
6-Way 4-Inch PVC Communications Ductbank	m	$230	1,600	$368,000	1,600	$368,000
8-Way 5-Inch PVC Electrical Ductbank	m	$330	1,600	$528,000	1,600	$528,000
75' Light Pole & Foundation	ea	$20,000	20	$400,000	20	$400,000
3-Inch Ductile Iron Pipe & Fittings (Potable)	m	$170	1,600	$272,000	1,600	$272,000
8-Inch Ductile Iron Pipe & Fittings (Potable)	m	$230	1,600	$368,000	1,600	$368,000
8-Inch Ductile Iron Pipe & Fittings (Fire)	m	$230	1,600	$368,000	1,600	$368,000
Fire Hydrant	ea	$3,500	20	$70,000	20	$70,000
Electric Work	ls	$75,000	1	$75,000	1	$75,000
Total				**$90,516,969**		**$91,734,969**
TOTAL				**$90,500,000**		**$91,700,000**
Cost per meter				**$56,562.50**		**$57,312.50**
Cost per square meter				**$1,065**		**$1,079**
				$54,712,827		$55,930,827
				54,700,000		55,900,000
				34,188		34,938

Estimated Cost - Berth Structure - Design Option 3

Item			Locations 1 & 2		Location 3	
Dimensions						
Length	m	1,600				
Width	m	53.13				
	Units	**Unit Price**	**Quantity**	**Cost**	**Quantity**	**Cost**
Piles				***$57,977,100***		***$64,896,250***
Furnishing HP 14x89 Piles	m	$145	41,650	$6,039,250	56,350	$8,170,750
Handling & Driving HP 14x89 Piles	ea	$1,000	2,450	$2,450,000	2,450	$2,450,000
Field Splicing HP 14x89 Piles	ea	$500	2,450	$1,225,000	2,450	$1,225,000
Furnishing 36" x 1/2" Pipe Piles	m	$315	50,990	$16,061,850	61,500	$19,372,500
Drill & Socket Pipe Piles	m	$3,000	6,306	$18,918,000	6,306	$18,918,000
Handling & Driving 36" x 1/2" Pipe Piles	ea	$2,000	2,628	$5,256,000	2,628	$5,256,000
Concrete Fill for Pipe Piles	m^3	$700	10,210	$7,147,000	12,320	$8,624,000
Pipe Pile Test	ls	$50,000	1	$50,000	1	$50,000
Dynamic Pile Testing	ea	$1,750	200	$350,000	200	$350,000
Dynamic Pile Testing - Restrike	ea	$1,600	300	$480,000	300	$480,000
Deck				***$53,147,000***		***$53,147,000***
Concrete - Bent Caps	m^3	$1,150	13,500	$15,525,000	13,500	$15,525,000
Concrete - Waterside Crane Beam	m^3	$1,150	2,380	$2,737,000	2,380	$2,737,000
Concrete - Landside Crane Beam	m^3	$500	5,370	$2,685,000	5,370	$2,685,000
Concrete - Fascia Beam	m^3	$1,150	1,600	$1,840,000	1,600	$1,840,000
Concrete - Precast Deck Panels	m^2	$500	44,160	$22,080,000	44,160	$22,080,000
Concrete - Topping Slab & Bent Infill	m^3	$500	16,560	$8,280,000	16,560	$8,280,000
Vessel Associated Hardware				***$3,520,000***		***$3,520,000***
Panel Fenders	ea	$35,000	88	$3,080,000	88	$3,080,000
Mooring Bollards	ea	$5,000	88	$440,000	88	$440,000
Crane Rails				***$2,435,000***		***$2,435,000***
175# Crane Rail	m	$750	3,200	$2,400,000	3,200	$2,400,000
Crane Rail Expansion Joint	ea	$3,500	10	$35,000	10	$35,000
Associated Crane Items				***$4,295,560***		***$4,295,560***
Form & Cast Crane Cable Trench	m	$520	3,200	$1,664,000	3,200	$1,664,000
Super Panzerbelt P400	m	$550	3,200	$1,760,000	3,200	$1,760,000
Form & Cast Crane Cable Reel Vault	ea	$12,120	15	$181,800	15	$181,800
Form & Cast Utility Pits	ea	$1,580	10	$15,800	10	$15,800
Ductile Iron Utility Pit Frame & Cover	ea	$1,070	50	$53,500	50	$53,500
CIP Concrete Crane Stops	ea	$2,250	4	$9,000	4	$9,000
Crane Stowage Pin	ea	$1,530	42	$64,260	42	$64,260
Crane Storm Tie-Down	ea	$9,120	60	$547,200	60	$547,200
Miscellaneous :				***$1,134,000***		***$1,134,000***
Plastic Marine Lumber Curbing	m	$240	1,600	$384,000	1,600	$384,000
Cathodic Protection System	ls	$750,000	1	$750,000	1	$750,000
Civil/Infrastructure				***$2,769,000***		***$2,769,000***
Electrical/Communications Manhole	ea	$32,000	10	$320,000	10	$320,000
6-Way 4-Inch PVC Communications Ductbank	m	$230	1,600	$368,000	1,600	$368,000
8-Way 5-Inch PVC Electrical Ductbank	m	$330	1,600	$528,000	1,600	$528,000
75' Light Pole & Foundation	ea	$20,000	20	$400,000	20	$400,000
3-Inch Ductile Iron Pipe & Fittings (Potable)	m	$170	1,600	$272,000	1,600	$272,000
8-Inch Ductile Iron Pipe & Fittings (Potable)	m	$230	1,600	$368,000	1,600	$368,000
8-Inch Ductile Iron Pipe & Fittings (Fire)	m	$230	1,600	$368,000	1,600	$368,000
Fire Hydrant	ea	$3,500	20	$70,000	20	$70,000
Electric Work	ls	$75,000	1	$75,000	1	$75,000
Total				**$125,277,660**		**$132,196,810**
TOTAL				**$125,300,000**		**$132,200,000**
Cost per meter				**$78,313**		**$82,625**
Cost per square meter				**$1,474**		**$1,555**

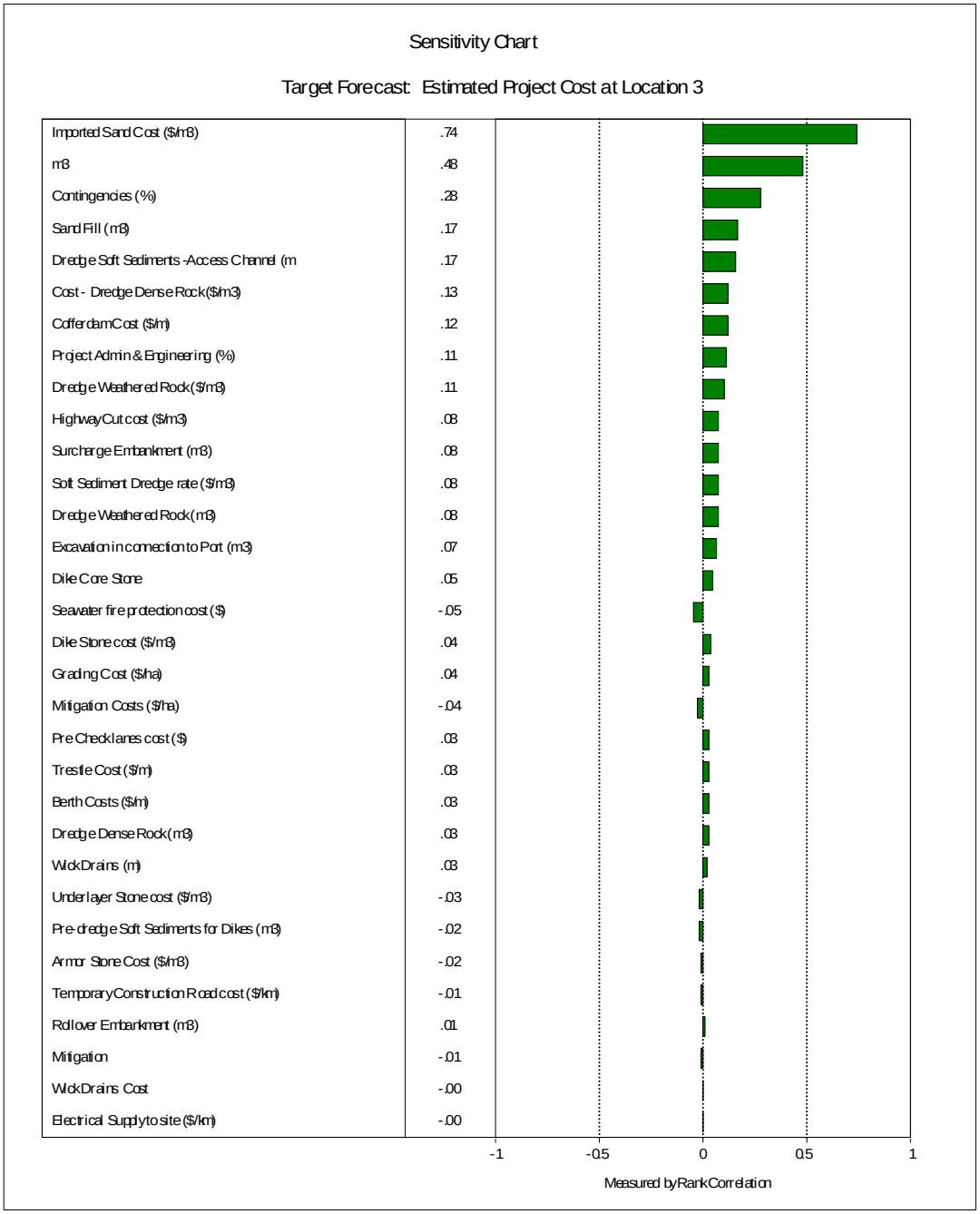
Conceptual Estimate	DATE PREPARED 29-Jun-05
ACTIVITY AND LOCATION Autoridad de Canal de Panama	CONSTRUCTION CONTRACT NO.
PROJECT TITLE	ESTIMATED BY Moffatt & Nichol
New Container Terminal	Alternate 3 Location

Variable Items - mean values indicated - XXXX

Description	Quantity	Units	Unit Cost	Total
Dredging and Reclamation				**$265,451,394**
Pre-dredge Soft Sediments for Dikes	1,100,000	m3	$5.42	$5,958,333
Dredge Soft Sediments -Access Channel	13,754,225	m3	$5.17	$71,063,496
Dredge Weathered Rock	755,000	m3	$15.83	$11,954,167
Dredge Dense Rock	535,236	m3	$43.33	$23,193,557
Sand Fill	14,238,054	m3	$5.38	$76,529,541
Sand License fee	14,238,054	m3	$0.00	$0
Dike Core Stone	1,546,000	m3	$7.75	$11,981,500
Dike Armor Stone	225,000	m3	$23.33	$5,250,000
Dike Underlayer Stone	144,000	m3	$15.00	$2,160,000
Rock License Fee	1,915,000	m3	$0.00	$0
Cofferdam Cell Retention Structure	1,600	m	$35,850.50	$57,360,800
Marginal Wharf and Access Trestle				**$63,770,400**
Marginal Wharf	1,600	m	$34,969.00	$55,950,400
Access Trestle	200	m	$39,100.00	$7,820,000
Site Stabilization				**$25,766,911**
Surcharge Embankment	1,351,200	m3	$5.38	$7,262,700
Rollover Embankment	2,184,000	m3	$3.00	$6,552,000
Wick Drains	6,375,400	m	$1.87	$11,952,211
Terminal Infrastructure				**$86,994,057**
Grading	112	ha	$14,375.51	$1,610,057
Storm Drainage	112	ha	$50,000.00	$5,600,000
Fire Protection - Sea Water System	1	LS	$2,750,000.00	$2,750,000
Fire Protection - Fresh water to Buildings	1	LS	$350,000.00	$350,000
Extend Water Main from Howard to Site	4	km	$125,000.00	$500,000
Holding tank for Fresh water system	1	LS	$250,000.00	$250,000
Potable Water & Ship supply	112	ha	$12,500.00	$1,400,000
Sanitary Sewage within terminal	112	ha	$4,500.00	$504,000
Riser Main and Waste Water Treatment Plant	1	LS	$450,000.00	$450,000
Electric Power to Site - Landside	12.0	km	$150,000.00	$1,800,000
Electric Power Distribution - Terminal	112	ha	$75,000.00	$8,400,000

Communication - Landside	12	km	$50,000.00	$600,000
Communication - Terminal	112	ha	$25,000.00	$2,800,000
Highmast Lightpoles	60	ea	$65,000.00	$3,900,000
Reefer Plugs (2 per reefer bay)	1,200.0	ea	$4,200.00	$5,040,000
Heavy-duty Pavement	880,000	m2	$58.00	$51,040,000
Entrance Gate & Roadway Pavement	42,300	m2	$35.00	$1,480,500
Construction Road and Highway Improvements				**$16,106,250**
Excavation in connection to Port	1,050,000.0	m3	$9.63	$10,106,250
Temporary Haul road	12.0	km	$500,000.00	$6,000,000
Right of Way Acquisition	120.0	ha	$0.00	$0
Entrance Gates and Buildings				**$7,245,000**
Precheck Lanes	6.0	ea	$265,000.00	$1,590,000
Administration Building	2,000.0	m2	$1,300.00	$2,600,000
Maintenance Building	2,350.0	m2	$1,300.00	$3,055,000
Mitigation				**$646,000**
Mitigation	136.0	ha	$4,750.00	$646,000
SUBTOTAL				**$465,980,012**
Contingency	1	LS	13.75%	$64,072,252
Planning, Engineering and Project Managen	1	LS	6.38%	$33,790,832
TOTAL				**$563,843,096**

Crystal Ball Report
Simulation started on 6/10/05 at 9:05:46
Simulation stopped on 6/10/05 at 9:05:50

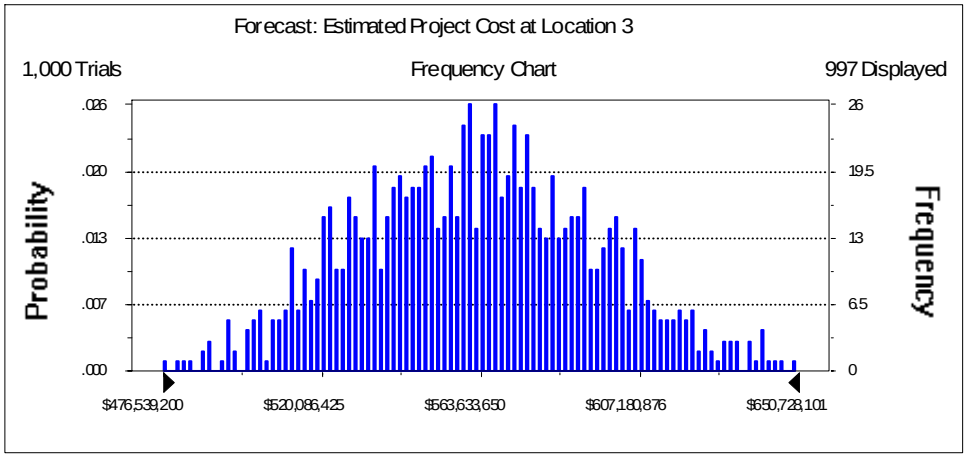


Forecast: Estimated Project Cost at Location 3 **Cell: E74**

Summary:

Display Range is from $476,539,200 to $650,728,101
Entire Range is from $476,539,200 to $675,602,136
After 1,000 Trials, the Std. Error of the Mean is $1,033,948

Statistics:	Value
Trials	1000
Mean	$562,977,641
Median	$563,037,478
Mode	---
Standard Deviation	$32,696,295
Variance	1E+15
Skewness	0.13
Kurtosis	2.74
Coeff. of Variability	0.06
Range Minimum	$476,539,200
Range Maximum	$675,602,136
Range Width	$199,062,935
Mean Std. Error	$1,033,947.62



Forecast: Estimated Project Cost at Location 3 (cont'd) **Cell: E74**

Percentiles:

Percentile	Value
0%	$476,539,200
5%	$511,656,237
10%	$520,963,002
15%	$527,714,312
20%	$533,670,265
25%	$539,535,783
30%	$544,394,735
35%	$549,028,675
40%	$553,984,414
45%	$558,931,965
50%	$563,037,478
55%	$566,856,076
60%	$570,991,525
65%	$575,247,388
70%	$579,935,045
75%	$585,294,365
80%	$591,461,693
85%	$598,238,940
90%	$605,816,975
95%	$617,623,457
100%	$675,602,136

End of Forecast

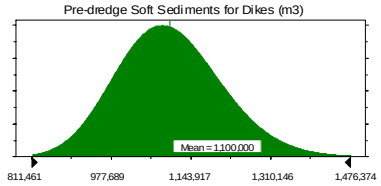
Assumptions

Assumption: Pre-dredge Soft Sediments for Dikes (m3) **Cell: B17**

Lognormal distribution with parameters:

Mean	1,100,000
Standard Dev.	110,000

Selected range is from 0 to +Infinity

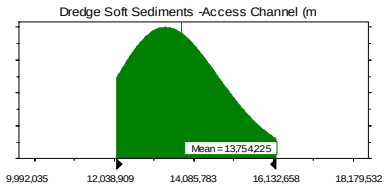


Assumption: Dredge Soft Sediments -Access Channel (m **Cell: B18**

Lognormal distribution with parameters:

Mean	13,545,000
Standard Dev.	1,354,500

Selected range is from 12,093,493 to 16,187,241

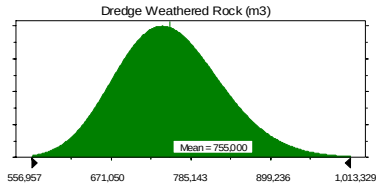


Assumption: Dredge Weathered Rock (m3) **Cell: B19**

Lognormal distribution with parameters:

Mean	755,000
Standard Dev.	75,500

Selected range is from 0 to +Infinity

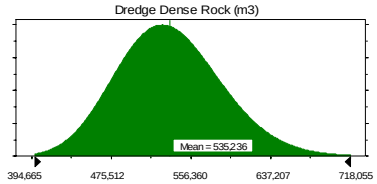


Assumption: Dredge Dense Rock (m3) **Cell: B20**

Lognormal distribution with parameters:

Mean	535,000
Standard Dev.	53,500

Selected range is from 397,899 to +Infinity

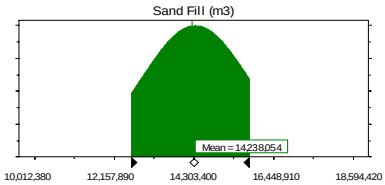


Assumption: Sand Fill (m3) **Cell: B21**

Normal distribution with parameters:

Mean	14,303,400
Standard Dev.	1,430,340

Selected range is from 12,615,599 to 15,790,954

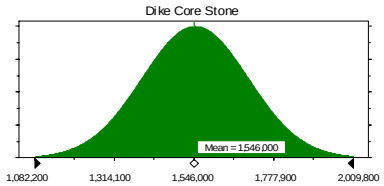


Assumption: Dike Core Stone **Cell: B23**

Normal distribution with parameters:

Mean	1,546,000
Standard Dev.	154,600

Selected range is from -Infinity to +Infinity

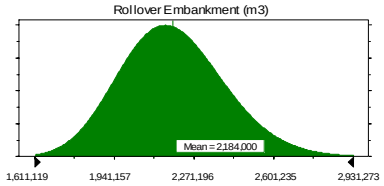


Assumption: Rollover Embankment (m3) **Cell: B35**

Lognormal distribution with parameters:

Mean	2,184,000
Standard Dev.	218,400

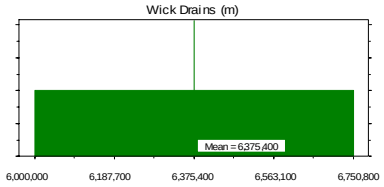
Selected range is from 0 to +Infinity



Assumption: Wick Drains (m) **Cell: B36**

Uniform distribution with parameters:

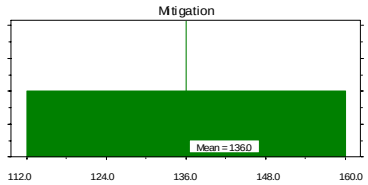
Minimum	6,000,000
Maximum	6,750,800



Assumption: Mitigation **Cell: B68**

Uniform distribution with parameters:

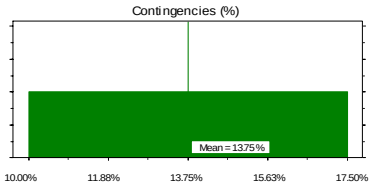
Minimum	112.0
Maximum	160.0



Assumption: Contingencies (%) **Cell: D72**

Uniform distribution with parameters:

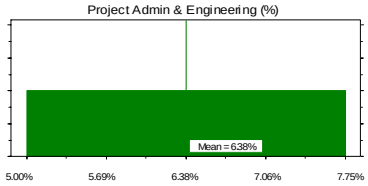
Minimum	10.00%
Maximum	17.50%



Assumption: Project Admin & Engineering (%) **Cell: D73**

Uniform distribution with parameters:

Minimum	5.00%
Maximum	7.75%

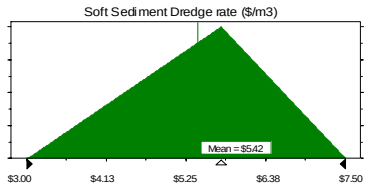


Assumption: Soft Sediment Dredge rate ($/m3) **Cell: D17**

Triangular distribution with parameters:

Minimum	$3.00
Likeliest	$5.75
Maximum	$7.50

Selected range is from $3.00 to $7.50

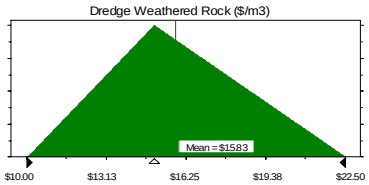


Assumption: Dredge Weathered Rock ($/m3) **Cell: D19**

Triangular distribution with parameters:

Minimum	$10.00
Likeliest	$15.00
Maximum	$22.50

Selected range is from $10.00 to $22.50

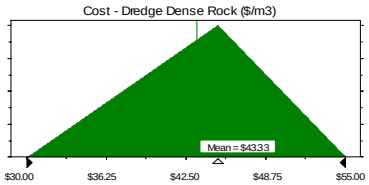


Assumption: Cost - Dredge Dense Rock ($/m3) **Cell: D20**

Triangular distribution with parameters:

Minimum	$30.00
Likeliest	$45.00
Maximum	$55.00

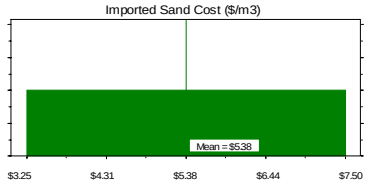
Selected range is from $30.00 to $55.00



Assumption: Imported Sand Cost ($/m3) **Cell: D21**

Uniform distribution with parameters:

Minimum	$3.25
Maximum	$7.50

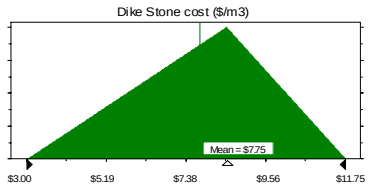


Assumption: Dike Stone cost ($/m3) **Cell: D23**

Triangular distribution with parameters:

Minimum	$3.00
Likeliest	$8.50
Maximum	$11.75

Selected range is from $3.00 to $11.75

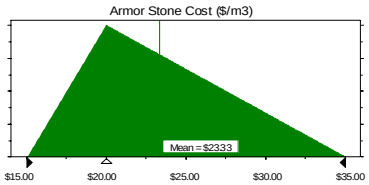


Assumption: Armor Stone Cost ($/m3) **Cell: D24**

Triangular distribution with parameters:

Minimum	$15.00
Likeliest	$20.00
Maximum	$35.00

Selected range is from $15.00 to $35.00

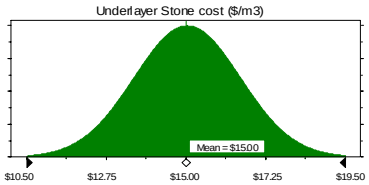


Assumption: Underlayer Stone cost ($/m3) **Cell: D25**

Normal distribution with parameters:

Mean	$15.00
Standard Dev.	$1.50

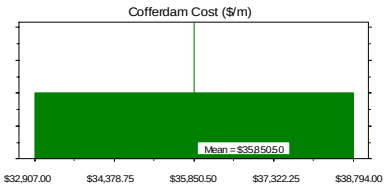
Selected range is from -Infinity to +Infinity



Assumption: Cofferdam Cost ($/m) **Cell: D27**

Uniform distribution with parameters:

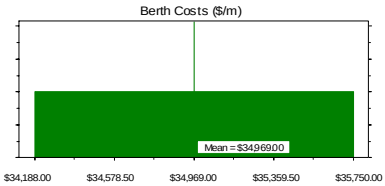
Minimum	$32,907.00
Maximum	$38,794.00



Assumption: Berth Costs ($/m) **Cell: D30**

Uniform distribution with parameters:

Minimum	$34,188.00
Maximum	$35,750.00

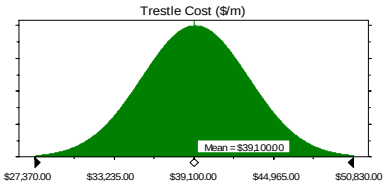


Assumption: Trestle Cost ($/m) **Cell: D31**

Normal distribution with parameters:

Mean	$39,100.00
Standard Dev.	$3,910.00

Selected range is from -Infinity to +Infinity

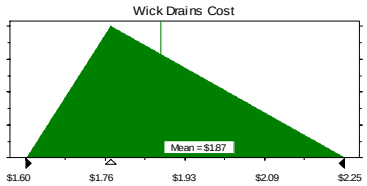


Assumption: Wick Drains Cost **Cell: D36**

Triangular distribution with parameters:

Minimum	$1.60
Likeliest	$1.77
Maximum	$2.25

Selected range is from $1.60 to $2.25

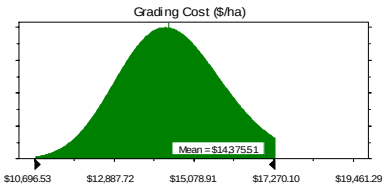


Assumption: Grading Cost ($/ha) **Cell: D39**

Lognormal distribution with parameters:

Mean	$14,500.00
Standard Dev.	$1,450.00

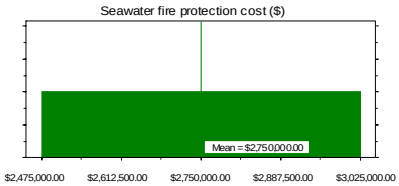
Selected range is from $0.00 to $17,299.32



Assumption: Seawater fire protection cost ($) **Cell: D41**

Uniform distribution with parameters:

Minimum	$2,475,000.00
Maximum	$3,025,000.00

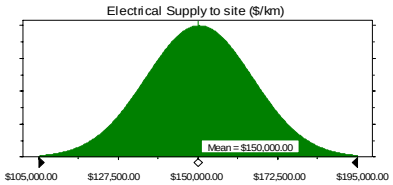


Assumption: Electrical Supply to site ($/km) **Cell: D48**

Normal distribution with parameters:

Mean	$150,000.00
Standard Dev.	$15,000.00

Selected range is from -Infinity to +Infinity

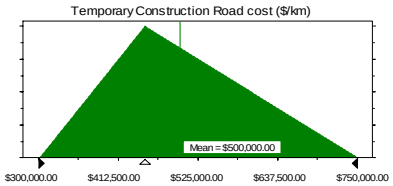


Assumption: Temporary Construction Road cost ($/km) **Cell: D59**

Triangular distribution with parameters:

Minimum	$300,000.00
Likeliest	$450,000.00
Maximum	$750,000.00

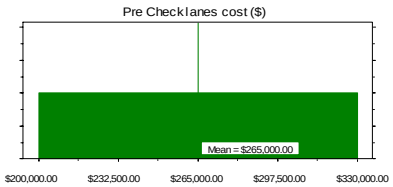
Selected range is from $300,000.00 to $750,000.00



Assumption: Pre Check lanes cost ($) **Cell: D63**

Uniform distribution with parameters:

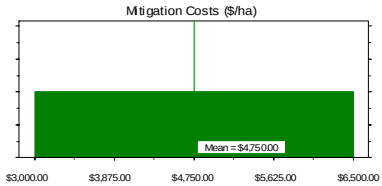
Minimum	$200,000.00
Maximum	$330,000.00



Assumption: Mitigation Costs ($/ha) **Cell: D68**

Uniform distribution with parameters:

Minimum	$3,000.00
Maximum	$6,500.00

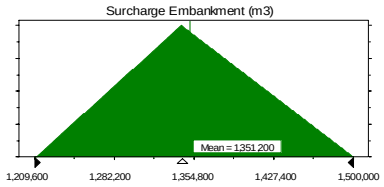


Assumption: Surcharge Embankment (m3) **Cell: B34**

Triangular distribution with parameters:

Minimum	1,209,600
Likeliest	1,344,000
Maximum	1,500,000

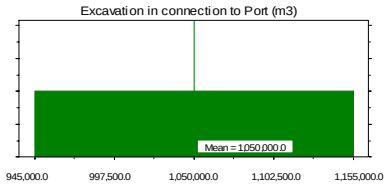
Selected range is from 1,209,600 to 1,500,000



Assumption: Excavation in connection to Port (m3) **Cell: B58**

Uniform distribution with parameters:

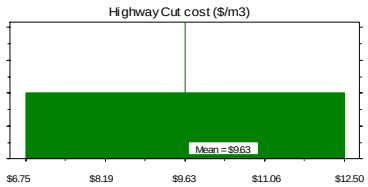
Minimum	945,000.0
Maximum	1,155,000.0



Assumption: Highway Cut cost ($/m3) **Cell: D58**

Uniform distribution with parameters:

Minimum	$6.75
Maximum	$12.50

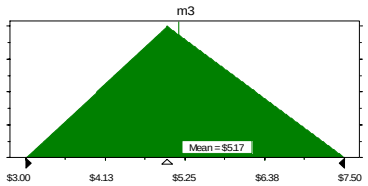


Assumption: m3 **Cell: D18**

Triangular distribution with parameters:

Minimum	$3.00
Likeliest	$5.00
Maximum	$7.50

Selected range is from $3.00 to $7.50



End of Assumptions

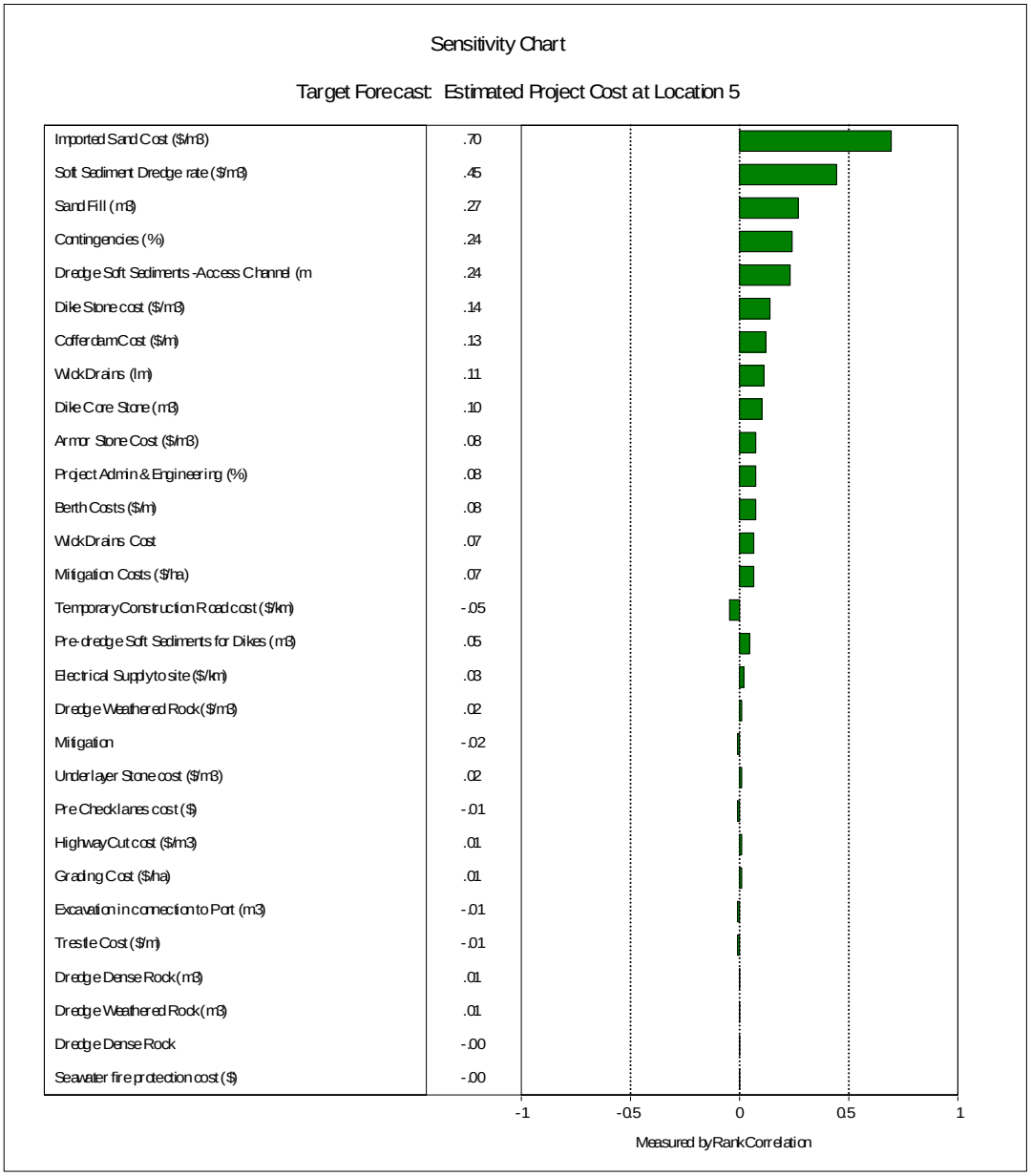
Conceptual Estimate	DATE PREPARED 29-Jun-05
ACTIVITY AND LOCATION Autoridad de Canal de Panama	**CONSTRUCTION CONTRACT NO.**
PROJECT TITLE	**ESTIMATED BY** Moffatt & Nichol
New Container Terminal	**Alternate 5 Location**

Variable Items and Mean values shown - XXXXXXX

Description	Quantity	Units	Unit Cost	Total
Dredging and Reclamation				**$298,122,872**
Pre-dredge Soft Sediments for Dikes	4,783,000	m3	$5.47	$26,145,823
Dredge Soft Sediments -Access Channel	12,500,000	m3	$5.47	$68,330,082
Dredge Weathered Rock	150,000	m3	$15.83	$2,375,000
Dredge Dense Rock	14,000	m3	$43.33	$606,667
Sand Fill	18,930,000	m3	$5.38	$101,748,750
Sand License fee	18,930,000	m3	$0.00	$0
Dike Core Stone	3,633,000	m3	$7.75	$28,155,750
Dike Armor Stone	420,000	m3	$23.33	$9,800,000
Dike Underlayer Stone	240,000	m3	$15.00	$3,600,000
Rock License Fee	4,293,000	m3	$0.00	$0
Cofferdam Cell Retention Structure	1,600	m	$35,850.50	$57,360,800
Marginal Wharf and Access Trestle				**$63,770,400**
Marginal Wharf	1,600	m	$34,969.00	$55,950,400
Access Trestle	200	m	$39,100.00	$7,820,000
Site Stabilization				**$44,642,364**
Surcharge Embankment	1,351,200	m3	$5.38	$7,262,700
Rollover Embankment	2,184,000	m3	$3.00	$6,552,000
Wick Drains	16,443,709	m	$1.87	$30,827,664
Terminal Infrastructure				**$86,994,057**
Grading	112	ha	$14,375.51	$1,610,057
Storm Drainage	112	ha	$50,000.00	$5,600,000
Fire Protection - Sea Water System	1	LS	$2,750,000.00	$2,750,000
Fire Protection - Fresh water to Buildings	1	LS	$350,000.00	$350,000
Extend Water Main from Howard to Site	4	km	$125,000.00	$500,000
Holding tank for Fresh water system	1	LS	$250,000.00	$250,000
Potable Water & Ship supply	112	ha	$12,500.00	$1,400,000
Sanitary Sewage within terminal	112	ha	$4,500.00	$504,000
Riser Main and Waste Water Treatment Plant	1	LS	$450,000.00	$450,000
Electric Power to Site - Landside	12.0	km	$150,000.00	$1,800,000
Electric Power Distribution - Terminal	112	ha	$75,000.00	$8,400,000
Communication - Landside	12	km	$50,000.00	$600,000
Communication - Terminal	112	ha	$25,000.00	$2,800,000
Highmast Lightpoles	60	ea	$65,000.00	$3,900,000
Reefer Plugs (2 per reefer bay)	1,200.0	ea	$4,200.00	$5,040,000
Heavy-duty Pavement	880,000	m2	$58.00	$51,040,000
Entrance Gate & Roadway Pavement	42,300	m2	$35.00	$1,480,500

Construction Road and Highway Improvements				**$16,106,250**
Excavation in connection to Port	1,050,000.0	m3	$9.63	$10,106,250
Temporary Haul road	12.0	km	$500,000.00	$6,000,000
Right of Way Acquisition	120.0	ha	$0.00	$0
Entrance Gates and Buildings				**$7,245,000**
Precheck Lanes	6.0	ea	$265,000.00	$1,590,000
Administration Building	2,000.0	m2	$1,300.00	$2,600,000
Maintenance Building	2,350.0	m2	$1,300.00	$3,055,000
Mitigation				**$646,000**
Mitigation	136.0	ha	$4,750.00	$646,000
SUBTOTAL				$517,526,943
Contingency	1	LS	13.75%	$71,159,955
Planning, Engineering and Project Management	1	LS	6.38%	$37,528,790
TOTAL				**$626,215,687**

Crystal Ball Report
Simulation started on 6/10/05 at 9:16:49
Simulation stopped on 6/10/05 at 9:16:53

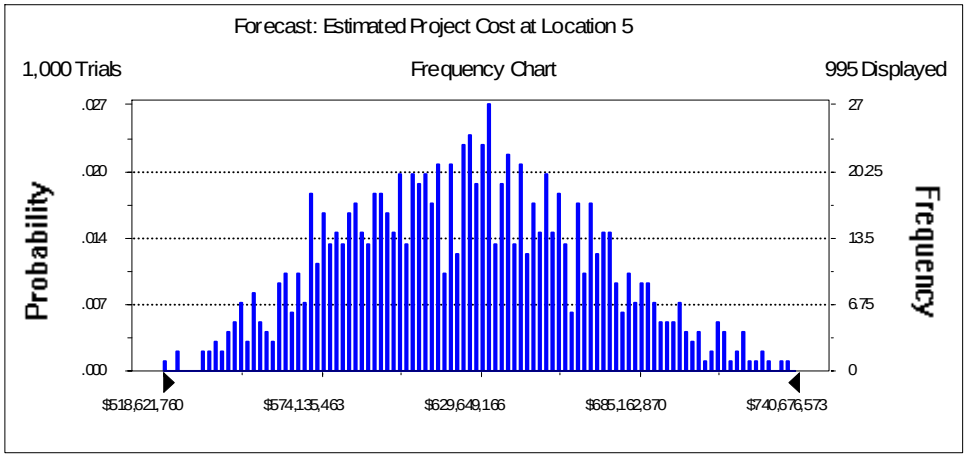


Forecast: Estimated Project Cost at Location 5 **Cell: E72**

Summary:

Display Range is from $518,621,760 to $740,676,573
Entire Range is from $518,621,760 to $781,610,444
After 1,000 Trials, the Std. Error of the Mean is $1,363,305

Statistics:	Value
Trials	1000
Mean	$625,357,158
Median	$625,075,506
Mode	---
Standard Deviation	$43,111,475
Variance	2E+15
Skewness	0.20
Kurtosis	2.71
Coeff. of Variability	0.07
Range Minimum	$518,621,760
Range Maximum	$781,610,444
Range Width	$262,988,685
Mean Std. Error	$1,363,304.53



Forecast: Estimated Project Cost at Location 5 (cont'd) **Cell: E72**

Percentiles:

Percentile	Value
0%	$518,621,760
5%	$558,195,225
10%	$570,389,176
15%	$578,136,648
20%	$585,786,595
25%	$592,819,393
30%	$600,152,525
35%	$606,901,052
40%	$612,110,479
45%	$619,329,990
50%	$625,075,506
55%	$630,042,500
60%	$635,165,907
65%	$640,988,238
70%	$648,530,996
75%	$654,842,804
80%	$663,376,621
85%	$671,684,942
90%	$681,616,823
95%	$698,228,627
100%	$781,610,444

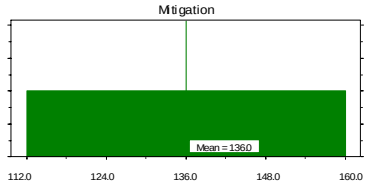
End of Forecast

Assumptions

Assumption: Mitigation **Cell: B66**

Uniform distribution with parameters:

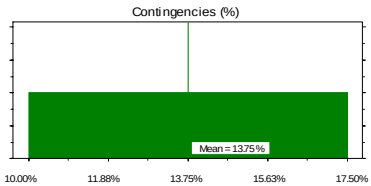
Minimum	112.0
Maximum	160.0



Assumption: Contingencies (%) **Cell: D70**

Uniform distribution with parameters:

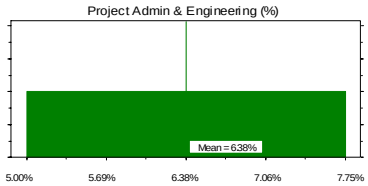
Minimum	10.00%
Maximum	17.50%



Assumption: Project Admin & Engineering (%) **Cell: D71**

Uniform distribution with parameters:

Minimum	5.00%
Maximum	7.75%

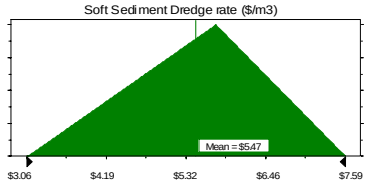


Assumption: Soft Sediment Dredge rate ($/m3) **Cell: D15**

Triangular distribution with parameters:

10% - tile	$4.16
Likeliest	$5.75
90% - tile	$6.68

Selected range is from $3.06 to $7.59

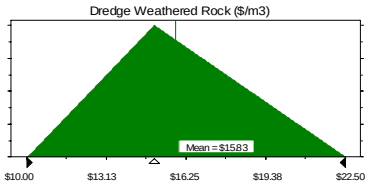


Assumption: Dredge Weathered Rock ($/m3) **Cell: D17**

Triangular distribution with parameters:

Minimum	$10.00
Likeliest	$15.00
Maximum	$22.50

Selected range is from $10.00 to $22.50

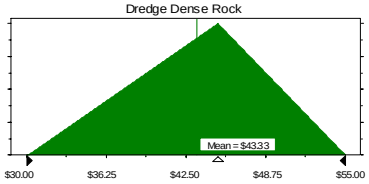


Assumption: Dredge Dense Rock **Cell: D18**

Triangular distribution with parameters:

Minimum	$30.00
Likeliest	$45.00
Maximum	$55.00

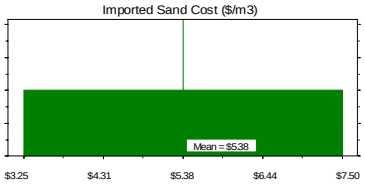
Selected range is from $30.00 to $55.00



Assumption: Imported Sand Cost ($/m3) **Cell: D19**

Uniform distribution with parameters:

Minimum	$3.25
Maximum	$7.50

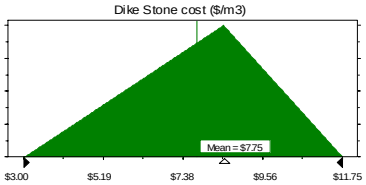


Assumption: Dike Stone cost ($/m3) **Cell: D21**

Triangular distribution with parameters:

Minimum	$3.00
Likeliest	$8.50
Maximum	$11.75

Selected range is from $3.00 to $11.75

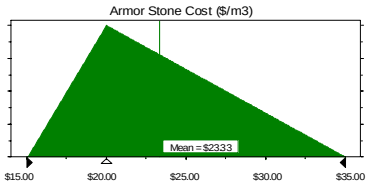


Assumption: Armor Stone Cost ($/m3) **Cell: D22**

Triangular distribution with parameters:

Minimum	$15.00
Likeliest	$20.00
Maximum	$35.00

Selected range is from $15.00 to $35.00

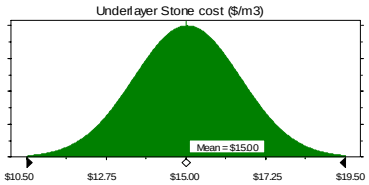


Assumption: Underlayer Stone cost ($/m3) **Cell: D23**

Normal distribution with parameters:

Mean	$15.00
Standard Dev.	$1.50

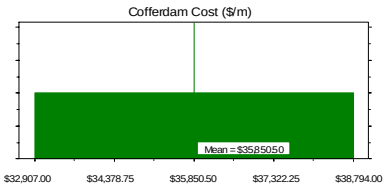
Selected range is from -Infinity to +Infinity



Assumption: Cofferdam Cost ($/m) **Cell: D25**

Uniform distribution with parameters:

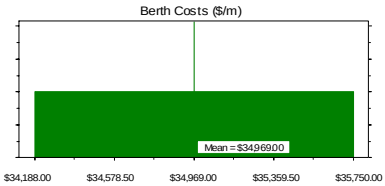
Minimum	$32,907.00
Maximum	$38,794.00



Assumption: Berth Costs ($/m) **Cell: D28**

Uniform distribution with parameters:

Minimum	$34,188.00
Maximum	$35,750.00

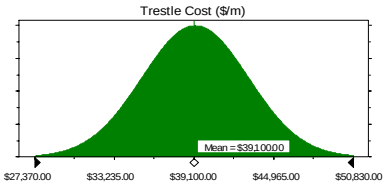


Assumption: Trestle Cost ($/m) **Cell: D29**

Normal distribution with parameters:

Mean	$39,100.00
Standard Dev.	$3,910.00

Selected range is from -Infinity to +Infinity

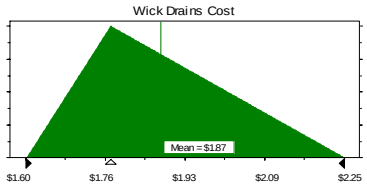


Assumption: Wick Drains Cost **Cell: D34**

Triangular distribution with parameters:

Minimum	$1.60
Likeliest	$1.77
Maximum	$2.25

Selected range is from $1.60 to $2.25

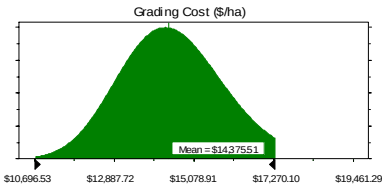


Assumption: Grading Cost ($/ha) **Cell: D37**

Lognormal distribution with parameters:

Mean	$14,500.00
Standard Dev.	$1,450.00

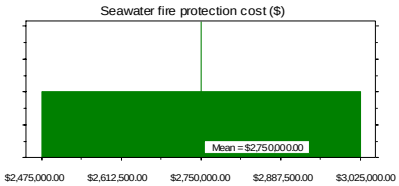
Selected range is from $0.00 to $17,299.32



Assumption: Seawater fire protection cost ($) **Cell: D39**

Uniform distribution with parameters:

Minimum	$2,475,000.00
Maximum	$3,025,000.00

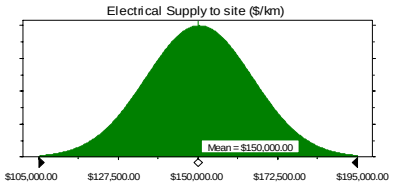


Assumption: Electrical Supply to site ($/km) **Cell: D46**

Normal distribution with parameters:

Mean	$150,000.00
Standard Dev.	$15,000.00

Selected range is from -Infinity to +Infinity

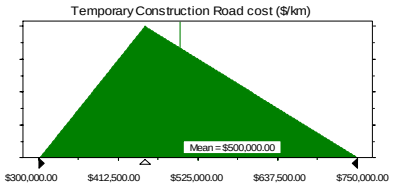


Assumption: Temporary Construction Road cost ($/km) **Cell: D57**

Triangular distribution with parameters:

Minimum	$300,000.00
Likeliest	$450,000.00
Maximum	$750,000.00

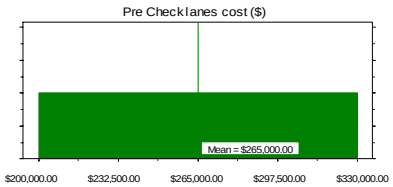
Selected range is from $300,000.00 to $750,000.00



Assumption: Pre Check lanes cost ($) **Cell: D61**

Uniform distribution with parameters:

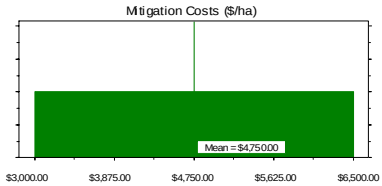
Minimum	$200,000.00
Maximum	$330,000.00



Assumption: Mitigation Costs ($/ha) **Cell: D66**

Uniform distribution with parameters:

Minimum	$3,000.00
Maximum	$6,500.00

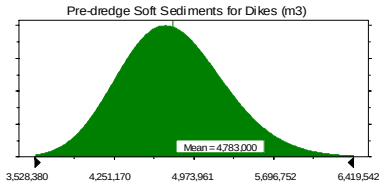


Assumption: Pre-dredge Soft Sediments for Dikes (m3) **Cell: B15**

Lognormal distribution with parameters:

Mean	4,783,000
Standard Dev.	478,300

Selected range is from 0 to +Infinity

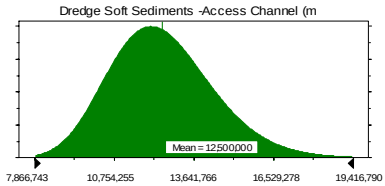


Assumption: Dredge Soft Sediments -Access Channel (m **Cell: B16**

Lognormal distribution with parameters:

Mean	12,500,000
Standard Dev.	1,893,000

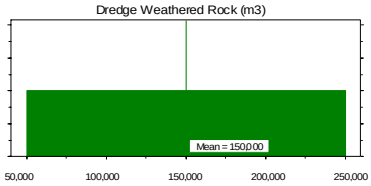
Selected range is from 0 to +Infinity



Assumption: Dredge Weathered Rock (m3) **Cell: B17**

Uniform distribution with parameters:

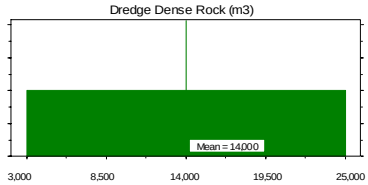
Minimum	50,000
Maximum	250,000



Assumption: Dredge Dense Rock (m3) **Cell: B18**

Uniform distribution with parameters:

Minimum	3,000
Maximum	25,000

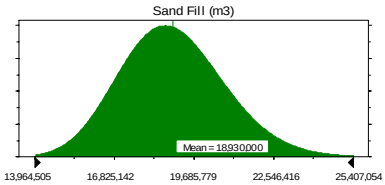


Assumption: Sand Fill (m3) **Cell: B19**

Lognormal distribution with parameters:

Mean	18,930,000
Standard Dev.	1,893,000

Selected range is from 0 to +Infinity

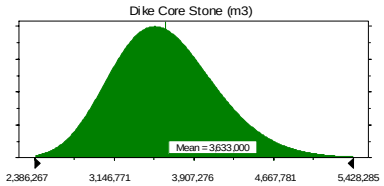


Assumption: Dike Core Stone (m3) **Cell: B21**

Lognormal distribution with parameters:

Mean	3,633,000
Standard Dev.	500,000

Selected range is from 0 to +Infinity

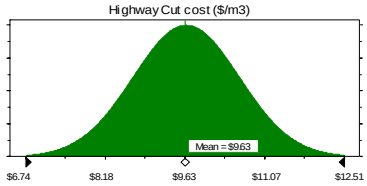


Assumption: Highway Cut cost ($/m3) **Cell: D56**

Normal distribution with parameters:

Mean	$9.63
Standard Dev.	$0.96

Selected range is from -Infinity to +Infinity

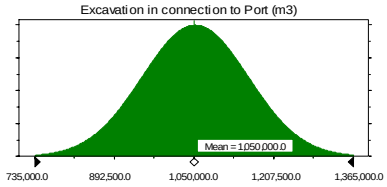


Assumption: Excavation in connection to Port (m3) **Cell: B56**

Normal distribution with parameters:

Mean	1,050,000.0
Standard Dev.	105,000.0

Selected range is from -Infinity to +Infinity

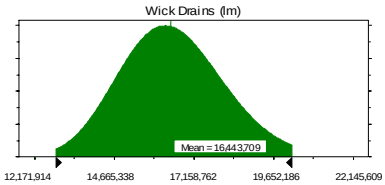


Assumption: Wick Drains (lm) **Cell: B34**

Lognormal distribution with parameters:

Mean	16,500,000
Standard Dev.	1,650,000

Selected range is from 12,836,827 to 20,217,362



End of Assumptions

Estimated Cost - Trestle Structure - 200m

Item	Units	Unit Price	Quantity	Cost
Piles				***$5,559,250***
Furnishing 26" Steel Pipe Piles	m	$230	2,300	$529,000
Drill & Socket Piles	m	$2,200	210	$462,000
Handling & Driving Piles	ea	$2,000	105	$210,000
Dynamic Pile Testing	ea	$1,750	15	$26,250
Dynamic Pile Testing - Restrike	ea	$1,600	20	$32,000
Deck				***$2,150,000***
CIP Concrete Topping	m^3	$500	850	$425,000
Precast Concrete Deck Panels	m^2	$500	3,450	$1,725,000
CIP Concrete Bent Caps	m^3	$1,150	550	$632,500
Precast Utililty Vault	m^3	$1,000	280	$280,000
Miscellaneous				***$108,000***
Jersey Barriers	m	$170	400	$68,000
Lighting	LS	$15,000	1	$15,000
Striping and Signage	LS	$25,000	1	$25,000
Total				**$7,817,250**
TOTAL				**$7,820,000**
Cost per meter				**$39,100**
Cost per square meter				**$1,827**

APPENDIX F - ENVIRONMENTAL & SOCIO ECONOMIC ASSESSMENTS

ENVIRONMENTAL & SOCIO ECONOMIC IMPACT ASSESSMENT

Introduction

This section of the report describes the potential environmental and social impacts associated with preliminary study related to the project during the construction and operation phases. The data available and the time/schedule constraints for this study do not allow for a complete quantitative analysis of the impacts, necessitating a partial quantitative and qualitative analysis of the impacts. The environmental management of the potential impacts discussed in this report together with the economic benefits derived from the implementation of the Project will need to be designed to ensure a sustainable project that is environmentally and economically favorable to the country.

In general the objectives of this environmental assessment are:

- To identify the potential beneficial and adverse environmental and socio-economic impacts that could potentially result from the construction and operation of the Project and its related infrastructure.
- To assess potential temporary, residual, and cumulative impacts produced by the construction and operation of the Project.
- To assess the magnitude of the impacts identified in terms of duration and spatial context.
- To rank the potential impacts identified according to their importance with regard to the environmental setting in the Project area

The impacts described in this report are potential in nature with varying degrees of occurrence and are based in many cases on worst-case scenarios assuming static environmental conditions, which in reality vary naturally and may actually heighten or lessen impacts..

Methodology

The environmental assessment to identify the potential impacts has been performed through a review of existing environmental reports and data, site visits, and an interactive process between ACP, and the engineering and environmental consulting team and

meetings with Panamanian Institute of Development and Tourisms (IPAT), National Authority of the Environment (ANAM), National Institute of Culture (INAC), Panama Canal Railroad Company, and Interoceanic Regional Authority (ARI). The interaction between ACP and the consultants allowed the evaluation of design options and the planning of the Project during this preliminary phase in order to minimize the adverse impacts and to maximize the beneficial impacts during the construction and operation phases.

Site visits were conducted on February 14-17 and April 11-13, 2005. The February site visit consisted of a reconnaissance to the project site, access roads and nearby communities such as Veracruz, Vacamonte, Amador Causeway, as well as interconnection points to the existing rail corridor west of the Miraflores Locks to identify those facilities that would be affected by the proposed construction and operation of the container terminal and associated rail/access road. The site reconnaissance consisted of a road tour consisting of viewing the site from Amador Causeway, a visit to the site (existing retirement/hospital), Kobbe Beach Resort, Veracruz and Vacamonte. In addition, potential access roads north of Miraflores locks were evaluated as well as sources of borrow material.

The April 12th site reconnaissance was conducted to evaluate the marine environment along Palo Seco. The reconnaissance included a visit to Farfan Beach and the mouth of the Farfan River, the proposed project shoreline near the hospital, and Kobbe Beach.

An analysis of the potential impacts associated with the construction and operation of the Project was performed during the desk-top environmental assessment, by overlaying the proposed activities on the existing environmental conditions as established during the site visits and based on a review of available literature.

A qualitative and quantitative identification and assessment of environmental impacts using modified Leopold cause-effect matrices was conducted by the environmental specialists based on information provided by review of available literature, field studies, identification of sensitive areas, and their interaction with project design and implementation activities. During the identification of impacts the following were considered: 1) the cause or the promoting agent of change in those activities being implemented by the Project; and 2) the social and environmental impacts or changes that will be observed as a result of the implementation of the Project activities. The following sections explain the assessment process.

The prediction and evaluation of social and environmental impacts described in this chapter provide a balance of the interests of the ACP, the general and affected public, and the Government of Panama. This balance has been achieved by incorporating

project specific information from a variety of sources that have been involved in the development of this project, such as the environmental and engineering departments of ACP, the various technical studies reviewed during the preparation of the existing conditions report for this Project, and the site reconnaissance conducted. Since this phase of the Project is a feasibility study, no input from the general and affected public was obtained during this study.

The results from this evaluation of impact will be used to define preliminary management strategies for controlling, preventing and mitigating the impacts associated with the Project.

Identification of impacts

The potential environmental impacts were identified based on the activities related to the construction and operation of the Project alternatives or options as defined in this preliminary study. The actions or agents that can potentially lead to a change of an environmental indicator, when the activity is implemented, were identified for each of the Project activities.

Project Options or Alternatives

The project consists of constructing an artificial island for a container port facility. Although a number of island locations or positions are under consideration from a geotechnical and cost perspective, all of the options are considered to have identical environmental and social impacts at this feasibility level, due to their proximity to each other. Additional fieldwork, outside the scope of this report, would be needed to identify differences in impacts associated with each location option. Road and rail access are also being evaluated for this project.

There is one proposed road alignment, which is to upgrade the existing roads between the site and the Bridge of the Americas. There are two rail/road alignments. The first (Option 1) would begin at the artificial island, run through Palo Seco and along the eastern edge of the former Howard Air Force Base to connect to the Miraflores Locks area. The second rail/road alignment (Option 2) would begin at the island and run on a trestle or pilings around the coastal edge of Palo Seco to near the mouth of the Farfan River where it turns to the west, comes across land, and follows the same route as the first alignment to reach Miraflores locks. Two rail terminal locations were also evaluated. The first location would be on the artificial island itself, while the alternative location would be on land in Palo Seco. In the event that the land based rail terminal location is chosen, any rail alignment chosen would begin at that location.

The following options or alternatives were evaluated as part of this study:

- Artificial island with access through upgraded existing roads and intersections only
- Artificial island with access through upgraded existing roads and intersections as well as rail/road alignment Option 1
- Artificial island with access through existing roads and intersections as well as rail/road alignment Option 2
- Rail terminal located on the artificial island
- Rail terminal located on land in Palo Seco

Project Activities

The following activities are anticipated during the construction phase of the Project:

- ***Transportation and Mobilization,*** includes all the activities related to the transportation of equipment, machinery, supplies and personnel to and from the proposed container terminal site. Transportation activities are anticipated to take place over land and water.
- ***Site Preparation*** includes all the activities related to earthwork (cut and fill) that is required on the landward (rail and access roads) and seaward portions of the site for the construction of the proposed container island, laydown areas, storage, and construction support-building areas.
- ***Construction of Infrastructure and Utilities*** includes the construction of access roadways and rail, administrative buildings, power, firewater system, effluent treatment system and other services to support the construction of the proposed terminal and associated infrastructure.
- ***Construction of Container Terminal*** includes the construction of a container port island including the placement of select structural fill and foundations for the gantry crane.

The following activities are anticipated during the operation of the Project:

- ***Operating the Container Terminal*** consists of the operation of the terminal and the management of container vessels, terminal and associated infrastructure.
- ***Operating the Access Road and Rail*** includes all of the operations associated with the proposed access road and rail.
- ***Maintenance of the Terminal and Related Structures*** includes all the activities required to ensure the proper civil, mechanical, electrical and automatic operational systems of the terminal and associated infrastructure.
- ***Closure of Operations and Abandonment*** includes all the activities related to the closure of the container port terminal and its installations at the end of the estimated useful life and the activities related to the proper abandonment of the installations and the rehabilitation of the site.

Environmental Components & Change Indicators

Based on the information collected during the preparation of an existing conditions report for the various physical, biological, socio-economic and cultural components represented in the Direct Impact Area (DIA) of the Project, change indicators (events that show the occurrence of an impact) have been identified based on the susceptibility of the component to exogenous agents. This analysis is summarized in Table 32. A code was assigned for each of the indicators identified in each environmental component analyzed. These codes will be used to facilitate the information management in the process of impact identification and its easy representation in the matrix of environmental impact assessment.

Table 32: Change Indicators

Environmental Component	Code	Change Indicators	Effects
Air	A-1	Alteration in the air quality	Refers to the environmental effects such as: dust and particulate generation (PM10), atmospheric emissions of mobile sources associated with the transportation of fill during construction and transportation of containers during the operation of the terminal (NO2, SO2 and CO).
Noise	R-1	Increase of the noise levels	Considers the increase of environmental noise above baseline levels due to the temporary/permanent introduction of noise levels.
Water	H-1	Increase in turbidity	Refers to the direct increase in suspended particulate material in Bay of Panama and the alteration of the aquatic habitat.
	H-2	Alteration of physical-chemical quantity and quality of Bay of Panama	The physical quality refers to changes in the water flow and volumes and their relation to the typical sediment transport associated with the development of a terminal island. This indicator also refers to changes in the physical or chemical quality of the water that may be produced by accidental spills of hydrocarbons (such as combustibles, greases and oils) or other substances related to discharges that deteriorate the quality of the resource.

Soils and Landforms	SU-1	Alteration of the physical-chemical quality	The physical quality refers to the erosion caused by container port island or water-related transport of sediments, or the combination of both. The chemical quality refers to characteristics of the soil that may be affected by accidental hydrocarbon spills (such as combustibles, greases and oils) or other substances related to discharges that deteriorate the quality of the resource.
	SU-2	Alteration of landforms	Refers to the alteration of landscape caused by cut and fill activities and soil compaction during the construction phase for the road and rail access and the loss of shoreline and caused by the proposed terminal.
	SU-3	Alteration of Morphology	Refers to the changes in the deposition of sediments patterns caused by the interaction with new terminal island on the Bay of Panama.
Terrestrial and Aquatic Flora and Fauna	FF-1	Loss of upland and wetland terrestrial vegetation cover/habitat	Refers to the removal of upland and/or wetland vegetation at the proposed location of the new access road and rail access to the container port island.
	FF-2	Alteration of marine habitats	Refers to the loss of hard bottom and other habitat due to the construction of the container port island.
	FF-3	Changes in the fish catch	Effects to the artisan fishery and the change in fish and shellfish catch due to the construction of the container port island.
	FF-4	Reduction in the threatened or endangered terrestrial and aquatic fauna	Refers to the decrease in the number of sightings in the area or the direct eradication of species with conservation ranking that are directly related to accidental contacts with Project elements or indirectly related due to the effects on their habitats.
	FF-5	Reduction in coastal and migratory birds	Refers to the decrease in the number of sightings in the area or the direct eradication of species that are directly related to accidental contacts with Project elements or indirectly related due to the effects on their habitats.

Social	S-1	Nuisance to the population	Refers to the impacts on the population living in the areas of indirect impact near terrestrial or aquatic corridors used for transporting equipment, machinery, supplies and personnel required for the project and the increase in vehicular traffic and the potential for accidents. Also refers to the impacts on the population due to noise and light pollution due to operation of the container port terminal
	S-2	Interruption of infrastructure	Refers to the impacts on the transit conditions and on structures such as roads, bridges and waterways that impede the normal traffic flow and the planning and permitting that will take place to prevent damage to infrastructure.
	S-3	Restrictive access to fishing facilities	Refers to the restrictive access to artisan fishing and shellfish collection areas due to the construction of the container port island.
	S-4	Visual impacts	Refers to the impacts to nearby populations, businesses, tourism, and future development
Economic	E-1	Increase in the capacity to move goods from one side of Panama to the other	Refers to the increased capacity or ability to move containers from one side of the country to the other, without increasing traffic or congestion through the canal.
	E-2	Increase in the demand of goods and services	Refers to the increase in the purchase of supplies, goods and services directly related to the construction and operation of the proposed container port terminal, which will result in the increase of available quality and the supply of some goods and services at local, regional and national levels.
	E-3	Job Creation	Refers to the demand of workers (skilled and non-skilled) that the Project will require throughout the construction of the proposed container port terminal, access and rail corridors and the operation of the terminal. The development of this project will produce two types of employment: direct employment, during the construction of the Project which will help alleviate the levels of

			unemployment in the area; and indirect employment created by the increase in the demand for local goods and services.
Cultural	AR-1	Alteration or destruction of archaeological resources	Refers to unknown archeological resources uncovered during the construction activities.

Evaluation of Impacts

The evaluation of impacts consisted of defining the attributes to be assessed for each of the impacts analyzed and assigning a relative value for each of these attributes. The process developed a ranking of each of the impacts generated by the Project activities during the construction and operation phases of the project as described as follows.

Evaluation Criteria

In the process of assessing the environmental impact of the Project options or alternatives, the attributes and the values were defined for the impact analysis. The attributes established for the environmental impacts were based on the characteristics and the spatial-time behavior produced by the interaction of the project activities and the environmental component affected.

The attributes defined for the evaluation of the potential impacts included:

- Type
- Geographic extent
- Length
- Magnitude
- Probability of occurrence
- Frequency
- Reversibility

The ranking of these attributes is shown in Table 33. The definition of these attributes is based on the behavior of know typical impacts, derived from the construction and operation of similar projects.

Table 33: Ranking Criteria

Impact Attribute	Classification	Definition
Type	Beneficial	Net benefit for the resource
	Neutral	No net benefit or detriment for the resource
	Adverse	Net detriment for the resource
Geographic Extent	Direct	Confined to the area directly affected by the project.
	Local	Impacts extend beyond the areas directly affected but it is located within the boundaries of the assessment study area that will be specified for each discipline or indicator.
	Regional	Impacts extend beyond the local or administrative boundaries specified for each discipline or indicator. It is considered as an indirect impact.
Duration	Short-term	Less than a year
	Medium-term	Between 1 and 5 years
	Long-term	More than 5 years
Magnitude	None	No change is foreseen
	Low	Predicted disturbance will be slightly greater than the existing typical conditions.
	Medium	Predicted effects are much higher than the typical existing conditions but without exceeding the criteria established in the permissible limits or without causing changes in the economic, social, and biological parameters within the ranks of natural variability or social tolerance.
	High	Predictable effects exceed the criteria established or the limits permitted related to potential adverse effect, or they cause a detectable change in social,

		economic and biological parameters beyond the natural variability or social tolerance.
Frequency	Permanent	Occurs continually
	Temporary	Limited to a specific period (For example: during construction)
	Periodic/ Occasional	Occurs intermittently but repeatedly either at equal time intervals or at irregular time intervals (occasional) (For example, during maintenance activities)
Occurrence Probability	Low	Low probability
	Medium	Possible or probable
	High	High occurrence
Reversibility	Short-Term	Effect could be reverted in less than a year
	Medium-Term	Effect could be reverted in greater than a year but in less than ten years
	Irreversible	Permanent effect

Evaluation of Impacts

The evaluation of impacts performed by a multi-disciplinary team was carried out using a Leopold modified matrix, in which the environmental and social factors potentially impacted and the Project activities that can lead to a potential impact were represented.

The evaluation method used for the matrix consisted of assigning values, in a relative scale, to all the attributes of the impact analyzed for each of the interrelations of project activity to environmental effect.

Table 34 represents the relative scale of values established for each of the attributes shown previously.

Table 34: Scale of Values for Ranking of Impacts

Type (C)			Duration (Du)	
Negative	-1		Long-Term	3
Positive	1		Medium-Term	2
Neutral	0		Short-Term	1
Magnitude (M)			*Frequency (F)*	
High	3		Permanent	3
Medium	2		Periodic	2
Low	1		Temporary	1
Probability of Occurrence(Po)			*Reversibility (R)*	
High	1		Irreversible	3
Medium	0.9-0.5		Reversible at medium-term	2
Low	0.4-0.1		Reversible at short-term	1
Geographic Extent (E)				
Regional				3
Local				2
Direct				1

Using the above ranking, values were assigned to each interaction analyzed to determine an index using the following equation that represents the quantitative and qualitative characteristics of the impact:

$$Ca = C \times Po \times (M + E + Du + F + R)$$

The information obtained from the literature review, field studies, observations, suggestions and recommendations from the engineering and environmental representatives of the consulting team and ACP were reviewed prior to assigning values to each of the impacts according to their attributes. Appendix B contains all of the assigned values and final scores given to all potential changes for each project component or alternative location that may occur during the environmental and social component interactions with the Project activities.

With the aim to visualize these quantitative and qualitative characteristics of the impact analyzed in the matrix of interactions, a rank of values was established assigning a color code to each one (Table 35).

Table 35: Ranking of Values and Color Code

Ranks of Value				
			Predicted Effect	**Color Code**
15	To	+.1	Positive	
0		0	NEUTRAL	
-5	To	-.1	Slightly negative	
-10	To	-5.1	Moderately negative	
-15	To	-10.1	Highly negative	

The results of this evaluation process are shown in the matrices of evaluation of impacts presented in Table to Table 40.

Table 36: Evaluation of Impacts, Artificial Island with Access through Upgraded Existing Roads and Intersections

Environment	Component	Change Indicators	Project Phase							
			Construction				Operation			
			Transportation and Mobilization	Site Preparation	Construction of Infrastructure and Utilities	Construction of Container Port Island	Operation of Container Port Terminal	Operation of Access Road and Rail	Maintenance of Terminal and Related Structures	Closure of Operations and Abandonment
Physical	Air	A-1								
	Noise	R-1								
	Water	H-1								
		H-2								
	Soil and Landforms	SU-1								
		SU-2								
		SU-3								
Biological	Terrestrial and Aquatic Flora and Fauna	FF-1								
		FF-2								
		FF-3								
		FF-4								
		FF-5								
Social	Social	S-1								
		S-2								
		S-3								
		S-4								
	Economics	E-1								
		E-2								
		E-3								
	Cultural	AR-1								

Table 37: Evaluation of Impacts, Artificial Island with Access Option 1

Environment	Component	Change Indicators	Project Phase							
			Construction				Operation			
			Transportation and Mobilization	Site Preparation	Construction of Infrastructure and Utilities	Construction of Container Port Island	Operation of Container Port	Operation of Access Road and Rail	Maintenance of Terminal and Related	Closure of Operations and Abandonment
Physical	Air	A-1								
	Noise	R-1								
	Water	H-1								
		H-2								
	Soil and Landforms	SU-1								
		SU-2								
		SU-3								
Biological	Terrestrial and Aquatic Flora and Fauna	FF-1								
		FF-2								
		FF-3								
		FF-4								
		FF-5								
Social	Social	S-1								
		S-2								
		S-3								
		S-4								
	Economics	E-1								
		E-2								
		E-3								
	Cultural	AR-1								

Table 38: Evaluation of Impacts, Artificial Island with Access Option 2

Environment	Component	Change Indicators	Project Phase							
			Construction				Operation			
			Transportation and Mobilization	Site Preparation	Construction of Infrastructure and Utilities	Construction of Container Port Island	Operation of Container Port Terminal	Operation of Access Road and Rail	Maintenance of Terminal and Related Structures	Closure of Operations and Abandonment
Physical	Air	A-1								
	Noise	R-1								
	Water	H-1								
		H-2								
	Soil and Landforms	SU-1								
		SU-2								
		SU-3								
Biological	Terrestrial and Aquatic Flora and Fauna	FF-1								
		FF-2								
		FF-3								
		FF-4								
		FF-5								
Social	Social	S-1								
		S-2								
		S-3								
		S-4								
	Economics	E-1								
		E-2								
		E-3								
	Cultural	AR-1								

Table 39: Evaluation of Impacts, Rail Terminal on Island

Environment	Component	Change Indicators	Project Phase							
			Construction				Operation			
			Transportation and Mobilization	Site Preparation	Construction of Infrastructure and Utilities	Construction of Container Port Island	Operation of Container Port Terminal	Operation of Access Road and Rail	Maintenance of Terminal and Related Structures	Closure of Operations and Abandonment
Physical	Air	A-1								
	Noise	R-1								
	Water	H-1								
		H-2								
	Soil and Landforms	SU-1								
		SU-2								
		SU-3								
Biological	Terrestrial and Aquatic Flora and Fauna	FF-1								
		FF-2								
		FF-3								
		FF-4								
		FF-5								
Social	Social	S-1								
		S-2								
		S-3								
		S-4								
	Economics	E-1								
		E-2								
		E-3								
	Cultural	AR-1								

Table 40: Evaluation of Impacts, Rail Terminal at Palo Seco

Environment	Component	Change Indicators	Project Phase							
			Construction				Operation			
			Transportation and Mobilization	Site Preparation	Construction of Infrastructure and Utilities	Construction of Container Port Island	Operation of Container Port Terminal	Operation of Access Road and Rail	Maintenance of Terminal and Related Structures	Closure of Operations and Abandonment
Physical	Air	A-1								
	Noise	R-1								
	Water	H-1								
		H-2								
	Soil and Landforms	SU-1								
		SU-2								
		SU-3								
Biological	Terrestrial and Aquatic Flora and Fauna	FF-1								
		FF-2								
		FF-3								
		FF-4								
		FF-5								
Social	Social	S-1								
		S-2								
		S-3								
		S-4								
	Economics	E-1								
		E-2								
		E-3								
	Cultural	AR-1								

Analysis of Impacts

This section presents an analysis of the environmental impacts that may potentially occur during the project construction and operation phases, determined according to the process described above.

Physical Environment

Air Quality

Construction Phase

The Project construction activities most likely to affect air quality in the region will be associated with the transportation of equipment to the site, site preparation and construction of the proposed container port terminal and access routes. The maximum air quality impacts during construction are anticipated to be temporary and intermittent from construction sources. These emissions will occur during the construction period when heavy equipment is engaged in the earthwork operations during the clearing, grading, and compaction of the site, as well as the installation of cofferdams, demolition, foundation or pile installation, buildings and associated structures.

The air pollutant emissions due to these sources are primarily associated with potential dust or particulate matter (PM) associated with earthwork. Earthwork operations including site clearing are expected to be of moderate duration compared to the length of the operational life of the proposed container port terminal and associated infrastructure. Air quality impacts during construction are considered to be a local impact, since the dispersion of dust will be less than 1 km from the proposed container port terminal.

Construction equipment used to prepare the site will produce emissions to the atmosphere from the combustion of fuels such as diesel and gasoline. These gases include NOx, hydrocarbons, CO, PM, and SO2.

The proposed container port terminal site and most of the road and rail access routes are located in rural areas or within the Canal Operating Area where the air quality is considered to be relatively good and representative of rural tropical areas where wind transported particulate matter are major sources of air pollution other than water crafts and motor vehicles. Ambient air quality impacts associated with the construction phase are considered insignificant.

Operation Phase

The air quality impacts during the operation of the container port terminal are expected to be slightly worse than the existing air quality conditions prior to the implementation of

this Project due to potential increases in vessel, vehicular, and rail traffic. The predicted air quality as established from a literature review as presented in the Existing Conditions Report indicates that the ambient air quality impact of the Direct and Indirect Impact Area are predicted to be significantly below the World Bank Ambient Air Quality Guidelines (World Bank, 1999).

Noise

Construction Phase

Noise impacts from the transportation of construction equipment, materials, and personnel on-site for construction of the container port terminal and road and rail access will be temporary and intermittent. All construction activities will be carried out in areas that are more than 2.0 kilometers from the nearest residences or businesses, such as the Kobbe Beach Resort. In the early stages of the construction of the container port terminal and rail and road access work performed onsite will consist entirely of grading, surveying, soil boring, and test drilling required determining specific geophysical characteristics. Active construction will begin with site preparation work and will proceed in accordance with the project schedule. Construction activity will be continuous until completion of the construction.

Typical construction equipment will be used, including light and heavy earth-moving equipment, large cranes, lighter mobile cranes and hoisting equipment, concrete placement equipment, miscellaneous pumps and compressors, pile driving and sheet pile driving equipment, welding and metalworking equipment, and heavy trucks and other vehicles.

There will be some construction activities, such as grading, compaction, blasting, and pile driving that will increase instantaneous and short-term ambient sound levels significantly. Site preparation activities are relatively short in duration and could dramatically increase near ambient sound levels for short periods, relative to the duration of the construction phase of the Project.

The noise levels generated during the construction phase are expected to be localized and of short-term duration. The noise level is not expected to constitute a significant adverse impact. Noise levels produced during construction may cause the wildlife in the area to migrate temporarily away from the Project site to areas were they will not be disturbed.

Operation Phase

The noise impacts associated with the operations phase of the Project are predicted to be at noise levels that are greater than those that currently exist in the project area. Noise levels are expected to be fairly constant at the container port island as operations

are expected to run 24 hours per day. Noise generated from the road and rail alignments are expected to be intermittent and dependent on shipping schedules.

Soils and Landforms

Construction Phase

The most significant impact to soils and landforms will occur during the construction associated with the proposed artificial island and the road and rail alignments. To a lesser extent other impacts to soil and landscape are anticipated to occur with the construction of infrastructure such as temporary access roadways, temporary construction field offices, and temporary laydown areas required to support the construction phase.

The modification of soils and landforms at the location of the road and rail alignments will require blasting, excavation, and compaction of soils that will result in a permanent impact to the soil structure landscape of the footprint. Clearing of vegetation will result in soil removal, mixing, and compaction by heavy equipment which will result in a destruction of their matrix system consisting of both soil nutrients and root matrix that will expose the soil to extreme temperatures, direct and intense rainfall resulting in erosion, landslides, and decomposition of the humus zones.

The potential for alteration of the physical and chemical quality of the soil by accidental hydrocarbon spills during the construction (machinery, equipment and motor vehicles) estimated as low since appropriate control and handling measures will be applied for counteracting these types of incidents.

Soil excavation in the area of the proposed rail/road alignments (Options 1 and 2) will also require the appropriate screening and management of unexploded ordinances prior to any activities associated with this Project, especially in the areas where various warning signs of unexploded ordinances were posted.

Operation Phase

The impacts associated with operation of the container port terminal island are related to the potential changes in coast line morphology as a result of changes in currents, hydrodynamics, erosion, and sediment transport related to the presence and position of the artificial island. The alteration of the physical and chemical quality of the soil by accidental hydrocarbon spills or other process-related substances during the operation of the Project is estimated as a slightly negative impact.

Water Resources

Construction Phase

During the construction phase, water will be used for dust control, soil compacting and concrete mix. Water required for these activities will be extracted from a permitted location, while potable water for construction workers will be delivered to the project. Estimated water volume that will be extracted daily during the construction phase cannot be established at this time, but the quantities should not be significant.

The construction of an artificial island to house a container port will produce a temporary increase in the ocean turbidity in the coastal region of the proposed relocation. The degree of re-suspension of the material in the water (turbidity plume) is related to several factors such as sediment characteristics (type of material and size), wind and currents prevailing during the execution of these activities and the type of construction and methods used. The turbidity plume can adversely affect the aquatic species and habitats causing a reduction of light and obstructing the respiratory mechanisms of the aquatic species. The effects of the turbidity with proper mitigations can vary from a negative to slightly negative. Deposition of suspended materials may render previously suitable areas unsuitable habitat for certain aquatic species. The impact takes into consideration that the species and habitats in the construction areas have some level of tolerance to the increase of suspension materials and to the light reduction and their ability to migrate to avoid temporary increases in turbidity. The dredging and blasting that will be required to create the island base, turning basin, and approach channel are considered to be activities generating the type of impact defined above.

The alteration of the physical and chemical quality of the water by accidental hydrocarbon spills (fuel, grease and oils) or other substances from work barges and ships, equipment and machinery used during the water construction activities are considered as a slightly negative impact. All possible precautions will be taken during the construction phase to avoid hydrocarbon spills. The potential for a spill will be minimized by using trained fuel handling personnel, establishing spill prevention procedures, maintaining spill cleanup equipment, and preparing a contingency plan.

Operation Phase

The impacts related to the management of surface drainage and discharge of effluents from the artificial island and associated infrastructure during the operation phase are considered as slightly negative; however, the magnitude of the effect will be reduced in a short-term when all the systems designed for its management and treatment are completed and the monitoring of the effluent discharge parameters for ensuring the compliance with both Panamanian and international discharge standards are implemented in order to establish adequate controls.

The environmental management and treatment systems that will be utilized during the operation of the Project include the proper management of industrial and domestic wastewater discharges from the container port terminal and equipment.

A potential impact to the water environment is the discharge of contaminated water to Panama Bay. However, this impact can be managed by including the following treatment systems for residual waters prior to discharge:

- An API oil/water separator for surface water runoff contaminated with oil and grease,
- Sanitary sewage treatment units will be used to treat sanitary waste from the container port terminal.

Water collected from the process areas and utility areas will be routed to the API oil/water separator. Collected oil is stored in appropriate tanks and is then trucked to an offsite disposal at an approved recycle/disposal facility.

Effluent from the container port terminal will be monitored to ensure compliance with Panamanian and/or applicable World Bank Guidelines for Liquid Effluents for Process Wastewater, Domestic Sewage and Contaminated Stormwater Discharge to Surface Waters effluent limits for those parameters applicable.

Biological Environment

Terrestrial and Aquatic Flora and Fauna

Construction Phase

The project study area is located in the tropical humid life zone, which provides habitat for a variety of flora and fauna, many of which are considered rare, threatened, or endangered. Several thousand species of flora and fauna are found near the Panama Canal. Many of these species are included in conservation rankings established in international conservation agreements and some are protected by Panamanian laws. Several animal and plant species with conservation rankings are reported from areas adjacent to the Project and the area is known to be a stopover location for migratory birds.

Impacts to flora and fauna associated with the transportation and mobilization phase of construction are anticipated. Most transportation activities would take place by boat or by land over existing roadways. Increased road traffic may cause additional mortality of animals crossing roadways for dispersal, foraging, or breeding. Wildlife crossings and fish friendly culverts should be part of the design of the road and rail access alignments to reduce road mortality and to facilitate dispersal and migration.

The impacts to flora and fauna associated with site preparation vary among the different options or alternatives. Earthwork associated with site preparation would cause permanent irreversible loss of forest lands, wetlands, seafloor, and ocean habitat, which would result in habitat loss for species utilizing these areas. Motile species may be able to move to unimpacted habitats near the project; however, it is unclear whether these habitats would be able to support the influx of new individuals. Less motile or non-motile species would be directly and adversely impacted by earthwork associated with site preparation. Short-term, temporary increases in turbidity and sedimentation are likely to cause temporary alteration in the structure and composition of plankton and benthic communities, which may have impacts on fish abundance and diversity. Aquatic species previously present in areas impacted by turbidity and sedimentation during site preparation are expected to re-colonize these areas once disturbance ceases, provided sedimentation is not so great as to permanently alter the habitat.

Operation Phase

Maintenance of the artificial island container port terminal and related structures is not likely to result in loss of terrestrial vegetative cover. These activities may result in temporary localized changes in the structure and composition of aquatic communities, but these communities are expected to return to their original condition once maintenance operations cease. Maintenance operations are not expected to impact rare or endangered fauna as all structures would be located within areas that have been previously or are currently disturbed by human activities.

Closure of operations and abandonment may result in some loss of terrestrial vegetative cover as structures are demolished or decommissioned. However, native vegetative may be planted or allowed to colonize these areas once human activities cease. These impacts are expected to be positive as the areas would move towards a more natural condition. Impacts to rare or endangered species are expected to be neutral to slightly positive since these species are not expected to be found in areas of human activity. Over the long-term, rare or endangered species may benefit from closure or abandonment as these areas may evolve through succession into needed habitats. Due to the magnitude of this project, it is unlikely that any of the major operations would cease. Likewise, closure and abandonment of the spillway or other major structures is not anticipated.

Social, Economic and Cultural Environment

Social

Construction Phase

<u>Nuisances to the Population</u>

The construction activities related to this Project will include the transportation and mobilization of equipment, machinery, supplies and personnel to the project site. Personnel and equipment will be transported overland or water during the mobilization phase of the project and will create temporary nuisances to the population living close to the transportation routes. Control measures will be implemented to minimize the impacts associated with these activities.

Interruption and Deterioration of the Infrastructure

A temporary construction road will be built alongside the existing public highway to avoid the interruption of the normal traffic patterns during the construction of the project caused by transporting oversize and large heavy equipment and machinery. However, some impacts on the existing highway system will be inevitable at the entrance to the project site and the intersection with the Bridge of the Americas. Transportation of equipment over water will be conducted using work barges, cranes and other similar construction equipment.

Access Restriction to Fishing Areas and Recreational Activities

The purpose of restricting access to certain portions of Farfan/Palo Sec shoreline and coastal zone during construction is to protect the fishermen and individuals passing through the area from hazards related to the construction of the Project. The access near the artificial island and other facilities during the construction phase will be restricted because of risk management concerns during the construction.

Economic

The proposed project will result in a significant capital investment, exceeding US$500 million. The resulting project would permit an increase in the capacity to move goods from one side of Panama to the other without increasing Canal traffic. Historically, investment in canal related projects has had a multiplicative positive impact on the Panamanian economy such as an increase in tax revenues and fees, an increase in demand for goods and services and job creation. For all these reasons, the impacts associated with the construction phase of the project are considered highly beneficial.

Increase in Demand of Goods and Services

At a national level, benefits will be derived from the Project. The Project will cause a general increase in business activity which will affect local, regional and national economies in a positive manner. The construction activities will generate and increase in the demand for goods and services directly and indirectly associated with the Project. This increase in demand will enhance the local economy by the production of goods and supplies of construction materials, local support services (hotels, restaurants, transportation, stores and warehouses) and an increase in trade among the districts.

The Project will require a high standard of goods and therefore this demand may result in an increase in the quality and the supply of some goods and services offered locally. For all of the above reasons mentioned above, the effect on goods and services during the construction phase is considered as highly positive.

Job Creation

Considering the level of unemployment and the limited available low wage jobs at the local level, the construction of the Project provides a new source of temporary employment that could increase per capita income of some qualified local residents in the Project's direct area of influence, and could result in an indirect benefit to the construction sector.

The creation of new employment opportunities will allow an influx of capital to areas that have been traditionally lacking of funds to meet basic necessities. Such increases in employment may lead to the improvement of social conditions such as housing, health, education, etc. from the added tax revenues associated with the Project. In addition to the direct employment, it is estimated that construction activity generates at least three to five indirect jobs for each direct job position. Therefore, induced jobs will be derived from the construction of the Project. Approximately 1,000 permanent full-time jobs at the container port terminal are expected to be created through the construction of the Project.

Cultural

Alteration or Destruction of the Archaeological Heritage

The review of existing information shows that the possibilities of finding archaeological resources in the areas where earthworks will be performed are high. Archaeological surveys are recommended before earthwork is performed in previously undisturbed areas to identify and remove archaeological resources prior to land disturbance activities. Protocols will be established for handling archaeological resources found during land disturbing activities.

Operation Phase

Access Restriction to Fishing Areas

The access near the proposed will be restricted during the operation of the Project because of risk management concerns. Non-authorized personnel will be restricted in certain areas to assure their safety and the safety of others working at the container port terminal.

<u>Economic</u>

The economic performance of the Panama Canal is very much aligned with the global economy in particular the economy of the United States, the main user of the canal, Japan and Europe. As reported in the 2002 annual report, the most recent annual report available on the internet, the uncertainty in the world economy resulted in a 2.8% downturn in cargo tonnage as compared with the previous year. The report also indicated a drop in the transits of 2.3% and an average vessel increase of 3.9%. The actual transit by larger vessels resulted in a positive impact on toll revenue to the level of B/.588.8 million. The outlook for economic growth as reported in the annual report is projected in increase by 2.9% trend as the world economies recover. Construction of the Project could alleviate some of the Canal congestion by offering alternative method of transporting containers from one side of the isthmus to the other.

Increase of the Demand of Goods and Services

At a national level, benefits will be derived from the Project during the operational phase. The Project will cause a general incremental increase in business activity which will affect local, regional and national economies in a positive manner. This will enhance the local economy by the production of goods and supplies of construction materials, local support services (hotels, restaurants, transportation, stores and warehouses). The Project will require a high standard of goods and therefore this demand may result in an increase in the quality and the supply of some goods and services offered locally. For all of the above reasons mentioned above, the effect on goods and services during the operation phase is considered as highly positive.

Visual Impacts

The introduction of the port into the view from Amador and also from the Palo Seco/Farfan area will change the characteristics of the area. As a 24 hour operation, the nighttime vista will also change as the vessels, cranes and yard area will be illuminated by powerful lighting and high mast light pole systems.

The reaction to this modification of the visual characteristics of the area will vary according to the perspective and preferences of the viewer. Some may see the port as a logical extension of the Canal traffic and economic activities that are important to Panama, while others may object to any change of the natural views of the area.

Clearly the public reaction to this project will be an important element of the approvals process for the new Port.

Summary and Conclusions

The proposed project consists of building an artificial island to house a container port terminal. Three general island locations were examined from an engineering and cost perspective. However, environmental and socioeconomic impacts were not estimated

for each location due to the close proximity of the potential locations. Further studies, including bottom surveys of aquatic species and habitat, will need to be performed to accurately identify the potential impacts associated with each location option. Construction of an artificial island at any of these locations will result in a loss of marine bottom habitat that may be utilized by benthic invertebrates, shrimp, spiny lobsters, bivalves, and certain fishes. The large rip-rap that will be placed on three sides of the artificial island may provide habitat for certain types of invertebrates and fish, but it should not be considered in-kind replacement for habitat lost through construction.

Three access alignments were also studied in conjunction with the artificial island. The first option considered was to provide automotive access only to the island by upgrading the existing roads and intersection and installing a minimum amount of new alignment. This alignment would connect the artificial island to the Bridge of the Americas. Also considered were two options for providing automotive and rail access from the artificial island to the proposed swing bridge over the Miraflores Swing Bridge and new locks, in addition to road upgrades between the island and the Bridge of the Americas. The first rail/road alignment (Option 1) would proceed northwest from the island location, following mostly existing road corridors to reach the Miraflores swing bridge. The second rail/road alignment option (Option 2) would proceed from the artificial island along the Palo Seco coastline and around Guinea Point on a trestle and causeway before coming back to land at the mouth of the Farfan River. New alignment would be used to cross the Farfan floodplain before connecting to the existing road corridor that leads to the Miraflores swing bridge. Upgrading the existing roads and intersections to provide automotive access only to the artificial island would have the least amount of negative environmental and social impacts because only a minimal amount of new alignment would be needed and most construction would occur in existing right-of-way or already disturbed areas. However, this option would provide automotive access only and if rail access is added at a later date, the cumulative impact of the separate projects may be more than that of a combined road and rail project. Of the two rail/road access alignments, Option 1 would have the least amount of negative environmental and social impacts. While Option 1 may impact more forest area than Option 2, Option 2 would impact a large portion of the nearshore marine habitat utilized by invertebrates, fishes, and coastal and migratory birds. Option 2 and may also potentially impact more mangrove area that Option 1. Option 2 will cause greater negative visual impacts due to its coastal location and visibility from the Amador Causeway. Also, visual impacts and noise levels from road and rail traffic may discourage development of the coastal areas. Providing access through upgrading the existing roads and intersections or by building rail/road alignment Option 1 (If rail access is desired) is recommended to minimize environmental and social impacts of the Project.

Also considered as part of this Project were two locations for the rail terminal (intermodal facility). The first location considered for the rail terminal would be on the artificial island

with the container port. The second location considered for the rail terminal was on the coast of Palo Seco in an area of dry forest. Locating the rail terminal on land would allow a greater portion of the island to be used for containers. However, locating the rail terminal on the artificial island would minimize environmental and social impacts because all construction would occur on a previously disturbed site (the artificial island). Construction at the Palo Seco rail terminal location would require destruction of dry forest habitat, which is becoming rare in Central America, and has the potential to unearth or destroy previously undiscovered archaeological objects. For these reasons, it is recommended that the preferred location for the rail terminal should be on the artificial island, in the event that it is considered to be a financially viable element of the Project.

Table 41 below presents an estimate of the impacted area for each island location and alignment option.

Table 41: Estimated Direct Impact Area (m^2) for Each Island Location and Alignment Option

Location/Alignment	Total Area Impacted	Seafloor Impacts	Wetland Impacts
Island Locations 1, 2, and 3	2,417,830[3]	2,417,830	0
Island Location 4	3,452,000	3,452,000	0
Island Location 5(a)	2,240,000	2,240,000	0
Land-based Intermodal Terminal	270,000	0	0
Upgrades to Existing Roads	100,000	0	20,000
Rail/Road Alignment Option 1	600,000	20,000-55,000[4]	131,000
Rail/Road Alignment Option 2	560,000	400,000	27,000

[3] The estimated impact area for Locations 1, 2, and 3 was assumed to be the same due to their similarity in size and location.

[4] Varies according to Island location

Mitigation and monitoring

Basis for Mitigation

The government of Panama has established a system of tariffs or mitigation fees associated with projects involving the loss of natural resources. According to representatives from ACP, the tariffs per hectare for primary and secondary forest are B/5,000 and B/3,000, respectively. The tariff for mangroves is B/10,000 hectare[5]. It is unknown at this time if tariffs are required for the destruction of other habitats, such as marine bottom.

The estimated footprint of impacts associated with each Project Option or Alternative is approximately 160 ha, for the island, trestle and highway improvement land requirements. On this basis, and assuming an average tariff of B/.$5,000 per ha for the loss of the sub tidal and upland zones, the allowance for mitigation is expected to be approximately B/. 800,000. Once the complete footprint of impact is determined for the preferred or final construction option, and following agreement with the government of Panama over mitigation tariffs for the project, a final cost estimate can be presented.

Mitigation projects may possibly be used in lieu of or in conjunction with tariffs to offset negative environmental and social impacts associated with the proposed Project. Potential mitigation projects could include enhancement of local beaches, environmentally sensitive areas, or important habitats. Potential mitigation projects suggested in the Island Feasibility Study (Moffat Nichol et al., 2004) included:

- Protection of the dry forest at Palo Seco
- Restoration of contaminated intertidal areas in the Rodman area that are used by migratory birds
- Enhancement of the protected forest area at Punta Bruja
- Beach enhancements or improvement of shore side facilities at Veracruz
- Community benefit projects, such as a road link from Veracruz to the Vacamonte Highway.

Compensation payments were suggested in the Island Feasibility Study (Moffat Nichol et al, 2004) as means to compensate for shrimp habitat destroyed by the construction of the artificial island. Although not fished, due to the shallow depths and rock outcrops in the area, the sub tidal areas under the island may be shrimp habitat. If the island location is determined to be prime shrimp habitat, then appropriate mitigation measures should be determined by a team of government and industry representatives.

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[5] Mitigation/tariff information provided by ACP.

Monitoring

A monitoring program should be developed to ensure that the Project construction and operation activities are incompliance with all applicable regulations. Possible monitoring provisions could include:

- Stormwater runoff from construction areas and from the container port terminal once it is operational
- Water quality in the vicinity of the artificial island and where the road or rail alignments cross streams or wetlands
- Wildlife mortality associated with crossing road or rail alignments
- Noise levels associated with construction activities and with operation of the container port terminal and associated road and rail access
- Air quality in the vicinity of construction areas and the container port terminal once it is operational
- Fisheries surveys of the coastal area of Palo Seco and the artificial island
- Birds surveys (coastal and migratory) of the coastal area of Palo Seco and the artificial island

APPENDIX G - REFERENCES

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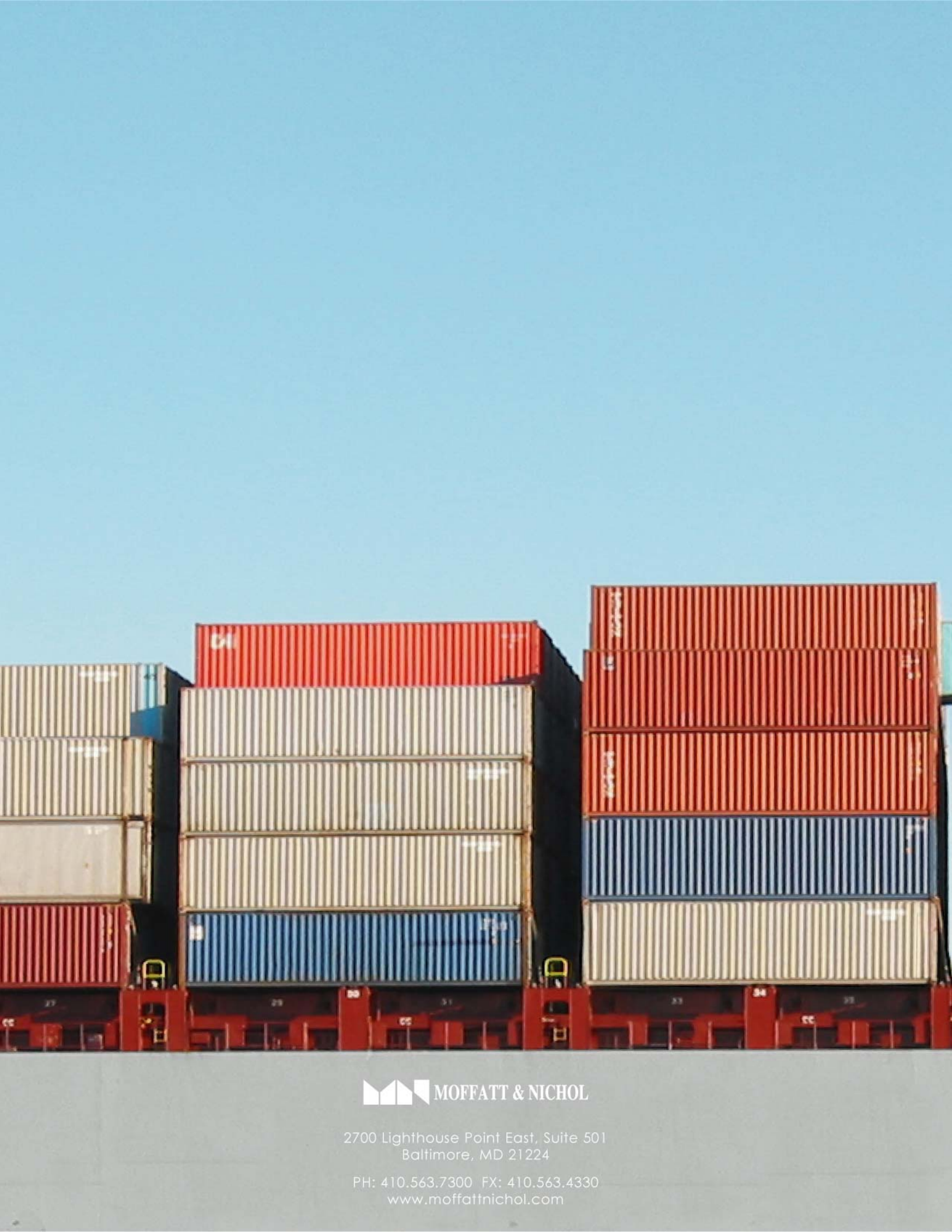

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2700 Lighthouse Point East, Suite 501
Baltimore, MD 21224

PH: 410.563.7300 FX: 410.563.4330
www.moffattnichol.com